ingegneria sismica
International Journal of Earthquake Engineering
Anno XLIII - Num. 2 - 2026

The Impact of Market Competition, Government Subsidies, and Corporate Innovation Behavior on Resource-based Enterprises

Mengjun Yang[1,*] *and Tao Zhong*[1]

[1] School of Digital and Intelligent Economics and Management, Chengdu College of Arts and Sciences, Chengdu 610400, Sichuan, China

SUMMARY: *Resource-based enterprises are located at the intersection position of energy supply guarantee, raw material supply and green transformation, and competition pressure and government subsidies jointly affect their innovation input. Taking resource-based listed enterprises in Shanghai and Shenzhen A-share markets from 2014 to 2020 as the sample, the research objects are identified according to 12 types of industries including mining, washing, primary processing and energy supply. After deleting ST, missing values, zero R&D input and zero subsidy samples, 717 firm-year observations are obtained. The study adopts industry and year fixed effects to examine the influence of market competition, government subsidies and their interaction on R&D input, and groups them according to ownership structure. The results show that market competition has a positive effect on innovation of resource-based enterprises, the full-sample competition coefficient is 0.099 and significant at the 5% level; in non-state-owned enterprises, this coefficient is 0.067 and significant at the 1% level, while state-owned enterprises are not significant. The direct effect of government subsidies in the full sample is insufficient, and it shows inhibition in state-owned enterprises, but the interaction terms of competition and subsidies in state-owned enterprises and non-state-owned enterprises reach 0.613 and 1.195 respectively, indicating that subsidies are more suitable as resource buffer and signal tools under competition pressure. The study provides empirical evidence for innovation governance and precise subsidy allocation of resource-based enterprises. This paper also redraws sample, mechanism and result evidence in a graphical way to enhance the readability and recheckability of the conclusions.*

KEYWORDS: *resource-based enterprises; market competition; government subsidies; corporate innovation; ownership structure*

1 Introduction

The operating scene of resource-based enterprises has relatively strong double constraints. On the one hand, coal, oil and gas, metal minerals, chemical raw materials and electric heat supply enterprises undertake the supply of basic products, and production capacity arrangement, resource continuation and safety production directly affect the stability of the industrial chain; on the other hand, energy conservation and carbon reduction, green mines, upgrading of raw material industry and adjustment of energy structure continuously change the cost boundary of enterprises. The stable income formed in the past by relying on resource endowment, scale capacity and administrative access has already been difficult to fully cover new equipment input, low-carbon process transformation and R&D failure risk. Resource-based enterprises therefore

*yang_mengjun@126.com
https://doi.org/10.65102/is2026933
Published: 30 April, 2026

face a more specific problem: when industry competition turns from output competition to comprehensive competition under technology, cost and emission constraints, whether enterprises will transform competition pressure into R&D input. Existing studies on Chinese resource-based enterprises show that government subsidies, digitalization and green transformation are reshaping the organizational capacity and industrial chain resilience of resource-based enterprises [1-3], and the energy transition of resource-based cities will also affect firms' green innovation through technology demand [4]. These studies provide scene basis for this paper, but the combined relationship among market competition, subsidy resources and enterprise innovation input still has room for further development.

The relationship between market competition and innovation has long had different judgments in industrial organization and innovation management research. Classic research points out that competition may push enterprises to speed up technological renewal through elimination pressure, and may also weaken the ability of enterprises to undertake high-risk R&D because of profit space compression; the inverted U-shaped relationship thus becomes an important theoretical path to explain this problem [5]. Some studies also find that competition intensity and innovation use, innovation input are not always in a one-way relationship, and the industry threshold, demand elasticity and technology distance where enterprises are located will change the direction of competition effect [6]. In emerging markets and small and medium-sized enterprise scenes, competition may bring external discipline, and may also induce short-term defensive behavior [7]. The industry structure of resource-based enterprises is different from that of general manufacturing. Resource licensing, mining right allocation, regional energy demand and fixed asset precipitation jointly form relatively high entry barriers. Market competition in such enterprises usually does not show complete price competition, but transmits among raw material cost, environmental constraint, alternative energy and downstream order stability. Therefore, directly using competition conclusions of general industries easily ignores the strong industry specificity of resource-based enterprises.

