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# Does the Supervision Mechanism Promote the Incentive Effects of Government Innovation Support on the R&D Input of Agricultural Enterprises?

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**ABSTRACT** The stimulating issues of government innovation support to the market players' R&D vitality has always been the focus of innovation. This article analyzes the impact of government innovation support's two policies, namely, government subsidies and tax & fee returns, on the R&D input of agricultural enterprises from the perspective of government intervention. Moreover, this article is primarily focusing on the institutional investors, leading shareholders, and social audit institutions in the corporate governance to play a role in the improvement of shareholding and audit supervision mechanism. This article conducts unbalanced panel data regression tests based on the relevant data of government innovation support of A-share agricultural enterprises listed in Shanghai and Shenzhen from 2009 to 2019. The conclusions are as follows: Firstly, government subsidies have a significant crowding-out effect on R&D investment of agricultural enterprises, while tax & fee returns have a significant stimulating effect. Secondly, when the shareholding ratio of institutional investors and leading shareholders increases, the shareholding supervision mechanism strengthens the effect of government innovation support on enterprise R&D input. Finally, with the improvement of social audit institutions' auditing opinions, the enhancement of auditing supervision mechanisms has weakened the effect of government innovation support on enterprise innovation investment. These research findings can provide some academic supports and policy references for formulating appropriate government innovation support and giving full play to the role of shareholding supervision and audit supervision in corporate governance.

**INDEX TERMS** Audit supervision, Government subsidies, shareholding supervision, tax & fee returns.

## I. INTRODUCTION

With the development of the rural revitalization strategy, the issue of "agriculture, rural areas, and rural residents" has become the top priority of the whole Party's work. Among them, agriculture as the foundation of the national economy, its development has received significant attention. In recent years, agricultural enterprises have been seeking transformation and upgrading. However, they still face many problems during development, such as low development quality and insufficient innovation. Simultaneously, to deal with agricultural products' severe challenges from multiple

pressures such as external resources, environment, science, and technology, agricultural enterprises' production technology must be reformed and innovated in real-time [1]. However, the innovation project has high risk and high uncertainty. Many agricultural enterprises often have low innovation initiative and innovation willingness, which affects agricultural production innovation. Therefore, the government needs to guide and support the innovation of agricultural enterprises. Therefore, the Chinese government has promulgated various supporting policies to guide and encourage agricultural enterprises to carry out production technology innovation to promote sustainable development. General Secretary Xi Jinping has stressed that "the key to agricultural modernization lies in science and technology", which requires both

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“giving full play to the decisive role of the market and better playing the role of the government” “vigorously promoting the mechanization and intelligence of agriculture, and to plug the wings of science and technology in agricultural modernization”. Agricultural listed companies are the key carriers of the realization of agricultural modernization with Chinese characteristics. The process of agricultural modernization is closely and directly related to its innovation and development. In the new era, the government should strengthen the policy support for agricultural technology innovation, stimulate the innovation vitality of agricultural enterprises in China, and make them play a positive role in promoting agriculture, driving rural economic development, and increasing farmers’ income.

Some scholars have investigated the mechanism of agricultural ecological compensation policy [2], agricultural fiscal taxation policy [3], agricultural insurance policy [4], and policy of agricultural product subsidy [5] on the promotion of agricultural modernization. These existing research achievements have laid a theoretical foundation to explore how the improvement of institutional shareholdings, leading shareholders’ shareholdings, and auditing opinion of social audit institutions affect the relationship between government innovation support and R&D input, which has weakened or enhanced the incentive effects of government innovation support on the R&D input of agricultural enterprises?

According to the collation of existing achievements, the relationship between different government innovation support and enterprises R&D behavior is concentrated in manufacturing industry [6] and high-tech industry [7], paying less attention to the agricultural industry and paying more attention to the influence of government [8] and public [9] supervision mechanisms. Based on previous studies on the impact of different government innovation support on agricultural modernization in various regions, we take agricultural listed enterprises data from 2009 to 2019 as sample, explore the impact of government subsidies and tax & fee returns on R&D input and output of listed agricultural enterprises. Furthermore, from the perspective of corporate governance, we explore the moderating or enhancing effects of three kinds of supervision mechanisms, supervision of institutional investors, supervision of leading shareholders and audit supervision of social audit institutions, between government innovation support and R&D input and output of agricultural listed enterprises. We hope to provide some theoretical support and constructive suggestions for improving the technological innovation and modernization of agricultural listed enterprises from the perspective of government intervention and corporate governance.

Therefore, this paper’s innovation points are as follows: First, Due to the lack of competitiveness and resources, many enterprises are reluctant to carry out innovation activities. Therefore, the government’s innovation support policy is critical [10]. Government innovation support can make up for the lack of technological innovation funds of enterprises, and reduce the enterprises’ R&D costs, helping the

enterprise engage in innovation activities more effectively [11]. Previous studies on government innovation support and enterprise innovation mainly focus on how government subsidies affect enterprise innovation activities. Such as the studies on the performance of enterprise innovation [12], enterprise value [13] and investment efficiency [14], which also laid a specific theoretical foundation. Simultaneously, the impact of tax & fee returns on enterprise innovation is less concerned, but as external financing, it can alleviate the shortage of enterprise innovation funds and is conducive to developing enterprise innovation activities. Therefore, based on previous government subsidies, the text increases the impact of tax & fee returns on enterprise innovation. Different from previous studies which only consider a single way of government subsidies, this article examines two forms of government innovation support policies: government subsidies and tax & fee returns, which makes the research of government subsidies more comprehensive; Second, different from previous studies, focus on the moderating role of internal and external factors such as heterogeneous enterprises [15], uncertain [16] and government supervision [8], ability constraints [17] and few kinds of literature focus on the impact of external supervision mechanism on innovation. This article focuses on the improvement and enhancement of the shareholding supervision mechanism (supervision of the institutional investors’ shareholdings and leading shareholders’ shareholdings) and audit supervision mechanism (social audit institutions’ auditing opinion) of corporate governance, result in the mitigation and enhancement of different support policies of government innovation and agricultural enterprise R&D input. Firstly, as one of the effective ways of external supervision, institutions can effectively alleviate the agency problem of companies and improve the decision-making efficiency of enterprises [18]. Secondly, audit supervision is independent of enterprises, which can effectively check and balance the irrational and opportunistic behaviors of enterprise managers and reduce their illegal behaviors [19]. By including governance and supervision mechanism into the investigation, we can explore the relationship between government support and enterprise innovation from a new perspective, and at the same time, enrich the scenario study of government subsidies.

## II. LITERATURE REVIEW AND RESEARCH HYPOTHESES

### A. GOVERNMENT INNOVATION SUPPORT AND ENTERPRISE R&D INPUT

The government, the market, and enterprises are the key components of the modern market economy system. Government support is closely linked and interacts with market competition, which has affected the top managers of enterprises’ business decision-making activities. The government provides policy support to the enterprises’ R&D activities to ensure continuous investment in enterprise innovation activities, which can help firm accumulate knowledge stock and derive new technologies, new products, and new processes, and finally drive national development by

innovation [20]. Typical means for government departments to support enterprise innovation activities include government subsidies directly allocated to enterprise R&D activities, tax refund, other financial and industrial policies. To guide the effective allocation of enterprise resources. However, there is still no consensus on whether government innovation support can improve innovation investment and resource allocation efficiency [21]. Chen *et al.* found that input-oriented subsidies usually bring more significant production risks to agricultural enterprises than output-oriented subsidies [22]. Simultaneously, compared with studying the influence of different government innovation support on agricultural enterprises' innovation. More scholars only pay attention to the influence of government subsidies on the innovation and production of agricultural enterprises [23], [24]. Akkaya *et al.* paid attention to the impact of taxes and subsidies on agricultural profits and social welfare [25]. Compared to the previous studies, this article focuses on the influence mechanism of government innovation support on R&D input.

Government subsidies mainly include enterprise R&D funding subsidies, upgrading equipment subsidies, technical transformation subsidies. Government subsidies may positively affect the enterprises' R&D input and produce particular complementary, spillover or stimulus effects [26], [27], and may negatively affect the enterprises' R&D input, resulting in substitution, suppression, or crowding-out private research and development input [28]–[30]. Moreover, the government's financial subsidy for R&D activities of listed companies has affected the company's independent R&D input and easy to dependence on listed companies' government subsidies, resulting in the company's R&D purpose becoming not pure enough. Many firms hope to obtain R&D financial subsidies from the government instead of producing high-quality R&D, and innovation outcomes, which would send a false signal of actively implementing technological innovation to the outside world. That would inhibit the company's high-quality, independent innovation R&D activities, crowding out the company's independent R&D input [31], [32]. Government subsidies would stimulate the demand for relevant production factors, leading to higher prices of production factors (such as the wage cost of R&D talents), which would increase the cost of R&D input, and also inhibit the willingness of enterprises to innovate, create a crowding-out effect on corporate R&D input [33].

Simultaneously, in addition to financial subsidies, the state has also formulated the subsidy tax & fee returns policies to support enterprises' technological innovation. Tax & fee returns play an essential role in promoting high-quality economic development, making up the internal R&D funding gap and reducing the tax burden of R&D activities of enterprises [34]. It can reduce corporate tax avoidance risks and R&D costs, promote companies to increase R&D input, produce more patent results, and develop more new products to meet consumer needs by formulating tax & fee returns policies to provide tax incentives for corporate

R&D activities [35], [36]. Especially for companies with weaker governance capabilities and fewer tangible assets, the positive impact of tax & fee returns on corporate innovation activities is more apparent [37]. Therefore, different forms of government innovation support may enable companies to find ways to obtain government subsidies and crowd out their independent R&D input. However, they may also reduce the marginal cost of R&D and innovation uncertainty of enterprises, which could stimulate the enterprises' R&D vitality. Based on the above analysis, this article proposes the following hypotheses from the perspective of government intervention:

Hypothesis 1a: The direct government subsidies are not conducive to promoting agricultural enterprises to increase R&D input. That is, government subsidies have a crowding-out effect on the R&D input of agricultural enterprises.

