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RESEARCH ARTICLE

The Impact of Technological Innovation Policy on the Performance of Chinese listed Seed Companies: The mediator role of R&D investment

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ABSTRACT

Given the changing role of government in the seed industry, the impact of technological innovation policy impact on the performance of Chinese seed firms, as well as the mediating effect of Research and Development (R&D) investment between the two were studied by taking listed companies in the seed industry in China from 2013 to 2022 as samples. The empirical results show that government subsidies facilitate the performance of seed firms though RD investment, while tax incentive directly impact performance of seed firms. When testing by heterogeneously, government subsidies and tax incentives do not significantly affect the performance of NEEQ listed seed firms but significantly impact A-share listed firms. R&D investment plays a mediating role between government subsidies and firm performance. Therefore, it is recommended that the government should improve the subsidy policy while increasing subsidies and decrease effective tax rate to the seed industry, and firms should promote the quality of their independent R&D.

INTRODUCTION

The seed industry is crucial for the sustainable development of the global food supply chain. Seed, as the starting point of the agricultural industry chain, is one of the most important inputs in agricultural industry (Pei et al., 2022; Zhang & Zhang, 2023, Kumo, 2024). According to the UN's 2020 state of Food Security and Nutrition in the World Report, the number of hungry people has been growing since 2014, which means that more than 840 million people would suffer lack of food in 2030. However, few studies focus on the seed industry and seed companies. Research has shown that technological innovation significantly enhances firm performance (Jin et al., 2018; Luo & Long, 2024 Aderibigbe, 2024), but this relationship is underexplored in the seed industry. In the innovation system, the government plays an important role in assisting firms to enhance their competitiveness and innovation (Lundvall, 2010; Porter, 2011; Watkins et al., 2015; Pei et al., 2022). The international seed market has shifted from a government-led model of innovation and promotion as a public product to an industry model led by large multinational corporations (Zhang & Zhang, 2023), which means that seed companies play more important roles in the seed market than before. Government subsidy, as an incentive, is an effective policy tool for improving R&D input incentives for companies (Luo & Long, 2024). However, given the changing role of government in the seed industry, does the government policy impact on the firm performance?

Therefore, the objective of this paper is to analyze the impact of government technological innovation policy on firm performance in Chinese seed industry. It would help the relevant government departments to formulate a more scientific and reasonable government technological innovation policy, and to realize the rational allocation of financial funds. At the same time, it helps seed companies to better carry out R&D activities and improve firm performance under the government technological innovation policy.

In China, the release of the Opinions on Accelerating the Development of Modern Crop Seed Industry and the National Development Plan for Modern Crop Seed Industry (2012-2020) elevated the development of the seed industry to a national strategy for the first time and started the process of seed industry modernization. There is an important year to note. In 2013, the Office of the State Council issued a document titled "Opinions on Deepening the Reform of the Seed Industry System and Improving Innovation Capability" (referred to as "Article 7"). This is the first time in the history of China's seed industry that the status of seed companies as the main market players in technological innovation was highlighted. Therefore, this study chosen 2013 as the starting point of the research, and use 10-year period (2013 to 2022) to study the performance of Chinese seed companies. 34 publicly listed crop seed companies in China are selected as a research sample, and the financial data from 2013 to 2022 are used to study the impact of government technological innovation policy on firm performance with R&D investment as a mediator.

The rest of the study is structured as follows. Section 2 provides the literature and hypothesis development. Section 3 discusses research methodology, variables and data description. Section 4 discusses the study results. Section 5 provides conclusion of the study.

2. LITERATURE REVIEW AND HYPOTHESIS

2.1 Technological innovation policy and firm performance

Scholars defined the technological innovation policy (TIP) to guide the development of firm innovation and broadly classified them into two categories, which are direct policies and indirect policies. Direct policies refer to policies that directly promote firm innovation, such as financial subsidies, R&D grants, and science and technology programs subsidies. Indirect policies, on the other hand, are mainly those that indirectly promote firm innovation and development through tax incentives, government purchasing and other means (Huang & Hu, 2023). Many economic scholars believe that government subsidies and tax incentives are the most common types of policy instruments (Martin, 2016; Becker, 2019).