Government subsidy is another type of key external condition that affects the innovation behavior of resource-based enterprises. Subsidy can ease R&D capital constraints, and can also release policy recognition signals, making enterprises easier to obtain bank credit, local project support and supply chain cooperation opportunities. Studies on high-tech industries show that government support and market competition will jointly affect innovation efficiency, and this influence has stage differences and nonlinear characteristics [8]. But in resource-based enterprises, the meaning of subsidy funds is more complicated. Part of subsidies is used for safety production, environmental governance, employment stabilization and technological transformation, and may not all enter the R&D link; because state-owned enterprises have relatively stable resource acquisition channels, subsidies may be absorbed into existing investment plans and non-R&D expenditures; non-state-owned enterprises are more affected by financing constraints and competition pressure, and subsidies are more likely to become the trigger condition for their additional R&D input. If only the average effect of subsidies is examined, it is difficult to explain the differentiation of subsidy use efficiency among enterprises with different ownership.

The existing manuscript has already constructed the basic empirical framework of market competition, government subsidies and corporate innovation, and obtained preliminary results with resource-based listed enterprises in Shanghai and Shenzhen A-share markets from 2014 to 2020 as the sample. On this basis, this paper conducts revision of Chinese journal manuscript, and mainly strengthens three aspects. First, around the industry attributes of resource-based enterprises, the research background is rewritten, so that sample selection, variable caliber and competition mechanism can correspond with each other. Second, government subsidies are expanded from a single fiscal support variable to resource buffer and policy signal variables, and the interaction between them and market competition is mainly analyzed. Third, mechanism diagram, sample organization diagram, three-dimensional response surface, coefficient forest diagram and moderation boundary diagram are added in result presentation, so that empirical results and figure evidence form direct correspondence.

Further, the innovation decision of resource-based enterprises is also affected by asset specificity. The investment cycle of mines, smelting lines, chemical installations and electric heat supply facilities is long, and equipment transformation often needs to be arranged simultaneously with safety production, environmental approval and capacity utilization rate. Even if enterprises realize the necessity of technological upgrading, they may delay R&D input because of shutdown cost, cash flow fluctuation and project trial-and-error risk. Market competition has two functions at this time: first, it compresses the tolerance space of inefficient production, forcing enterprises to include energy saving, consumption reduction and comprehensive utilization of resources into business plans; second, it increases the opportunity cost of R&D failure, making financially weak enterprises reduce long-term input. Whether government subsidies can change this trade-off depends on whether subsidies enter the innovation budget, and whether enterprises regard subsidies as stable signals of long-term technological input.

The advantage of the original manuscript is that it has already given clear samples and regression results, but the original writing pays more attention to hypothesis statement, and the support of figures and tables for argument is insufficient. Especially, there is obvious interaction among market competition, government subsidies and ownership structure. Only relying on tables is difficult to explain how competition pressure is amplified by subsidies, and it is also difficult to show the response differences between state-owned enterprises and non-state-owned enterprises. In this revision, 'numerical results' are transformed into 'figure evidence', and method figures are placed in the three positions of sample organization, mechanism identification and estimation protocol, so that readers can first understand where the sample comes from, then understand how variables enter the model, and finally understand how coefficients support the research judgment.

Accordingly, the research objectives of this paper focus on three questions: whether market competition can push resource-based enterprises to increase R&D input; whether the direct impact of government subsidies on corporate innovation is stable; under different ownership structures, whether government subsidies will change the stimulating intensity of market competition on innovation input. Compared with the linear text expression of the original manuscript, the revised manuscript summarizes the research contribution into three points: first, it tests the innovation incentive effect of competition pressure in the scene of resource-based enterprises, avoiding direct extrapolation of general manufacturing conclusions; second, it distinguishes state-owned and non-state-owned enterprises, and explains the use differences of subsidy resources in different governance structures; third, it displays samples, methods and results through multi-figure linkage, making the relationship among market mechanism, policy tools and enterprise behavior clearer.

2 Methods

2.1 Sample Construction and Data Processing

This study follows the data basis of the original manuscript and reorganizes the sample construction process. The research objects are resource-based listed enterprises in Shanghai and Shenzhen A-share markets, and the observation period is 2014-2020. The starting point of the period is put in 2014, mainly considering that after 2012, science and technology system reform and innovation support policies gradually fell to the enterprise level, and R&D expenditure and government subsidy disclosure in enterprise annual reports were also more comparable; the end point of the period is set as 2020, in order to reduce the abnormal disturbance of the epidemic impact on resource product prices, production capacity arrangements and R&D budgets. Enterprise data mainly come from the CSMAR database. Industry identification is based on the 2017 National Economic Industry Classification, and combined with the business attributes of resource-based enterprises, mining, washing, primary processing and electric heat supply related industries are included in the sample scope.