Hypothesis 1b: The government's tax & fee returns are conducive to promoting agricultural enterprises to increase R&D input. That is, tax & fee returns have a stimulating effect on the R&D input of agricultural enterprises.

## B. MODERATING EFFECT OF SHAREHOLDING SUPERVISION

With the maturity of China's capital market, the number and shareholding ratio of institutional investors are increasing, which has become an essential part of corporate governance. Compared with individual investors, securities firms, insurance, trusts, finance, banking, social security, and funds have more shares in enterprises and have more professional and vital investment ability. Generally, institutional investors are more willing to participate in corporate governance activities because institutional investors can alleviate agency problems by exerting external monitoring mechanisms. Moreover, they spend much time identifying enterprises and projects worth investing in, hoping to create more wealth for their financial sponsors and investors [38]. Therefore, institutional investors would influence the relationship between government innovation support and enterprise R&D input.

It is one form of institutional investors' governance mechanism to supervise the top managers' behavior. With the increasing shareholding ratio, institutional investors would pay more attention to and analyze the company's top managers' investment decision-making behavior and intervene to safeguard their interests and have more motivation and ability to monitor its operation management effect [39]. Innovative activities with high risks and unobvious short-term benefits often make company managers reluctant to invest, resulting in insufficient R&D input. Institutional investors who focus on long-term benefits can alleviate this problem using external monitoring mechanisms, and improve corporate governance as their shareholding increases and increases company R&D input. Secondly, institutional investors reduce the occupational risks of top managers. Under the assumption of professional risk, managers would worry about the consequences of the failure of R&D activities, but this approach would

not benefit institutional investors, and the pressure from institutional investors would force managers to innovate. Aghion & Van Reenen [40] found that institutional investors increase innovation by reducing managers' professional risks. Therefore, with the improvement of institutional investors' shareholdings, institutional investors would have more motivation to supervise listed companies and strengthen their external supervision in the past or future business behaviors. Therefore, the improvement and strengthening of enterprises' internal and external supervision mechanism regard the increase in the shareholding ratio of institutional investors, enhancing the enthusiasm of institutional investors to monitor and intervene in listed companies. Based on the above analysis, this article proposes the following hypotheses from the supervision perspective of institutional shareholding governance:

Hypothesis 2a: The improvement of institutional investors' shareholding supervision mechanism enhances government subsidies' crowding-out effect on R&D input of agricultural enterprises.

Hypothesis 2b: The improvement of institutional investors' shareholding supervision mechanism enhances the stimulating effect of tax & fee returns on R&D input of agricultural enterprises.

In addition to institutional investors, different company shareholders would also monitor and balance how top managers use government innovation support funds in inappropriate ways. Moreover, as more and more leading shareholders begin to participate in corporate governance, the improvement of supervision intensity can ensure the delicate operation of R&D input of enterprises, thus ensuring that investors get good investment returns. Therefore, the participation of leading shareholders in corporate governance would impact the R&D input of enterprises.

Because of the different benefits, the company's top management often pays attention to short-term results and ignores the agency costs brought by long-term benefits to a certain extent, which reduces the company's R&D input. The focuses of interest and governance power of leading shareholders restrict the self-interested behavior of high-level managers to a certain extent, enabling them to increase investment to achieve long-term company development. Besides, compared with the small and medium shareholders who have the characteristics of "free rider" and "voting with their feet", large shareholders have information advantages and better understand its operating conditions. They would participate in the company's investment decisions through the board of directors, the board of supervisors, and shareholders' meetings, which can alleviate the conflict between the small and medium-sized shareholders and managers and play a more significant role in supervision and intervention [41], to ensure that the investment decision-making of the top managers of the enterprise is beneficial to their interests. At the same time, leading shareholders have more voting rights. Shareholder voting plays an essential role in supervision and management, including manager elections, project proposals.

Leading shareholders can supervise and influence corporate decisions through direct intervention or withdrawal threats [42]. Therefore, with the improvement of leading shareholders' shareholdings, the supervision and checks and balances of leading shareholders continue to strengthen, allowing leading shareholders to appoint representatives into the board of directors, the board of supervisors, and the management of the company, which promotes the investment decisions of top managers of the company to be consistent with their own interests. Based on the above analysis, this article proposes the following hypotheses from the perspective of leading shareholder governance:

Hypothesis 3a: The improvement of the supervision mechanism for leading shareholders' shareholding enhances government subsidies' crowding-out effect on the R&D input of agricultural enterprises.

Hypothesis 3b: The improvement of the supervision mechanism for leading shareholders' shareholding enhances the stimulus effect of tax & fee returns on agricultural enterprises' R&D input.

### C. MODERATING EFFECT OF AUDIT SUPERVISION

Compared with the shareholding supervision of leading shareholders and institutional investors, social audit institutions' audit supervision opinions can effectively reflect enterprises' internal control effectiveness. Investors would often pay attention to the auditing opinions and audit fees of social auditing agencies on listed companies. Abnormal changes in auditing opinions and auditing fees are closely related to its high level of internal control. Audit supervision can effectively prevent the company's top managers from manipulating financial statements [43] and has a critical external governance role in the corporate governance process [44].

Audit supervision is an independent third-party audit conducted by an external social auditing agency on its top managers' investment decision-making behavior. Audit supervision can effectively supervise and balance the company's top managers' irrational and opportunistic behavior and alleviate the company top managers' inefficient investment behavior and illegal behavior under performance pressure [19]. Audit supervision can also alleviate the degree of information asymmetry between investors and operators, improve the quality of corporate information disclosure, and improve the quality of investors' decision-making [45], which shows that, as one of the components of the supervision mechanism, the audit supervision of the social audit agency can alleviate the degree of information asymmetry between investors and operators. Furthermore, they can conduct appropriate supervision and checks and balances on company managers' investment decision-making behavior and affect the relationship between government innovation support and corporate R&D input. Based on the above analysis, this article proposes the following hypotheses from the perspective of corporate governance control:

Hypothesis 4a: The improvement of audit supervision mechanism weakens the crowding-out effect of government subsidy support on R&D input of agricultural enterprises

Hypothesis 4b: The improvement of audit supervision mechanism weakens the stimulating effect of tax & fee returns support on R&D input of agricultural enterprises

### III. SAMPLE SELECTION AND RESEARCH DESIGN

#### A. RESEARCH SAMPLES

This article selects data from 2009 to 2019 for agricultural companies listed on the Shanghai and Shenzhen A-share markets for the study sample. Mainly including agriculture, forestry, animal husbandry, fishery, agriculture, forestry, agricultural and sideline food processing industry, food manufacturing, wine, beverages, and refined products Related agricultural listed companies and other related agricultural listed enterprises, and eliminated \*ST, ST category and sample enterprises with severe data deficiency. The range of preliminary data to be filtered is from 2008 to 2019 in the research sample. Furthermore, the range of data entering the regression model is from 2009 to 2019. The data comes from these databases of China Stock Market & Accounting Research (CSMAR), Flush Financial (iFinD), and China Research Data Service (CNRDS), mainly including government innovation support (government subsidies and tax & fee returns), enterprise characteristics (enterprise-scale, enterprise age, listing period), resource allocation (fixed asset investment, current assets, inventory, and cash flow), different subject supervision mechanisms (leading shareholder shareholding supervision, institutional investor shareholding supervision, and social auditing opinion supervision), and R&D activities (R&D inputs and outputs). Finally, this article obtains 1069 observations from 2009 to 2019 after screening outliers and extremes.

#### B. REGRESSION MODEL

This article analyzes mainly how government innovation support affects R&D input of agricultural listed companies based on previous research results. This article further explores the selective effect in the context of institutional investor shareholding supervision mechanism, leading shareholder shareholding supervision mechanism, and social auditing supervision mechanism incorporated into corporate governance. As well as the non-observational effect difference between individuals and time points, based on the 1069 unbalanced panel data of agricultural listed companies, set the individual time point double fixed effect model as follows:

$$\begin{aligned} TECINN_{i,t} = & \beta_1 GOVSUP_{i,t} + \beta_2 SUPAUD_{i,t} \\ & + \beta_3 GOVSUP_{i,t} \times SUPAUD_{i,t} \\ & + \sum_{j=1}^7 \varphi_j CONVAR_{i,t}^j + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (1) \end{aligned}$$

TECINN is the technological innovation activity of agricultural enterprises, which is a dependent variable. It is

a vector composed of two input-output variables, R&D expenditure ratio RADINV and patent application amount PATAPP, which respectively represent R&D input and innovation output of agricultural enterprises. GOVSUP is government innovation support, as an independent variable, a vector composed of two variables: government subsidy GOVSUB and tax & fee return TAFRET. SUPAUD is the improvement of supervising mechanism, and as a moderating variable, it is a vector composed of three variables: institutional investors' shareholding supervision mechanism PINSSUP, leading shareholders' shareholding supervision mechanism PMSHSUP, and auditing supervision mechanism INSAUD. The control variable CONVAR is a vector composed of seven variables composed of enterprise characteristics and enterprise resource allocation.  $\alpha_i$  is the individual fixed effect,  $\lambda_t$  is the time-point fixed effect,  $i$  is the agricultural enterprise, and  $t$  is the observation year. Figure 1 is the overall hypothesis framework of the research model.

#### C. VARIABLE DEFINITIONS

##### 1) DEPENDENT VARIABLES: R&D INPUT AND OUTPUT

The measurement indicators of enterprise technological innovation generally include R&D expenditure, R&D personnel investment, new product sales revenue, and patent application authorization amount [46]. Because the two indicators of new product sales revenue and R&D personnel investment are seriously missing in the public database of agricultural listed companies, the ratio of R&D expenditure to operating income, RADINV, is used to measure the cost investment of agricultural enterprises' technological innovation. Due to the time lag from input to output in R & D activities, this article uses the patent application amount (PATAPP) of T+1 to measure the agricultural enterprises' technological innovation achievements, and PATAPP is used to test the robustness of results.