The relationship between technological innovation and firm performance is a complex and multifaceted topic that has been the subject of extensive research in recent years. Numerous studies have demonstrated that technological innovation plays a crucial role in enhancing a firm's capacity to achieve a sustainable competitive advantage, leading to improved overall performance among seed companies (Singhal et al., 2022). Scholars found that government subsidies can have a positive impact on the firm performance by reducing the cost of firms, promoting the level of the firm's technological innovation, mitigating the failure phenomenon in R&D activities, and increasing the technological investment of firm (Tzeleyis & Skuras, 2004; Girma & Strobl, 2006; Zou et al., 2013; Jin et al., 2018; Luo & Long, 2024). While other scholars found that high government subsidies, on the contrary, reduce the rate of return on firm performance (Beason & Weinstein, 1996). Makeeva et. al (2019) Utilizing an empirical model grounded in data from 520 companies spanning the years 2007 to 2016, the researchers examine the influence of various R&D tax incentive schemes on corporate performance, as measured by return on assets (ROA) and the effective tax rate (ETR). Hartini & Dicriyani (2021) discuss the situation in Indonesia, the government has endeavored to bolster the skill set of its workforce by offering tax incentives to firms that engage in work practices, apprenticeships, and learning initiatives aimed at nurturing and enhancing specific competencies

known as Super Tax Deduction. Findings indicate that the Super Tax Deduction can significantly benefit a firm, provided it is complemented by supplementary reductions in gross income and adheres to a multitude of stipulations necessary to qualify for this tax benefit.

Therefore, the following hypotheses are proposed:

H1: Technological innovation policy (TIP) ***has significant impact on*** *Chinese seed firm performance (FP).*

H1a: Government subsidies (GS) ***have significant impact on*** *Chinese seed firm performance (FP).*

H1b: Government tax incentives (TAX) ***have significant impact on*** *Chinese seed firm performance (FP).*

2.2 Technological innovation policy, R&D investment and firm performance

Starting from the theories of externalities and signaling, it can be seen that the government R&D subsidies or tax incentive received by seed companies can alleviate the financial pressure caused by Research and development (R&D) investment. Moreover, in the long run, firms that receive government assistance and support can establish an image of having a promising development prospect, with products and production technologies that can be trusted by the public (Luo & Chen, 2016; Rong & Zhong, 2020). Huang et al.(2017) conducted an empirical analysis of the manufacturing industry in the Pearl River Delta and found that technological innovation acts as a catalyst for the operation and development of firms, especially for manufacturing firms. Government financial support can bring more resources to firms, ensuring the efficiency of R&D operations and ultimately bringing more performance to the firms. Rong and Zhong (2020) started from high-tech firms and proved that although government subsidies can improve firm performance, the mediating role of R&D investment in enhancing firm performance should not be overlooked. Therefore, when measuring the impact of R&D investment on firm performance, it is essential to consider the influence of government R&D subsidies and tax incentives on firm performance.

Therefore, the following hypotheses are proposed:

H2: RD investment (RD) mediates between technological innovation policy (TIP) ***and*** *Chinese seed firm performance (FP).*

H2a: RD investment (RD) mediates between government subsidies (GS) and Chinese seed firm performance (FP).

H2b: RD investment (RD) mediates between tax incentives (TAX) and Chinese seed firm performance (FP).

Base on the literature review and hypos, the research framework is shown as in following figure.