Resource-based enterprises do not only include mineral mining enterprises. This paper defines them as listed companies taking natural resource development, energy supply, mineral processing and primary manufacturing of raw materials as the main business basis. Specific industries include coal mining and washing, oil and natural gas extraction, ferrous metal mining and selection, non-ferrous metal mining and selection, non-metal mineral mining and selection, as well as petroleum processing, chemical raw materials, non-metal mineral products, ferrous metal smelting, non-ferrous metal smelting, metal products and production and supply of electric power and heat. Table 1 lists the sample industry caliber. In Table 1, the left side is mining and washing industries, and the right side is resource primary processing and energy supply industries. The two types of industries jointly constitute the observation basis of innovation behavior of resource-based enterprises.

Table 1: Industry Classification and Codes of Resource-based Enterprise Samples

Extraction and Washing Industry Code	Extraction and Washing Industry Name	Primary Processing and Energy Supply Industry Code	Primary Processing and Energy Supply Industry Name
B06	Coal Mining and Washing Industry	C25	Petroleum Processing, Coking and Nuclear Fuel Processing Industry
B07	Oil and Natural Gas Extraction Industry	C26	Chemical Raw Materials and Chemical Products Manufacturing Industry
B08	Ferrous Metal Mining and Selection Industry	C30	Non-metallic Mineral Products Industry
B09	Non-ferrous Metal Mining and Selection Industry	C31	Ferrous Metal Smelting and Rolling Processing Industry
B10	Non-metal Mineral Mining and Selection Industry	C32	Non-ferrous Metal Smelting and Rolling Processing Industry
		C33	Metal Products Industry
		D44	Electric Power and Heat Production and Supply Industry

Note: The industry classification is sorted according to the 2017 National Economic Industry Classification and combined with the main business attributes of resource-based enterprises.

Figure 1 shows the corresponding relationship among sample construction, industry scope and firm-year observations, as shown in Figure 1.

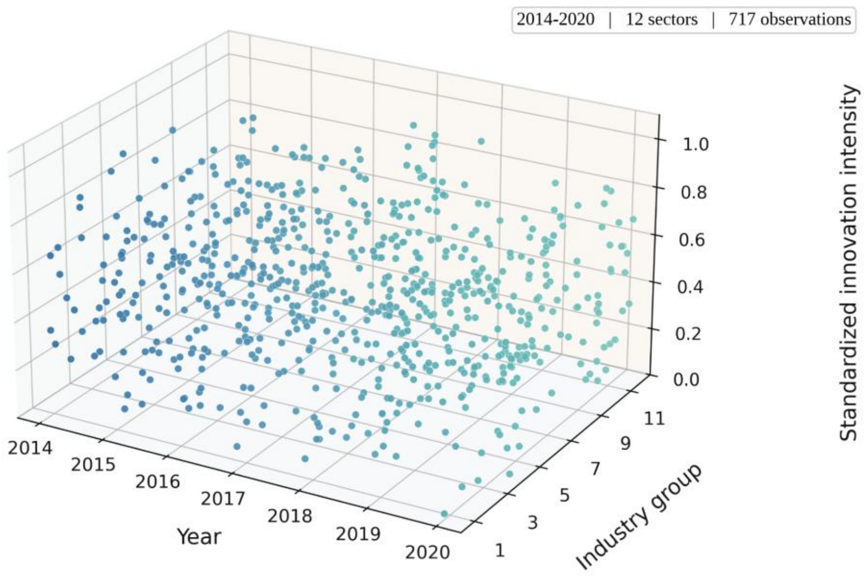

Figure 1: Three-dimensional Organization of Sample Construction, Industry Scope and Firm-year Observations

In Figure 1, the year dimension covers 2014-2020, the industry dimension covers 12 types of resource-related industries, and the firm-year observations form 717 effective samples after screening. Compared with an ordinary flow chart, this figure presents the panel structure among enterprises, years and industries with a three-dimensional sample cube, which can directly correspond to the industry control and year control in subsequent fixed effect estimation. During sample screening, ST and *ST companies are first deleted, companies with missing core variables are then deleted, observations with zero R&D input and zero government subsidy are further deleted, and finally continuous variables are winsorized at the 1% and 99% quantiles to reduce the influence of extreme values on regression coefficients.