##### 2) INDEPENDENT VARIABLES: GOVERNMENT SUBSIDIES AND TAX & FEE RETURNS

To encourage agricultural enterprises to carry out technological innovation activities, the government uses various innovation support policies (such as government subsidies, tax incentives, and policy incentives) to guide and encourage enterprises to implement technological innovation activities actively. The following two types of government innovation support are mainly considered: First, in order to alleviate the financial pressure encountered by agricultural enterprises in technological innovation activities (for example, the large amount of start-up funds, the long-term continuous investment of innovation funds, and the high risk of R&D), the government gives direct financial subsidies to agricultural enterprises' innovation projects, sharing the uncertainty and risks of technological innovation, and measuring the government's direct subsidy to agricultural enterprises by using GOVSUB, the non-operating income of agricultural enterprises [47], [48]; second, in order to give full play to the guiding role of financial science and technology

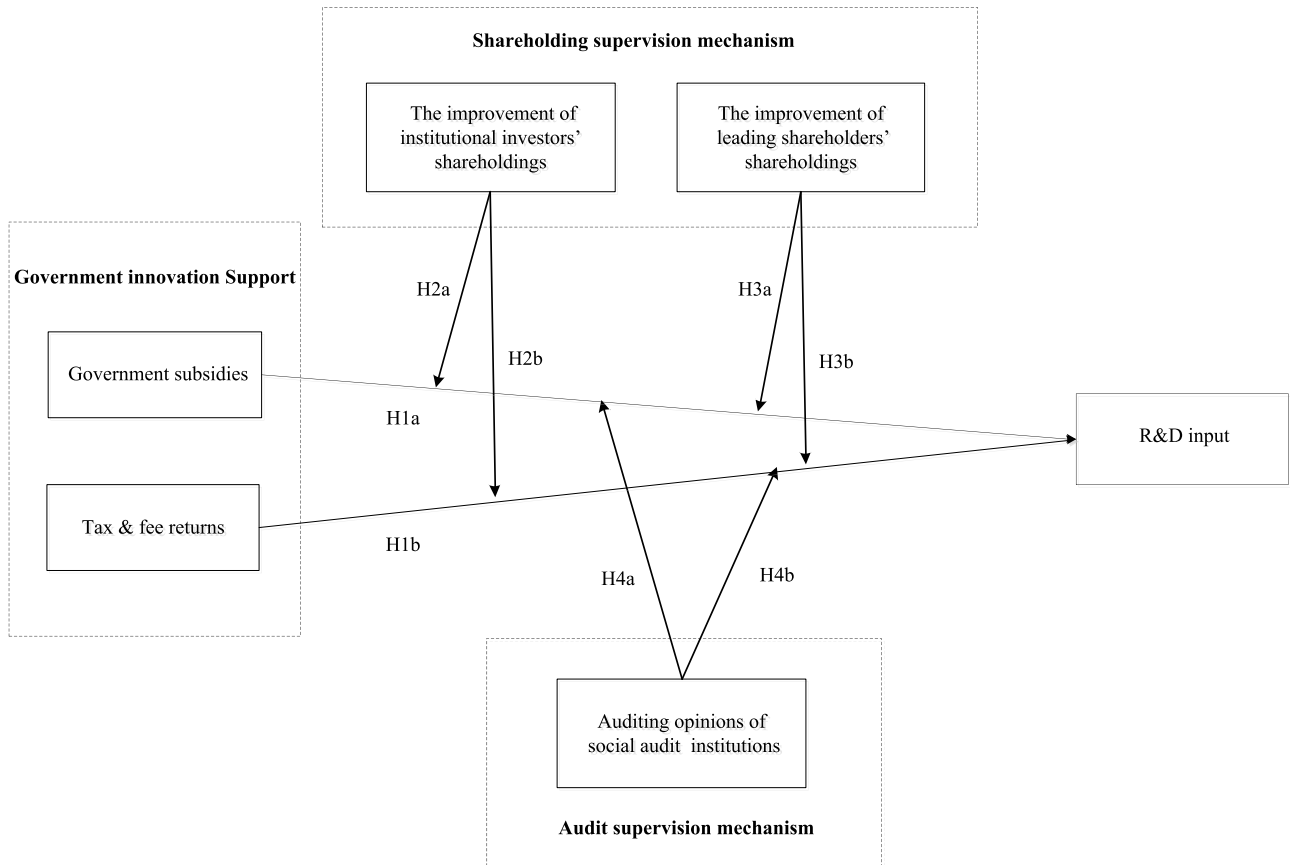


FIGURE 1. Overall hypothesis model.

funds and improve the efficiency of the use of financial funds, the government adopts the financial aid method of returning tax & fee to agricultural enterprises after they pass the acceptance examination or performance appraisal, and measures the government’s indirect subsidy to agricultural enterprises by returning taxes and fees received by agricultural enterprises to TAFRET.

3) MODERATING VARIABLES SHAREHOLDING SUPERVISION AND AUDIT SUPERVISION

From the perspective of corporate governance, we mainly measure the role of governance participation of three supervision mechanisms in moderating government innovation policies and agricultural enterprise R&D input: First, the shareholding supervision mechanism of institutional investors, when institutional investors such as brokerage, insurance, trust, finance, banking, social security, and funds continuously increase their holdings of listed companies, institutional investors pay more attention to the financial performance of listed companies, play a role of supervision and signal transmission in a certain. LI *et al.* used the year-end shareholding ratio of institutional investors to measure how institutional investors affect corporate environmental performance [49]. However, we consider that the relative shareholding change rate can better reflect the change of institutional

investors’ shareholding size than the year-end absolute shareholding ratio. So the rate of change over the same period last year PINSSUP is used to measure the improvement of institutional investors’ shareholding supervision mechanism. Second, with the increasing share of leading shareholders, the top ten shareholders’ shareholding supervision mechanism encourage leading shareholders to supervise the operational effectiveness of the top managers of listed companies and urge the top managers to improve their business performance and innovation performance.

Similarly, Lei *et al.* used the shareholding ratio of leading shareholders to measure the impact of leading shareholders on corporate earnings sustainability [50]. This article used the rate of change in the shareholding ratio of the top ten shareholders relative to the same period of the previous year PMSHUP is used to measure the improvement of leading shareholder’s shareholding supervision mechanism. Therefore, the specific calculation formula for the change of institutional investors and leading shareholders’ shareholding supervision mechanism is as follows:

$$PSHASUP_{i,t} = (SHASUP_{i,t} - SHASUP_{i,t-1}) / SHASUP_{i,t-1} \tag{2}$$

SHASUP in formula (2) indicates the shareholding ratio, which indicates institutional investor shareholding ratio

TABLE 1. Variable definition and indicator description.

Type	Variable	Variable code	Description	Measurement
Dependent variables	Innovation performance	RADINV	The proportion of R&D input	The ratio of total R&D input to operating income
		PATAPP	R&D output	Natural logarithm of T+1 patent application amount plus 1
Independent variables	Government support	GOVSUB	Government subsidies	Natural logarithm of government subsidy plus 1 in non-operating income
		TAFRET	Tax & fee returns	The natural logarithm of the tax & fee returns received plus 1
Moderating variables	Shareholding supervision	PINSSUP	Institutional shareholding promotion	The change rate of institutional investors' shareholding ratio in the observation period compared with the same period of last year
		PMSHSUP	Shareholder holding promotion	The change rate of the shareholding ratio of the top ten shareholders in the observation period compared with the same period of last year
	Auditing supervision	INSAUD	Auditing opinions strengthen	Numerical auditing opinions of social audit institutions during the observation period
		ENTSIZ	Enterprise-scale	Natural logarithm of total assets of enterprises
Control variables	Enterprise characteristics	ENTYEA	Enterprise age	Take the natural logarithm after the end of the observation year minus the establishment of the enterprise
		LISPER	Listing period	Take the natural logarithm after the end of the observation year minus the date of listing announcement
	Resource allocation	TANASS	Asset tangible	Proportional value of fixed assets divided by total assets
		INVEXP	Investment expansion degree	The rate of change of investment in fixed assets compared with the same period of last year
Management ability	EARGRO	Earning growth	The year-on-year growth rate of basic earnings per share	
	BANDEA	Bankruptcy coping capacity	Z-value early warning of financial information status	

INSSUP and large shareholder shareholding ratio MSHSUP. By this formula, this article respectively calculated the supervision strength of the institutional investor shareholding supervision PINSSUP and the leading shareholder holding ratio PMSHSUP.  $i$  is an agricultural enterprise, and  $t$  is observation year.

Finally, the audit supervision mechanism of social audit institutions and the audit institutions' auditing opinions reflect the audited enterprises' financial operation status, which can supervise the internal operation effect and internal control of the top managers of enterprises from the external audit. Most existing scholars mainly use the virtual value of 1 for non-standard unqualified auditing opinions and 0 for other opinions [51], [52]. This kind of virtual comparison is generalized, and five opinions are not distinguished. To better distinguish the auditing opinions and the internal control ability of audit institutions to enterprises expressed by the opinions, we further assign auditing opinions from high to low respectively, the standard unqualified opinions = 5; Unqualified opinion with emphasis paragraph = 4; Reservation = 3; Negative opinion = 2; Unable to express opinions = 1, INSAUD is used to measure the supervision intensity of the audit supervision mechanism of social audit affairs institutions by the numerical auditing opinion. The higher the value is, the better the internal control ability, which shows the improvement of enterprises' internal supervision mechanism.