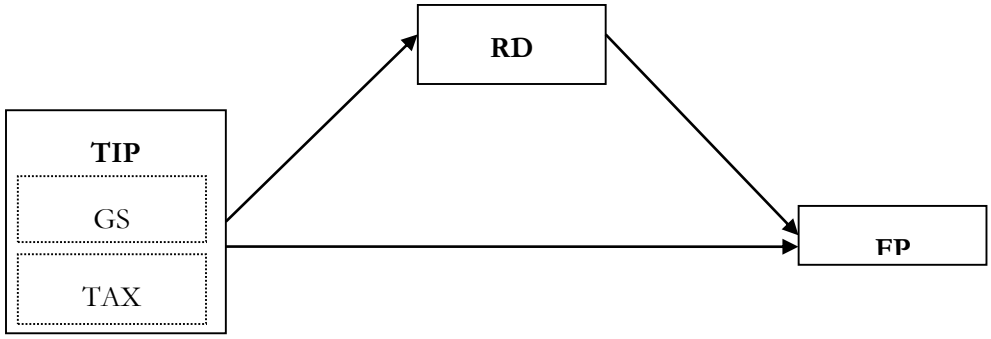

Figure 1: Research Framework

3 METHODOLOGY

3.1 Model specification

The mediating effect model would be test by Stepwise Regression Method, which is proposed by Baron and Kenny (1986).

The first step is to test whether technological innovation policy has an impact on Chinese seed firm performance. A direct effect model is built at the first step. Based on the research hypothesis, to minimize the influence of other factors, a fixed-effects model is used in the basic model as shown following was constructed to measure the direct effect.

$$FP_{it} = \alpha + \beta_1 GS_{it} + \beta_2 TAX_{it} + + \sum \beta_K Controls_{it} + u_{it} \quad (1)$$

$$FP_{it} = \alpha + \beta_1 GS_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (1a)$$

$$FP_{it} = \alpha + \beta_2 TAX_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (1b)$$

The next step is to analyze the regression of TIP on the mediator (TIE) to test the significance of the coefficient β.

$$TIE_{it} = \alpha + \beta_1 GS_{it} + \beta_2 TAX_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (2)$$

$$TIE_{it} = \alpha + \beta_1 GS_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (2a)$$

$$TIE_{it} = \alpha + \beta_2 TAX_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (2b)$$

The last step is to ascertain if technological innovation policy will influence firm performance through technology innovation efficiency, a mediating variable is added to the basicmodel.

$$FP_{it} = \alpha + \beta_1 TIE_{it} + \beta_2 GS_{it} + \beta_3 TAX_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (3)$$

$$FP_{it} = \alpha + \beta_1 TIE_{it} + \beta_2 GS_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (3a)$$

$$FP_{it} = \alpha + \beta_1 TIE_{it} + \beta_3 TAX_{it} + \sum \beta_K Controls_{it} + u_{it} \quad (3b)$$

In above models, i represents individual seed firm, t represents year. FP represent Chinese seed firm performance, TIP represents technological innovation policy, GS represent government R&D subsidies, TAX represents tax incentive. u_{it} indicate the fixed effect of firm, the fixed effect of year and the error respectively.

3.2 Variables

Dependent Variable (DV). Firm Performance (FP) is the dependent variable of this study. ROA (Return on Assets) and ROE (Return on Equity) are a common measure of firm performance (Keter et al., 2023; Hagel et al., 2013; Sher et al., 2005), reflecting both profitability and growth. Referring to related research (Si et al., 2020), this study selects return on total assets (ROA) to measure firm profitability. ROA is used to gauge performance because it is more appropriate for seed companies. The reason is seed companies usually have an unavailable or unfair estimation of the firm on the market, so market proxies for performance are not applicable (Makeeva et al., 2019). ROE is used to test robustness. All the indicators' calculation formulas are based on Chinese accounting regulation, and the result of the calculation can be found on CSMAR (China Stock Market & Accounting Research) database.

Independent variable (IV). Technological innovation policy (TIP) is independent variable of this study. Technological innovation policy (TIP) is expressed by two indicators in this study, which are government R&D subsidiary and tax incentive policy.

Government subsidiary (GS) is amount of money monetary or non-monetary assets that received by the companies from the government without compensation (Li & Chen, 2021). Considering that the

forms of tax incentives for companies also include additional deductions for R&D expenses, one-time tax deduction for purchased fixed assets, etc., these incentives are not included in the "tax rebate received by the firm", but are reflected in the effective tax rate of the firm income tax, therefore, this paper adopts the effective tax rate method by referencing Qian and Xu (2023). The effective tax rate can be expressed by the following:

Effective tax rate= Nominal tax rate- amount of income tax/EBIT*100%

The nominal tax rate in China is 25%.