In the sample screening caliber, this paper does not keep enterprises with zero R&D input as low-innovation samples, because the research focus of the original manuscript is the change of innovation input intensity, rather than whether enterprises have innovation. Among resource-based listed companies, some enterprises have zero R&D expenditure in annual reports, which may come from real no input, and may also come from R&D project capitalization, caliber consolidation or insufficient disclosure. If they are directly included in regression, disclosure quality differences and real innovation differences will be mixed together. Samples with zero government subsidy are also deleted, in order to ensure that the moderating variable has actual economic meaning. This treatment will sacrifice part of sample size, but it is beneficial to identify around the question of 'whether subsidies change competition incentives'. Winsorization treatment is only for continuous variables, and does not change ownership and industry classification.

The industry setting of Table 1 takes into account both the resource mining end and the resource processing end. Mining and washing industries directly face resource reserves, mining costs and safety production constraints; primary processing and energy supply industries more face downstream demand, environmental standards and capacity utilization constraints. Their common point is that the proportion of fixed assets is relatively high, the technological transformation cycle is relatively long, and energy consumption and emission constraints are relatively strong. Bringing the two types of industries into the same research framework can observe the common function of competition pressure at different positions of the resource chain, and at the same time control the basic differences between industries through industry fixed effects.

2.2 Variable Setting and Mechanism Identification

The explained variable of this paper is enterprise innovation input, measured by the R&D expenditure of the enterprise in the current year. The innovation activities of resource-based enterprises are reflected to a considerable extent in mining and selection equipment upgrading, energy-saving and consumption-reducing technology, emission control technology, comprehensive resource utilization and safety production technology input. Although R&D expenditure cannot completely cover patent quality and process absorption capacity, it can relatively stably reflect the resource commitment of enterprises to innovation activities in the current budget, and is suitable for examining the direct influence of competition pressure and government subsidies on corporate innovation behavior.

The core explanatory variable is market competition. The original manuscript uses the Herfindahl index to identify industry concentration, and uses the opposite number of industry concentration as the market competition indicator. The closer this indicator is to zero, the higher the degree of competition in the industry where the enterprise is located; the lower the value, the higher the industry concentration and the weaker the competition pressure. This treatment can make the positive and negative direction of the market competition coefficient consistent with competition intensity.

The moderating variable is government subsidy. Government subsidies come from the subsidy details disclosed in the notes of annual reports of listed companies. This paper uses the total government subsidies of the previous year to measure the policy support basis faced by enterprises in the current period. Using lagged one-period subsidy has two considerations: first, there is a time lag from subsidy funds arriving to forming an R&D budget; second, lagged treatment can reduce the simultaneity interference between current R&D input and current subsidies. Existing studies have two explanations for the relationship between subsidies and innovation: one emphasizes the additional effect of subsidies on R&D input, and the other pays attention to resource misallocation and crowding-out effects that subsidies may cause [9-11]. This paper pays more attention to whether subsidies change the innovation response of enterprises under competition pressure, so government subsidies are treated both as a direct influence variable and a moderating variable.

Variable units also need to remain consistent in result interpretation. RD and Gov are both displayed in million yuan in the tables. Comp is the opposite number of industry concentration, Con is the shareholding ratio of the largest shareholder, ROA and Lev are financial ratios, and Size and Age are logarithmic indicators. Because variable dimensions are quite different, the result figures do not directly compare raw values in the same coordinate system, but respectively adopt standardization, heat map and coefficient forest plot for presentation. This treatment can avoid large subsidies and R&D expenditure compressing the visual space of other variables, and can also keep the original values in the tables.

The economic meaning of the interaction term is very important in this paper. If government subsidies only affect R&D input alone, then the Gov coefficient should be able to directly explain the effect of subsidy policy; if subsidies mainly play a role under competition pressure, then the direction and significance of the interaction term are more important. When resource-based enterprises face competition, innovation input needs to solve both capital source and project uncertainty problems. Subsidies reduce early-stage input pressure on the one hand, and transmit policy recognition signals to financial institutions and supply chain partners on the other hand. After the two functions are superposed, enterprises are more likely to transform competition pressure into R&D input, rather than simply compressing costs or reducing investment.