#### 4) CONTROL VARIABLES: ENTERPRISE CHARACTERISTICS, RESOURCE ALLOCATION, AND MANAGEMENT ABILITY

According to previous similar studies [53]–[55], the following related variables that affect the technological innovation activities of agricultural enterprises are mainly controlled:

enterprise size ENTSIZ, the natural logarithm of the total assets of the agricultural enterprise at the end of the observation period; enterprise age ENTYEA, the agricultural enterprise observation period minus the nature of the establishment date Logarithm; listing period LISPER, the observation period of agricultural enterprises minus the natural logarithm of the listing date; asset tangible TANASS, the amount of tangible assets has an irreversible impact on the subsequent investment behavior of agricultural enterprises, based on the ratio of fixed assets to total assets Measure; investment expansion degree INVEXP, measured by the rate of change of fixed asset investment during the observation period of agricultural enterprises relative to the same period of the previous year; earning growth ERGRO, measured by the rate of change of basic earnings per share in the observation period of agricultural enterprises relative to the same period of the previous year; the bankruptcy coping capacity BANDEA is measured by the Z-score warning that reflects the financial information status of agricultural enterprises. The larger the index, the stronger the ability of enterprises to deal with bankruptcy risks. Table 1 is the definitions of all variables and the calculation of measurement indicators.

#### D. DESCRIPTIVE STATISTICS

Table 2 is descriptive statistics such as sample size, minimum value, maximum value, mean value and standard deviation of the dependent variable, independent variable, moderating variable and control variable. Table 2 shows that the minimum value of the natural logarithm of government subsidies is  $-3.330$ , and the maximum value is  $3.950$ , which indicates that the amount of subsidies obtained by listed agricultural enterprises is quite different from 2009 to 2019.

**TABLE 2. Descriptive statistical results.**

Variable	N	Mean	Std.	Min	Pctl(25)	Pctl(75)	Max
RADINV	1,069	0.306	0.332	-0.647	0.090	0.399	1.485
PATAPP	1,069	3.609	1.436	-0.144	2.565	4.635	7.848
GOVSUB	1,069	0.001	1.002	-3.330	-0.628	0.344	3.950
TAFRET	1,069	0.001	1.000	-3.074	-0.651	0.481	3.291
PINSSUP	1,069	-0.046	0.229	-1.015	-0.079	-0.065	1.042
PMSHSUP	1,069	0.003	1.000	-3.244	-0.485	0.135	4.536
INSAUD	1,069	4.950	0.288	3.000	5.000	5.000	5.000
ENTSIZ	1,069	3.529	0.997	0.906	2.828	4.099	6.598
ENTYEA	1,069	2.864	0.293	1.958	2.708	3.045	3.638
LISPER	1,069	2.032	0.942	0.000	1.386	2.833	3.332
TANASS	1,069	0.273	0.135	0.006	0.175	0.355	0.679
INVEXP	1,069	-0.053	2.409	-14.867	-0.268	0.429	14.347
EARGRO	1,069	0.190	0.491	-1.000	-0.024	0.252	5.216
BANDEA	1,069	0.075	0.077	-0.006	0.031	0.086	0.476

Simultaneously, the minimum value of the logarithm of tax refund is  $-3.330$ , the maximum value is  $3.291$ , and the standard deviation is  $1.000$ , which shows that the different degrees of tax & fee returns of agricultural listed enterprises are also apparent.

#### IV. EMPIRICAL TEST AND RESULT ANALYSIS

Before testing the above theoretical hypothesis, this article deals with the empirical data according to the following steps: Firstly, Driscoll-Kraay standard deviation conversion for all continuous data entering the regression model to avoid the difference of measurement units of different variables. Secondly, this article centre the five variables for interaction item test to avoid the possible multicollinearity effects, such as the government subsidies, tax & fee returns, leading shareholders' shareholdings supervision mechanism, institutional investors' shareholding supervision mechanism and social audit institution supervision mechanism. Finally, considering the unbalanced panel data spanning ten years, the stationarity test for independent variables, dependent variables, regulatory variables and control variables reduces the correlation of variables to ensure the stability of variables and the follow-up's validity regression test results.

##### A. THE MAIN EFFECT OF GOVERNMENT INNOVATION SUPPORT: CROWDING-OUT OR STIMULATION

Table 3 reports the test results of the relationship between government innovation support and R&D input of agricultural enterprises. In table 3, regression results of the M1 show that enterprise-scale ( $\beta=0.229$ ,  $p<0.01$ ), enterprise age ( $\beta=0.278$ ,  $p<0.05$ ), listing period ( $\beta=-0.054$ ,  $p<0.01$ ), tangibility of assets ( $\beta=0.441$ ,  $p<0.01$ ), growth rate of earnings per share ( $\beta=0.003$ ,  $p<0.10$ ), fixed assets investment expansion rate ( $\beta=-0.028$ ,  $p<0.10$ ), ability to cope with production risks ( $\beta=0.024$ ,  $p=0.109$ ), these seven variables significantly affects R&D input of agricultural enterprises. Other control variables, such as solvency, cash flow, and financial constraints, have no significant impact on R&D input of agricultural enterprises. The basic model excludes the insignificant control variables through stepwise regression to ensure the research results' comparability and

reliability. Therefore, the benchmark model M1 includes the above seven control variables to test the relationship between government innovation support and R&D input of agricultural enterprises.

In table 3, the M2 adds the variable of GOVSUB based on the M1. The regression coefficient of GOVSUB is  $-0.087$  ( $p<0.01$ ) in the M2. Combined with the full model M4 adding the variable of TAFRET, the regression coefficient of GOVSUB is  $-0.088$  ( $p<0.01$ ) in the M4, that shows that the direct government subsidies to agricultural enterprises' innovation activities harm the R&D input of agricultural enterprises, verifying hypothesis 1a. Government subsidies to agricultural enterprises have a significant crowding-out effect on R&D input of agricultural enterprises, that confirms the research on the negative crowding-out effect of government subsidies by Sung (2018) [32] and Yu *et al.* (2016) [33]. That shows that under the current situation, it is invalid for the government to give financial subsidies to agricultural enterprises, the main reasons are as follows: First, compared with the intelligent manufacturing industry and information service industry, agriculture is difficult to recruit excellent talents and lack of operating funds, enterprises flinch to the high Complexity, high investment and long-term R&D projects, after receiving government subsidies, managers tend to use funds for projects with quick profit, low risk and short cycle, which results in the extrusion of R&D funds and the decision-making behavior of managers is relatively short-sighted. Second, after receiving government subsidies, business decisions depend on government subsidies, and they are more inclined to choose strategic innovation and subsidy seeking investment to send false innovation signals to the government, resulting in reverse rent-seeking behavior. Finally, after receiving government subsidies, enterprises increase the demand for external related resources in the innovations. The owners of relevant resources in the market raise the price of resources according to this signal, which leads to an increase in enterprise innovation input cost. They cannot effectively make up for market failure and damage enterprises' willingness to invest in R&D.



**TABLE 3. Test of R&D Effect of Government Innovation Support.**

	M1	M2	M3	M4
ENTSIZ	0.229***	0.233***	0.224***	0.228***
	0.000	0.000	0.000	0.000
ENTYEA	0.278**	0.266**	0.277**	0.265**
	0.033	0.040	0.034	0.041
LISPER	-0.054***	-0.050***	-0.052***	-0.047***
	0.004	0.007	0.005	0.010
TANASS	0.441***	0.454***	0.435***	0.448***
	0.000	0.000	0.000	0.000
EARGRO	0.003*	0.004*	0.004*	0.004**
	0.080	0.059	0.061	0.043
INVEXP	-0.028***	-0.028***	-0.027***	-0.028***
	0.007	0.006	0.009	0.008
BANDEA	0.024	0.025	0.024	0.024
	0.109	0.103	0.123	0.117
GOVSUB		-0.087***		-0.088***
		0.002		0.001
TAFRET			0.044*	0.046**
			0.061	0.050
Individual and time Point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample size	1,069	1,069	1,069	1,069
R <sup>2</sup>	0.480	0.490	0.484	0.494
F value	27.703***	25.832***	24.751***	23.467***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

In table 3, the M3 adds the variable of TAFRET based on the M1. The regression coefficient of TAFRET is 0.044 in the M3. Combined with the full model M4, the regression coefficient of GOVSUB term is 0.046 ( $p < 0.10$ ) in the M4. Which shows that the policy subsidy of tax & fee returns for the innovation activities on agricultural enterprises has a positive impact on the R&D input of agricultural enterprises, verifying hypothesis 1b. That is the government's tax & fee returns support to agricultural enterprises has a significant stimulating effect on R&D input of agricultural enterprises, which confirms the study found that positive incentive effect of the tax & fee return policy by scholars such as Kao (2018) [56] and Atanassov and Liu (2020) [37].

The results also show that in the current situation, the tax burden is an essential factor that hinders the R&D innovation of agricultural enterprises, and can stimulate enterprises to increase their funds for R&D input funds, which has an incentive effect. The primary reasons for this are the following: First, the external spillover effect of innovation and the phenomenon of "free rider" increase enterprise innovation's risk and cost. Tax & fee returns compensate for the risk and cost of innovation to a certain extent and directly increase the after-tax income. Second, compared with government subsidies, the impact of tax & fee returns on the market competition rules and degree is weak. Enterprises must work hard to meet the relevant tax return conditions, promoting enterprises' innovation and development. Finally, the tax & fee returns is a positive signal of government support for enterprise innovation, which stimulates the enterprise innovation passion and provides stable financial support for enterprise R&D from the institutional level. It makes the innovation incentive

effect of tax return more evident and convincing than that of government subsidies.