Mediating variable (MV). Research and Development investment (RD) would be the mediating variable of this study. Referring to the method by scholars (Hong et al., 2015, Forsman, 2011, Rasiah et al., 2016), RD would be measuring by the logarithm amount of R&D investment.

Control Variable (CV). Firm performance is influenced by a variety of internal and external factors. Firm specific control variables are essential to properly separate the casual effect of R&D subsidy. Based on relevant studies (Basit et al., 2018; Chen & He, 2021), this research introduces firm size, and capital structure as control variables.

For specific variable definitions and measurements, please refer to Table 1.

Table 1: Variable selection and definition

Variables	indicators	definition
Dependent variable (DV)		
Firm Performance (FP)	ROA	Net profit/total average assets×100%
Independent variable (IV)		
Technological Innovation Policy (TIP)	GS	government subsidies / operating income×100%
	TAX	(Nominal tax rate – amount of income tax /EBIT) ×100%
Mediating variable (MV)		
R&D investment (RD)	RD	Amount of R&D expenditure
Control variable (CV)		
Firm size	FA	amount of fixed asset
Capital structure	LEV	Total liability/total asset×100%

3.3 Data

3.3.1 Data collection

The study population for this research includes are the legally registered public listed seed companies in China. There are two type of listed seed companies in this study, which are A share listed firm and NEEQ (National Equities Exchange and Quotations) listed firm.

The A-share market is the stock exchange market in mainland China that is open to domestic investors and foreign institutional investors through the Qualified Foreign Institutional Investor (QFII) program. The NEEQ (National Equities Exchange and Quotations) market is an OTC (over-the-counter) system for trading the shares of public limited companies incorporated in mainland China

that are not listed on either the Shanghai or Shenzhen stock exchanges. NEEQ is also known as the New Third Board, is a Chinese over-the -counter (OTC) market for trading the shares of public limited companies that are not listed on any of the other stock exchanges in China. The purpose of NEEQ is to provide service for small and medium-sized firms.

A-share listed seed companies are chosen based on Shenwan Industry Classification Standard (2021). Under Shenwan Industry Classification standard, there is a specific industry category called "SEED". Until December 2023, there are 9 A-share listed companies in the small branch of SEED, based on Shenwan Industry Classification Standard (2021). NEEQ-listed seed companies are chosen based on codification issued by National Bureau of Statistics of China, which related with seed industry are 01-011-0111(called "Seed and Seeding activities"). There are 28 NEEQ listed seed companies, based on NEEQ officially released classification documents (by the end of May 2023). The NEEQ official documents are following the rule of the classification of National Bureau of Statistics of China.

Therefore, the study population is 37 publicly listed crop seed companies, of which 9 are A Share listed seed companies and the remaining 28 are NEEQ listed seed companies. Considering the availability and consecutive years of data, the 34 listed companies, which listed on the capital market before year 2021, in the Chinese seed industry are selected.

3.3.2 Data source

This research utilizes a panel dataset that spans a period from 2013 to 2022, covering multiple seed companies in China. The selection of companies and the time frame for this study were guided by the availability of comprehensive data. The data for this study were sourced from a variety of databases, including the CSMAR database (https://data.csmar.com/), WIND database (https://www.wind.com.cn/), China Seed Industry Big Data DATABASE (http://202.127.42.47:6009/Home/BigDataIndex), China National Intellectual Property Administration (CNIPA) (http://epub.cnipa.gov.cn/) and the Annual Reports of the seed companies ranging from 2013 to 2022.

4 RESULTS AND DISCUSSIONS

4.1 Descriptive statistics of variables

It is hereby stated that in order to facilitate measurement statistics and eliminate the influence of heteroskedasticity, this study has cleaned the original data, and the logarithmized data will be used as research data for empirical analysis. In addition, due to missing data for individual cities in individual years, this study uses zero to supplement the data. Table 2 shows the results of descriptive statistical analysis.