Control variables include equity concentration, enterprise age, asset-liability ratio, return on assets and enterprise scale. Equity concentration is measured by the shareholding ratio of the largest shareholder, used to identify the influence of control concentration on R&D decisions; enterprise age is measured by the natural logarithm of years of establishment, reflecting organizational inertia and experience accumulation; asset-liability ratio measures financing constraints and debt repayment pressure; return on assets reflects current profitability; enterprise scale is measured by the natural logarithm of total assets at year end. Table 2 lists the variable caliber. In Table 2, RD indicates R&D expenditure, Comp indicates market competition, Gov indicates lagged one-period government subsidy, Soe is the ownership identification variable, and industry and year dummy variables are used to control unobservable industry differences and year shocks.

Table 2: Variable Definitions and Caliber Description

Variable Type	Variable Code	Variable Name	Variable Meaning and Caliber
Explained Variable	RD	Enterprise Innovation Input	R&D expenditure, displayed in million yuan in the table
Core Explanatory Variable	Comp	Market Competition	Opposite number of industry concentration; the closer the value is to zero, the stronger the competition
Moderating Variable	Gov	Government Subsidies	Total government subsidies of the previous year, displayed in million yuan in the table
Grouping Variable	Soe	Ownership Structure	State-owned enterprises take 1, non-state-owned enterprises take 0
Control Variable	Age	Enterprise Age	Natural logarithm of years of establishment
Control Variable	Size	Enterprise Scale	Natural logarithm of total assets at year end
Control Variable	Lev	Asset-liability Ratio	Total liabilities at period end / total assets at period end
Control Variable	ROA	Return on Assets	Net profit / total assets at period end
Control Variable	Con	Equity Concentration	Shareholding ratio of the largest shareholder
Fixed Effect	Industry	Industry Effect	Control unobservable differences at the industry level
Fixed Effect	Year	Year Effect	Control annual macro shocks

Figure 2 summarizes the core action mechanism of this paper, as shown in Figure 2.

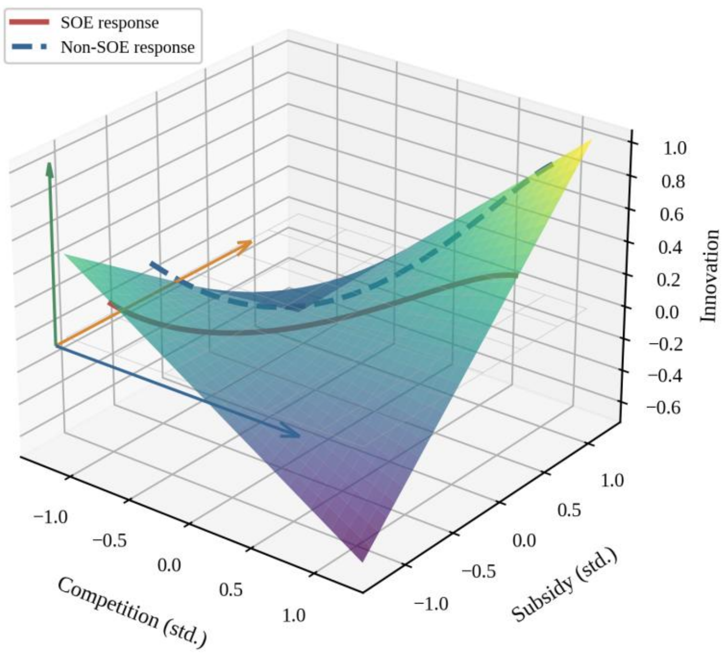

Figure 2: Three-dimensional Mechanism of Market Competition, Government Subsidies and Innovation Behavior of Resource-based Enterprises

In Figure 2, market competition, government subsidies and enterprise innovation input constitute a three-dimensional action space, and state-owned enterprises and non-state-owned enterprises correspond to different response trajectories. Competition pressure pushes enterprises to increase R&D input by compressing existing profits, strengthening cost constraints and increasing elimination risk; government subsidies change available resources of enterprises through capital buffer and policy signal; ownership structure determines the sensitivity of enterprises to competition and subsidies. This mechanism figure corresponds to the three empirical questions of this paper: whether competition promotes innovation, whether subsidies directly promote innovation, and whether subsidies change the marginal effect of competition on innovation.

2.3 Estimation Strategy, Figure-table Protocol and Robustness Arrangement

The estimation strategy adopts a stepwise expansion way. The first step only includes market competition and control variables, used to test the benchmark influence of competition pressure on enterprise innovation input; the second step adds government subsidies, observing whether the competition coefficient changes direction after the subsidy variable enters the model; the third step adds the interaction term of competition and subsidy, used to identify whether government subsidies strengthen or weaken the influence of competition pressure on R&D input. All regressions control industry effects and year effects. Because the sample is panel observations of the same enterprise in multiple years, the choice among pooled estimation, random effects and fixed effects is completed through the Hausman test, and the test results support fixed effect treatment. Estimation work is completed by using Stata 15.0.