### B. THE MODERATING EFFECT OF SHAREHOLDING AND AUDIT SUPERVISION ON GOVERNMENT SUBSIDIES: WEAKENING OR STRENGTHENING

Table 4 adds these variables of shareholding supervision mechanism and auditing supervision mechanism, respectively, based on the M2 to explore government subsidies' selective effect on Agricultural enterprise R&D input. Based on the M2, the M5 adds PINSSUP and  $PINSSUP \times GOVSUB$  to investigate whether institutional investors' enhanced supervision changed the crowding-out effect of government subsidies on agricultural enterprises' R&D input. The regression coefficient of  $PINSSUP \times GOVSUB$  in the M5 is  $-0.001$  ( $p < 0.10$ ). Moreover, the regression coefficient of  $PINSSUP \times GOVSUB$  in the full model M8 with supervision and audit mechanism was  $-0.001$  ( $p < 0.10$ ), which was consistent with the regression coefficient sign of GOVSUB in the M2, M5, and M8, both of which were negative signs, which shows that the improvement of supervision mechanism of external institutional investors enhances the crowding-out effect of government subsidies on R&D input of agricultural enterprises, verifying hypothesis 2a. The institutional investor shareholding supervision mechanism can significantly enhance government subsidies' crowding-out effect on R&D input of agricultural enterprises.

The M6 adds these variables of PMSHSUP and  $PMSHSUP \times GOVSUB$  based on the M2 to examine whether the increase of supervision willingness of the top ten shareholders of listed companies changes the crowding-out effect of

TABLE 4. Selection effect of shareholding and audit supervision on government subsidies.

	M5	M6	M7	M8
ENTSIZ	0.232***	0.231***	0.235***	0.233***
	0.000	0.000	0.000	0.000
ENTYEA	0.279**	0.268**	0.270**	0.284**
	0.032	0.038	0.037	0.029
LISPER	-0.053***	-0.048***	-0.053***	-0.054***
	0.004	0.008	0.004	0.004
TANASS	0.455***	0.456***	0.448***	0.451***
	0.000	0.000	0.000	0.000
EARGRO	0.003*	0.004**	0.004**	0.004**
	0.064	0.048	0.037	0.032
INVEXP	-0.029***	-0.028***	-0.026**	-0.027***
	0.005	0.007	0.011	0.010
BANDEA	0.025	0.023	0.029*	0.027*
	0.106	0.122	0.061	0.076
GOVSUB	-0.087***	-0.091***	-0.082***	-0.086***
	0.002	0.001	0.003	0.002
PINSSUP	0.000			0.000
	0.868			0.911
GOVSUB×PINSSUP	-0.001*			-0.001*
	0.066			0.099
PMSHSUP		0.002		0.002
		0.883		0.897
GOVSUB×PMSHSUP		-0.142**		-0.134**
		0.015		0.022
INSAUD			-0.025	-0.024
			0.176	0.197
GOVSUB×INSAUD			0.120	0.132*
			0.114	0.084
Individual and time Point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample size	1,069	1,069	1,069	1,069
R <sup>2</sup>	0.493	0.496	0.496	0.504
F value	21.041***	21.365***	21.407***	16.024***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

government subsidies on R&D input of agricultural enterprises. The regression coefficient of PMSHSUP × GOVSUB is -0.142 (p<0.05) in the M6. The regression coefficient of PMSHSUP × GOVSUB is -0.134(p<0.05) in the M8. It is consistent with the regression coefficient sign of GOVSUB in the M2, M6, and M8. All of which are opposing signs, this shows that the increase of the shareholding ratio of the top ten shareholders of listed companies enhances the crowding-out effect of government subsidies on R&D input of agricultural enterprises, verifying hypothesis 3a. The supervision mechanism of leading shareholders' shareholding can significantly enhance government subsidies' crowding-out effect on R&D input of agricultural enterprises.

The M7 adds these variables of INSAUD and INSAUD × GOVSUB based on the M2 to investigate whether the external audit mechanism of listed companies changes the crowding-out effect of government subsidies on R&D input of agricultural enterprises. The regression coefficient of INSAUD × GOVSUB is 0.120 (p=0.114) in the M7.

Which indicates the audit mechanism has a regulatory effect on the relationship between government subsidies and agricultural enterprise R&D input at a significance level of 10%. The regression coefficient of INSAUD × GOVSUB is 0.132 (p<0.10) in the M8. The regression coefficient sign of interaction term is inconsistent with the signs of the regression coefficients of GOVSUB in the M2, M7, and M8. That shows the improvement of auditing opinions of social audit institutions weaken the crowding-out effect of government subsidies on R&D input of agricultural enterprises, verifying hypothesis 4a. That is the supervision mechanism of social audit institutions can significantly reduce the crowding-out effect of government subsidies on R&D input of agricultural enterprises.

Simultaneously, to more accurately evaluate the moderating effects and action regions of different supervision mechanisms between government subsidies and R&D input of agricultural enterprises, using the simple slope estimation, interaction effect diagram, and Johnson-Neyman diagram

in-depth analysis. Johnson and Neyman first proposed the Johnson-Neyman chart method in 1936 [57]. Bauer and Curran extended the Johnson-Neyman chart to the simple slope of the regression model's moderating variable [58]. The Johnson-Neyman chart could calculate the range of covariates when the slope parallel assumption is not satisfied in covariance analysis and when the difference between the two groups of dependent variables is statistically significant [59].

Firstly, when the government subsidy is greater than 0 in the right region of figure 2, the supervision intensity of low institutional shareholding (Simple slope = 0.10\*\*\*, se=0.02, p<0.001) is higher than that of high institutional shareholding (simple slope =-0.03\*\*\*, se=0.02, p<0.010) under the circumstance. The increase of government subsidy is more likely to encourage agricultural enterprises to increase R&D input, bringing more substantial incentive effect. The Johnson-Neyman technical analysis chart in figure 3 further shows the confidence interval estimation from the point estimation in figure 2, When the value range of institutional shareholding supervision is beyond [0.01,0.21], the government subsidies on R&D input of agricultural enterprises is significant (p<0.05). Within the overlapping area of 95% confidence band (shaded part) with two vertical dashed lines in figure 3, the simple slope of government subsidy amount to R&D input of agricultural enterprises is not significant (confidence interval includes 0). Moreover, the coverage of the critical overlapping areas (pink part) is less, which indicates that the regulatory role of institutional investors' shareholdings in government subsidies and R&D input plays a relatively large role in the actual decision-making. Besides, with the increase of institutional shareholding supervision, the crowding-out effect of government subsidies on R&D input of agricultural enterprises is more significant.

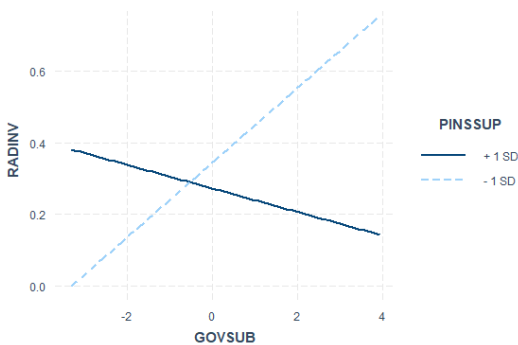


FIGURE 2. The moderating effect of institutional ownership on government subsidies and R&D input.

Secondly, it can be seen from figure 4 that, in the right region where government subsidy is greater than 0, the crowding-out effect of government subsidy on agricultural enterprise R&D input is more evident under the situation of low shareholder shareholding supervision intensity (Simple slope= -0.08\*\*\*, se=0.20, p<0.010) than high shareholder shareholding supervision intensity (simple slope=-0.68\*\*\*, se=0.20, p<0.001). The Johnson-Neyman

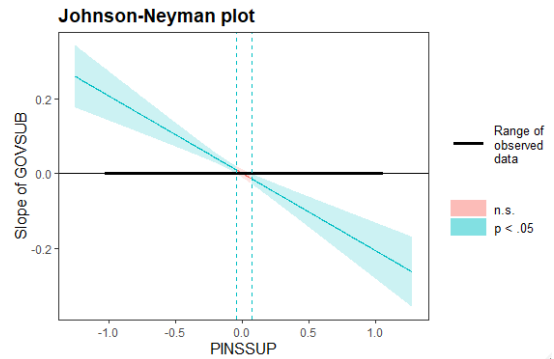


FIGURE 3. The simple slope of institutional ownership on government subsidies and R&D input.

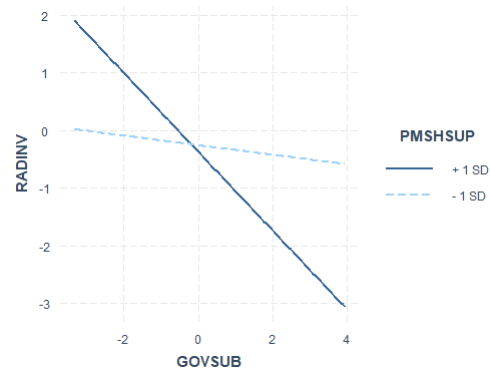


FIGURE 4. The moderating effect of shareholder shareholding on government subsidies and R&D input.

technical analysis diagram in figure 5 further shows that from the point estimation in figure 4 to the confidence interval estimation, when the value range of shareholding supervision intensity is beyond [-0.02, 1.15], the simple slope of government subsidies on R&D input of agricultural enterprises is significant (p<0.05). In the region where the two vertical dotted lines in figure 5 overlap with the 95% confidence zone, the government subsidy's simple slope to the agricultural enterprise R&D input is not significant (the confidence interval includes 0). Moreover, due to the

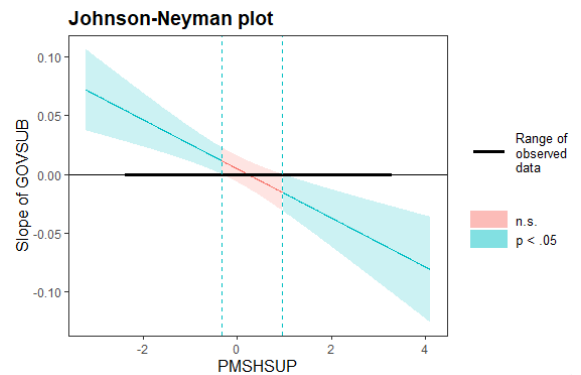


FIGURE 5. The simple slope of shareholder shareholding on government subsidies and R&D input.

relatively extensive coverage of critical overlapping areas, shareholder shareholding supervision's regulatory effect is not significant than institutional investors' supervision in this region. Only outside the region, the increase of shareholding supervision significantly enhances the crowding-out effect of government subsidies on R&D investment of agricultural enterprises.