Table 2: Descriptive Summary Table

Variable		N	Mean	SD	Min	Max	Median
DV							
	ROA	276	4.16	7.19	-18.2	28.35	3.53
IV							
	GS	276	14.7	2.68	0	18.04	15.04
	TAX	276	21.93	15.06	-25.57	120.83	23.92
MV							
	RD	276	15.88	1.6	11.76	19.84	15.82

CV							
	FA	276	13.06	1.2	9.32	18.33	13.07
	LEV	276	37.75	16.81	2.94	78.25	37.2

Displaying in table 2, the mean value of Firm performance (ROA) is 4.16, the standard deviation (SD) value of ROA is 7.19, and median is 3.53, which means the indicator selected in this paper have a certain degree of volatility and can be analyzed in a regression analysis.

In table 2, the mean value for government subsidies (Gov) is 14.7, indicating that, on average, companies receive a moderate level of government subsidies. The standard deviation of 2.68 suggests companies generally receive moderate government subsidies. The minimum government support is 0, indicating that some companies do not receive any government support. The maximum government support is 18.04, indicating that some companies receive relatively high levels of government support. The median government support (15.04) is slightly higher than the mean, suggesting a possible skewness towards higher values. The mean of TAX (effective tax rate) value is 21.93, indicating that, on average, companies face a moderate level of effective tax rate. The standard deviation of 15.06 suggests variability in the level of taxation among the companies. the mean value of R&D investment (RD) is 15.88, the standard deviation（SD）value of RD is 1.6, and median is 15.82, which means the data for RD appears to be relatively consistent (small SD) around the mean, with a median value close to the mean.

4.2 BENCHMARK REGRESSION

By examining the coefficients of the key explanatory variables derived from the regression, the impact of the independent variables on dependent variable can be better evaluated. In the context of a dissertation, the results of regression analysis serve to illuminate the relationships between variables, offer empirical validation, and provide a foundation for policy development and forecasting.

Table 3: Regression result of the effect of TIP on firm performance

	Model 1	**Model 1(a)**	**Model 1(b)**
	ROA	ROA	ROA
GS	0.084	0.093	
	(0.4510)	(0.493)	
TAX	-0.058***		-0.059***
	(-2.640)		(-2.870)
FA	-3.715***	-3.787***	-3.844**
	(-3.606)	(-3.632)	(-2.098)
LEV	-0.107***	-0.108***	-0.107**
	(-2.943)	(-2.923)	(-2.345)
_cons	56.764***	56.308***	59.661**
	(3.913)	(3.834)	(2.486)
N	276	276	276
R^2	0.117	0.091	0.116
F	7.860	7.957	6.022
***P<0.01", "**P<0.05", "*P<0.1			

From the regression model 1 in table 3, which regarding the impact of TIP (Technological Innovation Policy) on firm performance (FP), the following results are detected. The regression coefficient of GS is 0.084, indicating that Government subsidy is associated with increase firm's ROA. The regression coefficient for Tax is -0.058, reaching a significance level of 1%. This indicates that the amount of

R&D investment significantly contributes to corporate performance. Specifically, for every 1-unit increase in effective tax rate, the ROA of seed firm would decrease by 0.058 units. In summary, when test the impact of TIP on firm performance, TAX has negative effects and at 1% level are significant (t=-2.640). GS has positive effect but is not significant (t=0.4510). Therefore, hypothesis H1 can be partially supported. From the regression model 1(a) and 1(b) in table 3, which regarding the impact of government subsidy and tax respectively. The results are almost the same to that in model 1. Therefore, there is no evidence to support hypothesis H1a , but hypothesis H1b is supported.

Based on the findings above, it is plausible that the scale of government subsidies may be insufficient. The characteristics of seed companies dictate that they require large amount and substantial investment. Therefore, the government's R&D subsidies must exceed a certain amount to significantly enhance firm performance. Also, higher taxes rate reduces the net income a firm can retain, which can negatively affect its financial performance, such as profitability. This result aligned with the study of Amendola et al (2018) who indicated tax relief granted to business helps in improving performance. And it is similar to the result of Mauda et al.(2019) that tax incentives has influence on profitability in listed consumer goods companies in Nigeria. Therefore, the reason for this finding can be explained that small seed firms may struggle to fully capitalize on the potential benefits of tax incentives due to scale limitations, as they might lack the necessary resources or expertise to maximize the utilization of these reductions.