Ownership heterogeneity is an important part of the identification design of this paper. Existing studies explain from the angles of government subsidies, financing constraints, innovation efficiency of state-owned shareholding and private sector managerial incentives that corporate innovation behavior in China will be significantly affected by ownership structure

[14-16]. State-owned resource-based enterprises often have more stable resource acquisition channels, local project undertaking capacity and credit relationships, and the constraining effect of market competition on their innovation budgets may be relatively weak; non-state-owned enterprises are more easily affected by the external environment in resource acquisition, financing cost and order stability, and competition pressure is more likely to be transformed into R&D input. Based on this difference, this paper divides the sample into state-owned enterprises and non-state-owned enterprises, and respectively reports the estimation results of market competition, government subsidies and interaction terms. Figure 3 presents the empirical protocol, as shown in Figure 3.

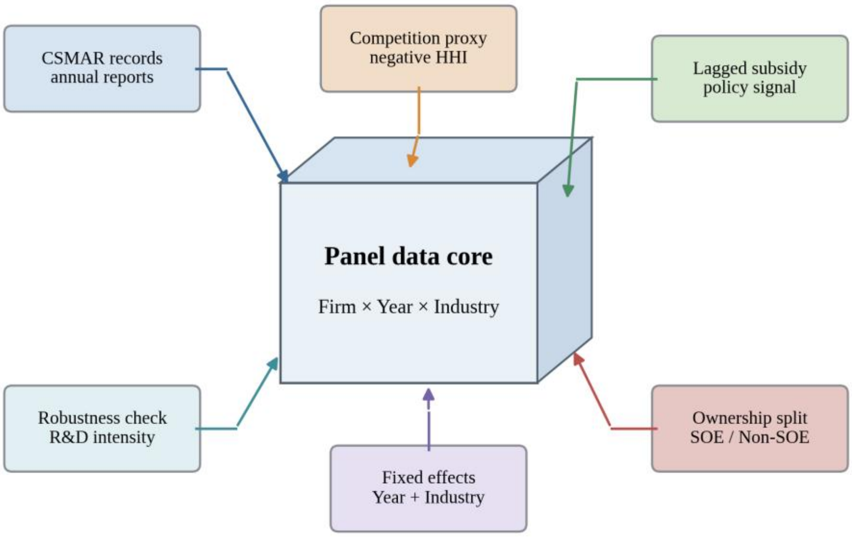

Figure 3: Empirical Identification Protocol and Variable Entry Path

In Figure 3, CSMAR records, market competition proxy variable, lagged subsidy, ownership grouping, fixed effects and robustness test are jointly connected to the panel data core, indicating that the estimation of this paper is not simply comparing means, but gradually identifying the effects of different variables on the same data base.

In estimation interpretation, this paper does not directly regard the insignificant result of government subsidies as policy ineffectiveness. The uses of subsidy projects of resource-based enterprises are relatively broad, including science and technology projects, and also including environmental governance, comprehensive resource utilization, safety production, employment stabilization and local industry support. If subsidies are used for non-R&D uses, their direct coefficient may be weak; but as long as subsidies can reduce the risk of enterprises adding R&D input in a competitive environment, they may still show policy function through the interaction term. Therefore, this paper discusses 'direct effect' and 'moderating effect' separately, avoiding mixing the two mechanisms into the same policy conclusion. Research on subsidy signals, green technology subsidies and carbon intensity governance also shows that subsidy effects need to be explained together with the institutional environment and competition environment where enterprises are located [12, 13].

3 Results and Discussion

3.1 Sample Structure, Variable Distribution and Ownership Difference

The results part first answers whether the sample has sufficient heterogeneity. If the differences of resource-based enterprises in R&D input, subsidy scale and competition intensity are small, even if subsequent regression obtains coefficients, it will lack economic explanation. Table 3 reports the descriptive statistics of the full sample, as shown in Table 3. In Table 3, the mean value of RD is 24.282, the standard deviation is 104.433, the minimum value is 0.011, and the maximum value is 1553.9, indicating that R&D input differences of resource-based enterprises are obvious. The mean value of Gov is 48.754, the standard deviation is 256.994, and the maximum value reaches 5004, showing stronger dispersion of the subsidy variable. The mean value of Comp is -0.071, the minimum value is -1, and the maximum value is -0.023, indicating that sample industries still have relatively high concentration, but the competition environments where different enterprises are located are not completely consistent.