Finally, in the right region of figure 6 where government subsidy is greater than 0, the increase of government subsidy is more likely to stimulate agricultural enterprises to increase R&D input and bring about a more substantial incentive effect under the situation of high audit supervision intensity (simple slope=0.05\*\*\*, se =0.01, p<0.001) than low audit supervision intensity (simple slope= 0.02\*\*\*, se=0.01, p<0.010). The Johnson-Neyman analysis diagram in figure 3 further shows that, When the intensity of audit supervision is within the range of [4.61, 6.13], the government subsidy amounts to agricultural enterprise R&D input is significant, That is, on the right side of the vertical dotted line in figure 8, the government subsidies on R&D input of agricultural enterprises is significant (p< 0.05). Moreover, because the critical overlapping region (left of the vertical dashed line in figure 8) is not significant, it shows that if the audit supervision intensity is low, it could not affect the correlation between government subsidies and R&D input. Only by increasing audit supervision intensity, audit supervision weakens the crowding-out effect of government subsidies on agricultural R&D input to a certain extent. Under the situation of strengthened audit supervision, government subsidies can stimulate agricultural enterprises to increase R&D input.

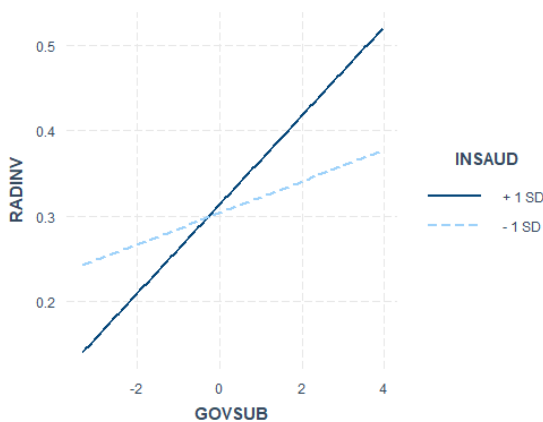


FIGURE 6. The moderating effect of audit supervision on government subsidies and R&D input.

**C. THE MODERATING EFFECT OF SHAREHOLDING AND AUDIT SUPERVISION ON TAX & FEE RETURNS: WEAKEN OR STRENGTHEN**

Table 5 adds shareholding supervision mechanism and audit supervision mechanism and based on the M3 to analyze the selective effect of the government tax & fee returns on R&D input of agricultural enterprises. Based on the M3, the M9 added the change rate of investment

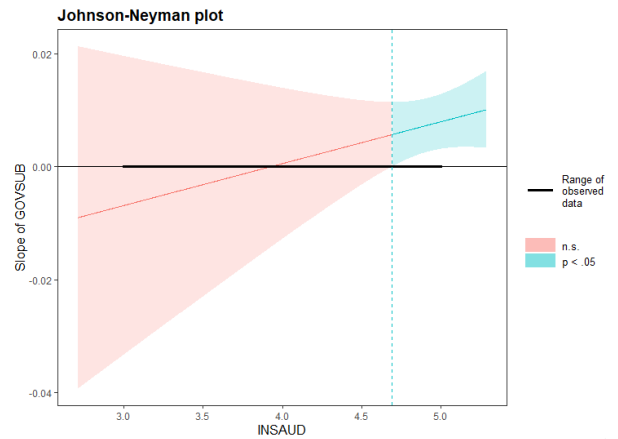


FIGURE 7. The moderating effect of audit supervision on government subsidies and R&D input.

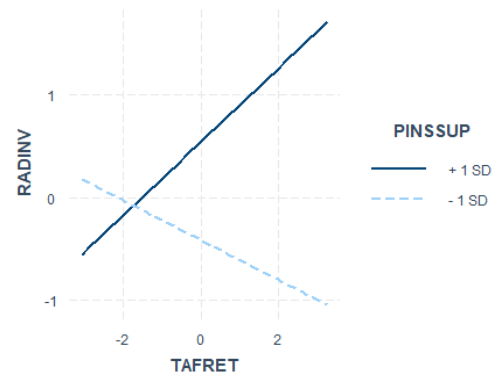


FIGURE 8. The moderating effect of institutional shareholding on tax & fee returns and R&D input.

institutions' shareholding PINSSUP, and the interaction item of PINSSUP and government tax & fee returns TAFRET. Furthermore, through the M9 to examine whether the enhancement of external institutional investors' supervision willingness changed the incentive effect of government tax & fee returns on agricultural enterprises' R&D input. The regression coefficient of PINSSUP × TAFRET is 0.031(p<0.01) in the M9, and the regression coefficient of PINSSUP × TAFRET is 0.008(p=0.578) in the M12 with shareholding supervision mechanism and audit supervision mechanism, which is consistent with the regression coefficient symbols of TAFRET in the M3, M9, and M12, and is all positive. External institutional investors' shareholding ratio enhances government tax & fee returns on agricultural enterprises' R&D input, verifying hypothesis 2b. Institutional investors' shareholding supervision mechanism significantly enhances the positive effects of government tax & fee returns on agricultural enterprises' R&D input.

Based on the M3, the M10 adds the variable of PMSHSUP, the rate of change of leading shareholders' shareholding, and the interaction term of PMSHSUP and government tax & fee returns TAFRET. Furthermore, through the M10 to examine whether the increase of the shareholding ratio of leading

**TABLE 5.** Selection effect test of shareholding and audit supervision on government tax & fee returns.

	M9	M10	M11	M12
ENTSIZ	0.221*** 0.000	0.183*** 0.000	0.223*** 0.000	0.182*** 0.000
ENTYEA	0.288** 0.027	0.315** 0.014	0.261** 0.045	0.304** 0.018
LISPER	-0.068*** 0.002	-0.074*** 0.000	-0.050*** 0.007	-0.078*** 0.000
TANASS	0.426*** 0.000	0.408*** 0.000	0.437*** 0.000	0.410*** 0.000
EARGRO	0.003* 0.070	0.004** 0.034	0.003* 0.075	0.004** 0.044
INVEXP	-0.028*** 0.008	-0.023** 0.026	-0.026** 0.012	-0.022** 0.033
BANDEA	0.023 0.122	0.013 0.379	0.026* 0.090	0.016 0.302
TAFRET	0.047** 0.044	0.047** 0.044	0.043* 0.070	0.046** 0.047
PINSSUP	0.008 0.134			0.003 0.616
TAFRET×PINSSUP	0.031*** 0.008			0.008 0.578
PMSHSUP		0.080*** 0.000		0.078*** 0.000
TAFRET×PMSHSUP		0.077*** 0.002		0.063** 0.044
INSAUD			-0.077 0.429	-0.091 0.345
TAFRET×INSAUD			-0.693** 0.030	-0.582* 0.065
Individual and time point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample Size	1,069	1,069	1,069	1,069
R <sup>2</sup>	0.491	0.514	0.489	0.518
F value	20.803***	23.895***	20.445***	17.467***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

shareholders of listed companies has changed the incentive effect of government tax & fee returns on agricultural enterprises' R&D input. The regression coefficient of PMSHSUP × TAFRET is 0.077(p<0.01) in the M10, and the regression coefficient of PMSHSUP × TAFRET is 0.063(p<0.05) in the M12, which is consistent with the regression coefficient sign of TAFRET in the M3, M10, and M12, and is positive. That shows the increase in the shareholding ratio of leading shareholders of listed companies enhances the government tax & fee returns on R&D input of agricultural enterprises, verifying hypothesis 3b. The supervision mechanism of leading shareholders' shareholding can significantly enhance the incentive effect of government tax & fee returns on R&D input of agricultural enterprises.

Based on the M3, the M11 adds these variables of the annual auditing opinion INSAUD of listed companies, and the interaction term of INSAUD and government tax & fee returns TAFRET. Furthermore, through the M11 to examine whether the auditing opinion of listed companies' external

auditors changes the incentive effect of government tax & fee returns on agricultural enterprises' R&D input. The regression coefficient of INSAUD × TAFRET is -0.693(p<0.05) in the M11. The regression coefficient of INSAUD × TAFRET is -0.582(p<0.10) in the M12. Which indicates that is inconsistent with the sign of regression coefficient of TAFRET in the M3, M11, and M12. The auditing opinions of external audit institutions weaken the incentive effect of government tax & fee returns on R&D input of agricultural enterprises, verifying hypothesis 4b. The audit supervision mechanism of social audit institutions can significantly weaken the government tax refund's incentive effect on R&D input of agricultural enterprises.

Simultaneously, to more accurately evaluate the moderator effect and action interval between government tax & fee returns and R&D input of agricultural enterprises, we combine the simple slope estimation, interactive effect diagram and Johnson-Neyman diagram for in-depth analysis. First of all, it can be seen from figure 8 that in the right area where

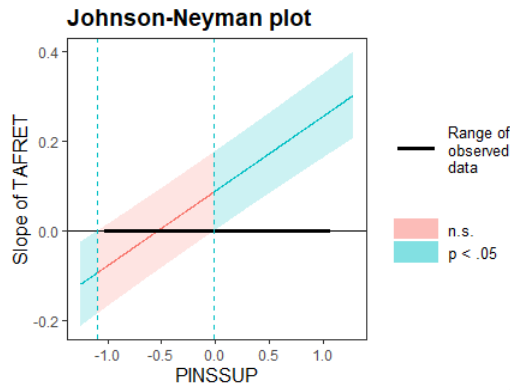


FIGURE 9. The simple slope of institutional shareholding to tax & fee returns and R&D input.