4.3 ROBUSTNESS TEST

Robustness testing in research, particularly in statistical analysis, is a set of methods used to verify that the results of a study are reliable and not sensitive to changes in the model specification or data.

Table 4: Regression result for robustness test

	(1)	**(2)**	**(3)**
	ROE	ROE	ROE
GS	-0.036	-0.022	
	(-0.108)	(-0.065)	
TAX	-0.093**		-0.093**
	(-2.311)		(-2.315)
FA	-6.517***	-6.631***	-6.461***
	(-3.478)	(-3.508)	(-3.596)
LEV	-0.095	-0.096	-0.096
	(-1.442)	(-1.443)	(-1.449)
_cons	97.890***	97.165***	96.634***
	(3.711)	(3.650)	(4.093)
N	276	276	276
R^2	0.081	0.060	0.081
F	5.204	5.066	6.964
***P<0.01", "**P<0.05", "*P<0.1			

In table 4, the regression coefficients of Gov on ROE and ROA are not significant. The coefficient sign changed. Since it is not significant, the result of the change may not be discussed. The regression coefficients of Tax on ROE (Return on Equity) and ROA (Return on Assets) are significantly negative and the significance level decreases from 5% to 1%. This suggests that as the tax increases, the profitability of the equity (ROE) and the efficiency of asset utilization (ROA) decrease.

Comparing the regression results in (1) (ROE as indicator) and (2) (ROA as indicator) in table 3, it can be seen that the direction sign and significance of regression coefficients of key variables have not changed significantly. Therefore, the robustness test is confirmed that the main results are reliable.

4.4 HETEROGENEITY ANALYSIS

This section focuses on grouped regression analysis of the sample, which was grouped according to the markets in which the sample companies were listed in order to analyse the impact of innovation policy (TIP) on the firm performance (FP).

Table 5: Regression result for heterogeneity analysis

	(1)	(2)	(3)
	ROA	ROA	ROA
Gov	0.084	0.091	2.580*
	(0.451)	(0.458)	(1.910)
tax	-0.058***	-0.035	-0.091***
	(-2.640)	(-1.183)	(-2.911)
FixA	-3.715***	-2.853**	-6.393***
	(-3.606)	(-2.254)	(-3.787)
LEV	-0.107***	-0.128***	-0.112
	(-2.943)	(-2.866)	(-1.655)
_cons	56.764***	46.380***	50.432*
	(3.913)	(2.625)	(1.734)
N	276	196	80

***P<0.01", "**P<0.05", "*P<0.1

One firm that requires attention is QIULE SEEDS TECHNOLOGY (831087) , which was listed on the National Equities Exchange and Quotations (NEEQ) market from 2014 to 2022. In 2022, it successfully became a publicly traded firm on the A-share market, which is one of the 9 A-share listed companies now. Therefore, QIULE Seed is treated as NEEQ listed company when grouped.

As shown in the table 5, the regression results of A-share are in column (3) and the regression results of NEEQ-listed firms are in column (2) according to the market division where the firms are listed and quoted. The regression results show that government subsidies and tax incentives of NEEQ-listed firms have insignificant effects on firm performance, but government subsidies of A-share-listed firms play a positive and significant role in firm performance, and tax incentives play a negative and significant effect on firm performance. This suggests that the current technological innovation policy currently does not have a good effect in NEEQ-listed firms. These results imply that R&D subsidy effects vary with the firm size, while A-share listed companies usually has larger amount of asset. Similarly, results are in line with Le et al. (2016), revealing that public R&D grant reception has differential effect in small to medium firms. Basit et al. (2018) found the opposite result, which indicating that medium and small firms R&D support program has remarkable effect on firm performance. The reason may be that the seed companies are high demand RD input type firms. Government grants and tax incentives tend to be acquired after the end of the project, which does not well alleviate the problem of firm capital shortage. For A-share listed companies, the technological innovation policy plays an impact. The government grants well alleviate the problem of firm capital shortage, which in turn affects the firm performance; and then the tax incentives policy firms obtain lower effective tax rate may be more inclined to will increase investment, which affects the performance of the firm in the short term.