Table 3: Descriptive Statistics of Core Variables in the Full Sample

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
RD	717	24.282	104.433	0.011	1553.9
Gov	717	48.754	256.994	0.007	5004
Comp	717	-0.071	0.078	-1	-0.023
Con	717	35.500	15.434	3.62	82.51
ROA	717	0.038	0.095	-2.071	0.333
Soe	717	0.432	0.496	0	1
Size	717	22.396	1.440	19.976	28.194
Lev	717	0.429	0.211	0.035	2.29
Age	717	17.414	4.980	5	40

To avoid too many numbers in the table weakening reading efficiency, this paper further draws the mean values, standard deviations and extreme value intervals in Table 3 into Figure 4.

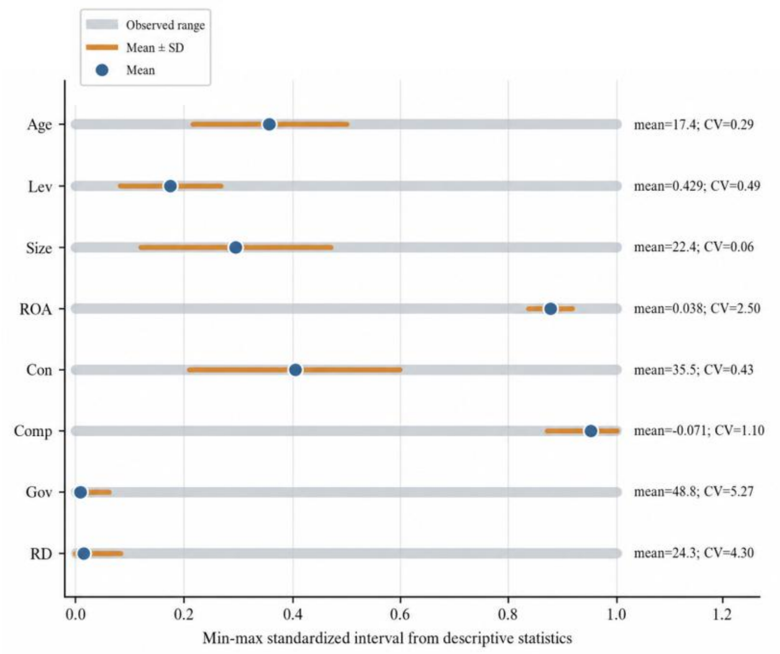

Figure 4: Distribution and Dispersion Degree of Core Variables in the Full Sample

In Figure 4, the coefficients of variation of RD and Gov are about 4.30 and 5.27 respectively, significantly higher than Size, Age, Lev and other control variables, indicating that innovation input and subsidy scale are the variables with the most explanatory tension in the sample. The mean value of Con is 35.5, showing that the control concentration of the largest shareholder is relatively high; the mean value of Lev is 0.429, indicating that most enterprises are still in a relatively conventional leverage interval. Figure 4 directly shows that subsequent models need to deal with the scale difference of innovation input, the high dispersion of subsidy variables and the characteristic of concentrated equity control of resource-based enterprises at the same time.

Ownership difference further amplifies the imbalance of variable distribution. Table 4 reports the descriptive statistics of state-owned enterprises and non-state-owned enterprises, as shown in Table 4. In Table 4, the mean RD of non-state-owned enterprises is 8.098, while that of state-owned enterprises is 54.516, and the latter is about 6.73 times the former; the mean Gov of non-state-owned enterprises is 11.993, while that of state-owned enterprises is 206.646, and the latter is about 17.23 times the former. This difference shows that state-owned resource-based enterprises have obvious resource advantages in R&D input and government subsidy scale. At the same time, the mean Comp of non-state-owned enterprises is -0.068, and that of state-owned enterprises is -0.091. Since the closer Comp is to zero, the stronger the competition is, this result indicates that non-state-owned resource-based enterprises face higher competition pressure.

Table 4: Descriptive Statistics of Core Variables by Ownership Groups

Variable	Non-SOE Mean	Non-SOE Standard Deviation	SOE Mean	SOE Standard Deviation
RD	8.098	11.425	54.516	191.343
Gov	11.993	24.860	206.646	2280.960
Comp	-0.068	0.076	-0.091	0.101
Con	32.886	14.548	41.471	16.007
ROA	0.058	0.053	0.025	0.107
Size	21.654	0.954	23.079	1.744
Lev	0.341	0.180	0.500	0.212
Age	15.277	5.724	17.388	5.692

Figure 5 transforms the ownership group differences into variable profiles.