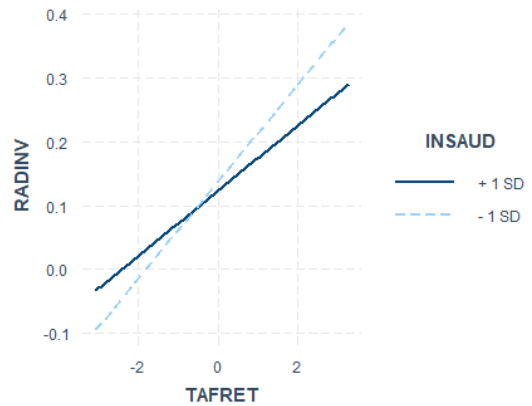


FIGURE 12. The moderating effect of audit supervision on tax & fee returns and R&D input.

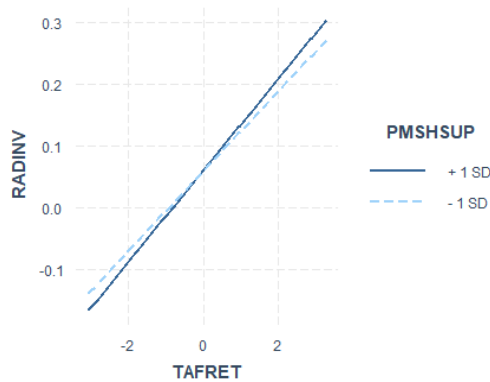


FIGURE 10. The moderating effect of shareholder's shareholding on tax & fee returns and R&D input.

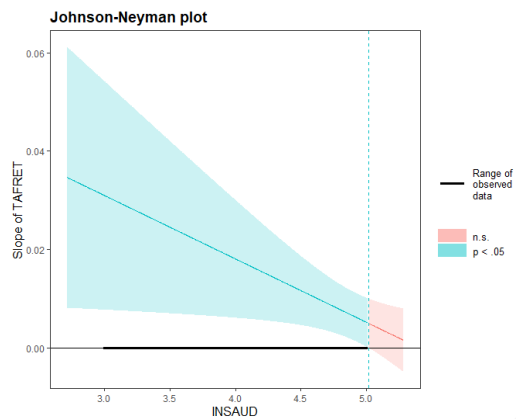


FIGURE 13. The simple slope of audit supervision on tax & fee returns and R&D input.

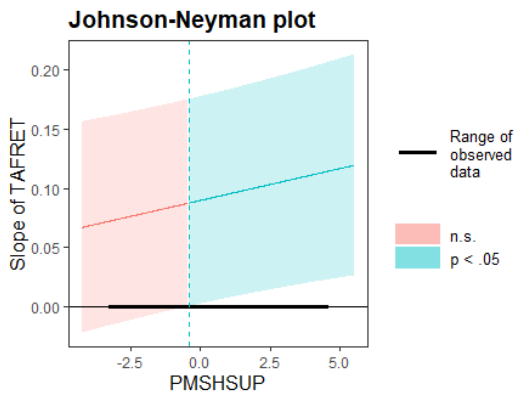


FIGURE 11. The simple slope of shareholder's shareholding to tax & fee returns and R&D input.

the tax & fee returns are more significant than 0, the situation of high institutional shareholding supervision intensity (simple slope=0.36\* \* \*, se=0.02, p<0.001) is higher than that of low institutional shareholding supervision intensity (simple slope=-0.19\* \* \*, se=0.02, p<0.001). Under the situation, the increase in government tax refund degree is more likely to encourage agricultural enterprises to increase R&D input, bringing a more substantial incentive effect. The Johnson-Neyman technical analysis chart in figure 9 is

the result of confidence interval estimation from the point estimation in figure 8, which shows that when the value range of institutional shareholding supervision intensity is outside [-1.09,-0.01], the simple slope of government tax & fee returns on R&D input of agricultural enterprises is significant (p<0.05). In the area where the two vertical dashed lines in figure 9 coincide with the 95% confidence band, the government tax refund's simple slope on R&D input of agricultural enterprises is not significant (the confidence interval contains 0). Moreover, since the coverage of the critical overlapping areas is less than 0, this indicates that in the areas where PINSSUP is greater than 0 in figure 9, the increase in the proportion of institutional shareholding is significantly conducive to the increase in the incentive effect of government tax & fee returns on agricultural enterprises' R&D input.

Secondly, in the area on the right where the tax return is greater than 0 in figure 10, the supervision intensity of high shareholder holdings (simple slope=0.07\*\*\*, se=0.00, p<0.001) is higher than the supervision intensity of low shareholder holdings (simple slope=0.06\* \* \*, se=0.01, p<0.001), which indicates that the incentive effect of government tax & fee returns on agricultural enterprise R&D input is

TABLE 6. Regression results of endogeneity test.

	M13	M14	M15	M16
GOVSUB	-0.046*		-0.063**	
	0.052		0.014	
TAFRET		0.019**		0.013**
		0.035		0.024
PINSSUP			0.000	-0.006
			0.370	0.289
INSAUD			-0.008	0.053
			0.745	0.648
PMSHSUP			-0.015	0.033**
			0.169	0.047
GOVSUB × PINSSUP			-0.002	
			0.267	
GOVSUB × INSAUD			0.090**	
			0.025	
GOVSUB × PMSHSUP			-0.140**	
			0.025	
TAFRET × PINSSUP				0.022
				0.184
TAFRET × PMSHSUP				-0.005*
				0.086
TAFRET × INSAUD				-0.508*
				0.071
Control variable	Yes	Yes	Yes	Yes
Lag phase	Yes	Yes	Yes	Yes
Sample size	594	594	594	594
AR(2) <i>p</i> value	0.304	0.224	0.162	0.481
J statistic( <i>p</i> )	32.754(0.528)	34.527(0.443)	29.289(0.398)	18.667(0.734)

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

higher when the PMSHUP is greater. The Johnson-Neyman technical analysis chart in figure 11 further shows from the point estimation of figure 10 to the confidence interval estimation that when the value range of shareholder supervision intensity is outside  $[-6.71, -0.43]$ , the simple slope of government tax & fee returns on R&D input of agricultural enterprises is significant ( $p < 0.05$ ). In the area on the left where the vertical dashed line coincides with the 95% confidence zone in figure 9, the area where PMSHSUP is less than 0, the simple slope of the government tax & fee returns on the R&D input of agricultural enterprises is not significant. Moreover, since the coverage of crucial overlap areas is all less than 0, this indicates that in the right area where PMSHSUP is greater than 0 in figure 11, that the increase in shareholder shareholding ratio is conducive to the improvement of the incentive effect of government tax & fee returns on agricultural enterprise R&D input.

Finally, as shown in figure 12, in the right area where the tax return is greater than 0, the low audit supervision intensity (simple slope = 0.08\*\*\*,  $se = 0.01$ ,  $p < 0.001$ ) is higher than

the high audit supervision intensity (simple slope = 0.05\*\*\*,  $se = 0.01$ ,  $p < 0.001$ ). The increase in government tax and fee rebates in the context of the situation can encourage agricultural enterprises to increase R&D input and bring stronger incentive effects. The Johnson-Neyman technical analysis diagram in figure 13 further shows from the point estimation in figure 12 to the confidence interval estimation, which shows that when the audit supervision intensity is outside the value range of  $[5.01, 10.60]$ , the simple slope of government tax & fee returns on the R&D input of agricultural enterprises is significant ( $p < 0.05$ ). On the right side of the vertical dashed line in figure 13, the simple slope of government tax & fee returns on R&D input of agricultural enterprises is not significant. Moreover, because the coverage of key overlapping areas is greater than 5, it shows that within the range of 1 to 5 of auditing opinions (left of vertical dashed line), if reducing the audit intensity of external audit institutions to a certain extent, which is beneficial to the improvement of incentive effect of government tax & fee returns on R&D input of agricultural enterprises.

TABLE 7. Robustness test of dependent variable selection bias.

	M17	M18	M19	M20
GOVSUB	-0.012**		-0.020**	
	0.039		0.018	
TAFRET		0.284**		0.260**
		0.020		0.035
PINSSUP			-0.001	-0.013
			0.204	0.689
INSAUD			-0.215*	-0.871
			0.067	0.184
PMSHSUP			-0.021	0.024
			0.748	0.798
GOVSUB×PINSSUP			-0.002	
			0.540	
GOVSUB×INSAUD			0.451**	
			0.031	
GOVSUB×PMSHSUP			-0.499**	
			0.013	
TAFRET×PINSSUP				0.117**
				0.024
TAFRET×PMSHSUP				0.091*
				0.058
TAFRET×INSAUD				-0.421**
				0.019
Control variable	Yes	Yes	Yes	Yes
Individual and time point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample size	831	831	831	831
R <sup>2</sup>	0.337	0.344	0.351	0.306
F value	2.845***	3.390***	2.337***	2.763***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

V. ENDOGENEITY TREATMENT AND ROBUSTNESS TEST

A. ENDOGENEITY TREATMENT

Considering that there may be mutual causality between government innovation support and R&D input of agricultural enterprises, some omitted control variables may affect enterprise R&D input, leading to endogenous problems in the research model. At present, the primary testing methods for endogeneity include natural experimental method [60], double-difference method [61], an instrumental variable method [62] and dynamic panel data method [63]. Firstly, the natural experiment method needs to find an exogenous emergency to divide the control group and the experimental group to infer the causal relationship between the government support mode and the innovation input of agricultural enterprises. Due to the long span of research years in this article, it is difficult to find a suitable exogenous emergency that continuously impacts the R&Dn activities of agricultural enterprises after a specific time point, and it is difficult to group the research objects randomly. Secondly, the double-difference method is more suitable for the endogeneity test of balanced panel data than overcoming the endogeneity of the non-balanced panel data model. Thirdly, the instrumental variable method needs to find exogenous variables that are related to the endogenous explanatory variables and not related to the random disturbance term. Since the random disturbance term is not observable, it is difficult to find the instrumental variables in a strict sense, and the unqualified instrumental

variables can only bring more serious estimation problems. Therefore, considering that the two-step differential GMM estimation method can solve weak instrumental variables and endogeneity [64], [65], we use GMM estimation method to carry out the endogeneity test for the unbalanced panel data model.