4.4 MEDIATING EFFECT RESULTS

The bootstrap method is a versatile approach that does not assume normality of the sampling distribution. Researchers estimate the indirect effect using resampling techniques. Rather than distinguishing between partial and complete mediation, the degree of mediation is expressed through the proportion of the indirect effect relative to the total effect (Zhao, 2010).

Table 6: Bootstrap Test Result for TIP

	Effect	Observed coefficient	Bootstrap Std.err.	Z	P>|Z|	Normal-based [90% conf. interval]	
TAX	indirect	0.0003	0.0022	0.16	0.870	-0.0048	0.0029
	direct	-0.0405	0.0212	-1.91	0.057	-0.0754	-0.0056
GS	indirect	-0.1623	0.0932	-1.74	0.082	-0.3157	-0.0089
	direct	0.4760	0.1417	3.36	0.001	0.2429	0.7091

For mediation relationship, hypothesis 2a proposed that there has a mediation effect of R&D investment in the relationship between government subsidy and Chinese seed firm performance. As shown in table 6, the result show significant effect of mediation with the confidence interval is [-0.3157, -0.0089] for indirect effect and for the direct effect the confidence interval is [0.2429, 0.7091], both excluding 0. This indicates that hypothesis H2a is supported. Government subsidy would impact on Chinese seed firm performance through R&D investment. Hypothesis 2b also proposed a mediation effect of R&D investment in the relationship between tax incentive and Chinese seed firm performance. The result show unsignificant effect of mediation with the confidence interval is [-0.0048, 0.0029] of indirect effect, including 0. Meanwhile, the confidence interval for tax incentive is between -0.0754 and-0.0056, excluding 0. The result indicates that hypothesis H2b is not supported.

The result is similar to the research conducted by Rong and Zhong (2020), which indicating that R&D investment mediates the relationship between government subsidy and firm performance in Chinese high-tech industry. Luo and Long (2024) also found the mediation relationship between government subsidy and firm performance in Chinese automobile industry. The significant impact of direct effect and indirect effect of government subsidy can deepen the implication that the amount of government RD subsidy may be not enough.

5. CONCLUSION

Given the changing role of government in the seed industry, the research objective is to test government policy impact on the firm performance of Chinese listed seed companies. The following are the conclusions:

Firstly, when testing all the firms in one group, government RD doesn't impact on firm performance directly, and R&D investment plays a mediating role in the relationship between government RD subsidy and firm performance; second, tax incentive impact on Chinese seed firm performance directly. Government subsidies can influence firm performance through the R&D investment of firm. The R&D investment of a firm can stimulate significant growth in firm performance, and government subsidies can encourage firms to pay more attention to R&D, thereby affecting their performance. While, lowering the effective tax rate can directly impact on firm performance. Secondly, when testing listed seed companies separately by listing market, opposite results are reached. Technological innovation policy, both indicators government RD subsidy and tax incentive, impact on firm performance significantly for A-share listed companies. However, there is no evidence to support that the technological innovation policy impacts on performance of Chinese listed seed firms that listed on the NEEQ market.

Therefore, based on the conclusions, recommendations for seed industry and seed firms are: firstly, on the basis of increasing firm concentration and enhancing firm scale, encourage seed firms to implement a vertical integration development strategy. Scale firms can only enhance their competitiveness by implementing an industrial chain development strategy. Scale firms can adopt an integrated vertical merger and acquisition strategy to achieve the goal of establishing an industrial chain. Secondly, encourage firms to accelerate technological innovation. Investment in technological

research is the foundation of continuous innovation in the seed industry. Firms have realized that if they cannot carry out independent innovation, they will face the risk of being eliminated. However, due to the particularity of the seed industry, the variety innovation cycle is generally more than 5 years, which is relatively long compared to other industries, and firms are prone to financing difficulties and other issues in the short term. As a government, it should encourage firms to invest in innovation, and appropriately increase the intensity of government subsidies, especially for leading firms.

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