The variables adopt an intertemporal setting, such as government innovation support and enterprise R&D input, to solve the endogenous problem. Based on regression formula (1), this article adds the lag first-period RADINV(-1) and lag second-period RADINV(-2) of dependent variables, and uses the dynamic GMM to estimate causality, which not only reflects the dynamic change characteristics of enterprise R&D input but also solves the estimation deviation caused by endogeneity to a certain extent. Table 6 is the results of the two-step differential GMM estimation. The AR(2) test of all models in table 6 shows that two-step difference GMM does not have second-order autocorrelation. The J test's statistical results show that the selected instrumental variables are useful, indicating no significant endogeneity problem in the model. However, the symbol of TAFRET\*PMSHSUP changes into a symbol. Which indicates that the regression results in table 6 show that, after overcoming the endogeneity of the model to a certain extent, the direct effect of shareholding supervision by leading shareholders becomes more sensitive and weakens the regulatory effect of shareholding supervision by leading shareholders on tax refund and



**TABLE 8. Robustness test of Sample property selection bias.**

	M17	M18	M19	M20
GOVSUB	-0.012**		-0.020**	
	0.039		0.018	
TAFRET		0.284**		0.260**
		0.020		0.035
PINSSUP			-0.001	-0.013
			0.204	0.689
INSAUD			-0.215*	-0.871
			0.067	0.184
PMSHSUP			-0.021	0.024
			0.748	0.798
GOVSUB×PINSSUP			-0.002	
			0.540	
GOVSUB×INSAUD			0.451**	
			0.031	
GOVSUB×PMSHSUP			-0.499**	
			0.013	
TAFRET×PINSSUP				0.117**
				0.024
TAFRET×PMSHSUP				0.091*
				0.058
TAFRET×INSAUD				-0.421**
				0.019
Control variable	Yes	Yes	Yes	Yes
Individual and time point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample size	831	831	831	831
R <sup>2</sup>	0.337	0.344	0.351	0.306
F value	2.845***	3.390***	2.337***	2.763***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

**TABLE 9. Robustness Test of sample period selection bias.**

	M25	M26	M27	M28
GOVSUB	-0.0184		-0.0206*	
	0.1258		0.0876	
TAFRET		0.2084*		0.2328**
		0.0639		0.0391
PINSSUP			-0.0004	-0.023
			0.3229	0.4092
INSAUD			-0.0205	0.086
			0.7274	0.2988
PMSHSUP			-0.015	0.1418
			0.8696	0.7733
GOVSUB×PINSSUP			-0.0013**	
			0.0584	
GOVSUB×INSAUD			0.6878**	
			0.0121	
GOVSUB×PMSHSUP			-0.1022*	
			0.0737	
TAFRET×PINSSUP				0.1191**
				0.0113
TAFRET×PMSHSUP				0.0721*
				0.0623
TAFRET×INSAUD				-0.7157*
				0.0829
Control variable	Yes	Yes	Yes	Yes
Individual and time point effect	Double fixation	Double fixation	Double fixation	Double fixation
Sample size	984	984	984	984
R <sup>2</sup>	0.3316	0.3329	0.3408	0.3465
F value	3.2490***	3.3899***	2.3998***	2.7519***

Note: \*, \*\*, and \*\*\* are significant at 10%, 5% and 1% levels respectively.

R&D input in agricultural enterprises. It also shows that the tax refund effect on the R&D input of agricultural enterprises is affected by the external situation. On the whole, the regression results after adopting GMM method to overcome endogenous factors showed that the main effect and regulatory effect were stable except for the inconsistency of positive and negative before and after the regression coefficient of TAFRET\*PMSHSUP, indicating that the impact of government support on the R&D input of agricultural enterprises was consistent with the previous paper.

### B. ROBUSTNESS TEST

Simultaneously, to test the robustness of the above-unbalanced panel data regression results, the following different methods are used to conduct alternative tests: (1) The influence of dependent variable selection bias, agricultural enterprise R&D input was replaced by research and development output. Due to the time lag of patent application, the number of patent applications in  $T + 1$  period measures the dependent variable. The test results show that the positive and negative signs of the main effect and selection effect are consistent with the previous article, and the difference lies in the size of the impact. (2) The influence of sample property selection bias, change of observed samples for testing. Because considering the sample listed companies have state-owned enterprises and non-state-owned enterprises, there is the substitution test according to enterprises' different nature. The results show that the influence on state-owned enterprises is consistent with the previous ones, and there are some differences in the influence on non-state-owned enterprises, which indicates that different sample attributes change the original mechanism to some extent. (3) The influence of sample period selection bias. Considering that the original sample period was 2009-2019, the sample period is changed to the period from the 12th Five-Year Plan to the 13th Five-Year Plan, i.e. the period from 2011 to 2019, for the substitution test. The results show that the main effect and selection effect only change the degree of influence, but the direction remains. Overall, the above three kinds of robustness test results show that different government innovation support has a different impact on Enterprise R & D input and output. (Table 7, Table 8 and Table 9 are robustness test results).

## VI. RESEARCH CONCLUSION AND MANAGEMENT IMPLICATIONS

### A. RESEARCH CONCLUSION

This article analyzes the impact of government subsidies and tax & fee returns on the R&D input of listed agricultural companies from the perspective of government intervention and corporate governance. From the perspective of different subjects' participation in corporate governance, this article puts leading shareholders' shareholding supervision, institutional investors' shareholding supervision and social audit institutions' audit supervision into the research model, and

investigates the impact of government innovation support on the R & D investment of agricultural enterprises. The results are as follows:

(1) Different types of government innovation support have different influence on the R&D input of agricultural enterprises. Government subsidies have a particular crowding-out effect on agricultural enterprises' R&D input, government tax & fee returns can stimulate agricultural enterprises to increase R&D input.

(2) The shareholding supervision mechanism of leading shareholder and institutional investors plays a consistent role between government innovation support and agricultural enterprise R&D input, its shareholding proportion increase enhances the crowding-out effect of government subsidies on agricultural enterprises R&D input. It strengthens the stimulus effect of government tax & fee returns on agricultural enterprises R&D input.

(3) The auditing opinions of social audit institutions play a consistent role between government innovation support and agricultural enterprise R&D input, the improvement of its auditing opinion weakens the crowding-out effect of government subsidy on agricultural enterprises R&D input, and also weakens the stimulating effect of government tax & fee returns on agricultural enterprises R&D input.

### B. MANAGEMENT IMPLICATIONS

To effectively stimulate the innovation vitality of market participants and reasonably eliminate government innovation support's negative effect, the following management implications are proposed based on the research conclusions.

(1) The support policies of Government innovation are a critical way to alleviate the inadequacies of enterprise R&Dn. To realize high-quality development of enterprises, the government should formulate diversified innovation support policies to guide and stimulate agricultural enterprises to carry out R&Dn activities of science and technology. However, different support policies of governmental innovation have different effects, and the government should give more consideration to the policy of indirect subsidies such as Tax & fee Returns and post-investigation to support and stimulate the R&D input of agricultural enterprises, which can reduce the policy of direct financial subsidy for the R&D activities of agricultural enterprises to some extent. Similarly, enterprises should make reasonable use of the government's innovation support policies and combine them with their innovation projects to improve their innovation ability.

(2) With the increasing maturity of China's capital market, the number and shareholding institutional investors are increasing, and they actively participate in and effectively improve corporate governance. First of all, the participation of institutions and leading shareholders can effectively supervise and balance enterprise managers' behavior to ensure the operation of enterprise R&D input. Secondly, it can avoid collision between senior managers and institutional investors by giving the reasonable and adequate supervision of senior managers from inside and outside, prevent them from

seeking private interests together, and thus harm the interests of small and medium shareholders and retail investors, and not conducive to the long-term value growth of enterprises.

(3) As an external social audit agency, it conducts an independent audit on senior managers' investment decision-making behavior to alleviate the irrational and opportunistic behaviors of top managers to a certain extent and reduce the non-efficient investment behaviors caused by performance pressure. Therefore, to ensure enterprises' efficient innovation, external independent institutions' audit function should be further strengthened. Moreover, the independent audit of social audit institutions also needs to improve the enterprises' internal control level. To protect the rights and interests of the majority of investors, promote the modernization of agricultural enterprises.

### C. SHORTCOMINGS AND PROSPECTS

Although this article analyses the relationship between government innovation support and agricultural enterprise R&D input and further explores the impact of the investors' shareholding supervision mechanism, leading shareholders' shareholding supervision mechanism, audit supervision mechanism on the relationship from the perspective of corporate governance, there are still some limitations in the research, which need to be further improved.

Firstly, due to information disclosure's incompleteness, agricultural listed companies' public data lack the two index data of new product sales revenue and R&D personnel investment. Therefore, this article uses the ratio of R&D expenditure to operating income and the number of patent applications in the T+1 period to measure innovation output. However, the patent application does not mean that enterprises entirely commercialize their innovative achievements and into the market sooner. New product sales revenue can more fully reflect the conversion of enterprise R&D output, and the research results obtained may be more accurate.

Secondly, because there are not many listed companies in agricultural companies, the number of samples used for research is relatively small. Simultaneously, the research sample data spans a large number of years, with 14 variables, resulting in an absolute lack of variable data, and it is challenging to ensure that each sample has data every year. Therefore, this article uses unbalanced panel data to estimate causality. However, the application of unbalanced panel data may lead to sample selection bias, which may lead to some endogenous problems. In further follow-up research, researchers can collect more comprehensive and balanced panel data to solve this problem. Use the PSM-DID method or natural experiment method to infer the causal relationship between government support methods and agricultural enterprise innovation input.

Finally, the institutional investors and leading shareholders' shareholding supervision mechanism and auditing supervision mechanisms are essential parts of corporate governance. It is worthwhile to analyze further its straightforward

role path to other government innovation support in follow-up research and expand relevant understanding.

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