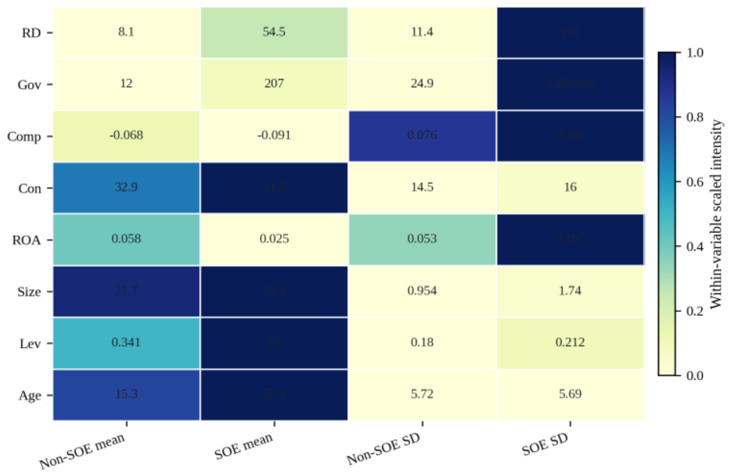

Figure 5: Variable Profiles of Resource-based Enterprises with Different Ownership

In Figure 5, the SOE group is higher than the non-SOE group in RD, Gov, Con, Size, Lev and Age, while the non-SOE group is higher in ROA and Comp. This structure shows that the sources of innovation incentives of the two types of enterprises are different. State-owned enterprises have higher subsidy scale and asset scale, but market competition pressure is weaker; non-state-owned enterprises are smaller in scale and receive fewer subsidies, but bear stronger competition and obtain a higher mean ROA. Therefore, directly explaining the subsidy effect in the full sample easily covers ownership differences, and grouped regression is necessary.

3.2 Benchmark Effect, Subsidy Function and Moderation Result

After confirming that the sample has obvious heterogeneity, this paper further examines the influence of market competition and government subsidies on innovation input. Table 5 reports the regression results of Model 1 to Model 3, as shown in Table 5. In Model 1, the full-sample Comp coefficient is 0.099 and significant at the 5% level, indicating that enhancement of market competition will push resource-based enterprises to increase R&D input. Grouped results show that the Comp coefficient of state-owned enterprises is 0.068 and not significant, while the Comp coefficient of non-state-owned enterprises is 0.067 and significant at the 1% level. This result supports that competition pressure has an innovation incentive effect, but the effect is mainly reflected in non-state-owned enterprises.

Table 5: Regression Results of Market Competition, Government Subsidies and Enterprise Innovation Input

Variable	M1 Full Sample	M1 SOE	M1 Non-SOE	M2 Full Sample	M2 SOE	M2 Non-SOE	M3 Full Sample	M3 SOE	M3 Non-SOE
Comp	0.099** (2.475)	0.068 (0.772)	0.067*** (3.382)	0.076 (1.488)	-0.036 (-0.345)	0.066*** (3.357)	0.106*** (2.809)	0.094 (1.113)	0.128*** (3.496)
Gov	-	-	-	-1.060 (-1.219)	-2.068*** (-4.326)	0.371 (0.890)	0.034 (0.134)	0.311 (1.560)	0.154 (0.380)
Comp×Gov	-	-	-	-	-	-	0.281 (1.049)	0.613*** (4.056)	1.195* (1.945)
Size	0.213*** (3.970)	0.196*** (8.070)	0.093*** (11.088)	0.258*** (6.036)	0.290*** (8.876)	0.088*** (9.691)	0.227*** (3.745)	0.193*** (6.970)	0.086*** (9.926)
Lev	-0.056 (-1.563)	-0.038* (-1.909)	-0.001 (-0.293)	-0.065* (-1.782)	-0.038* (-1.931)	-0.001 (-0.274)	-0.066* (-1.812)	-0.044** (-2.426)	-0.000 (-0.036)
ROA	-0.005 (-0.427)	-0.001 (-0.060)	0.021*** (3.138)	-0.004 (-0.310)	0.005 (0.604)	0.020*** (2.986)	-0.007 (-0.688)	-0.004 (-0.587)	0.019*** (2.907)
Con	0.016 (0.959)	-0.024 (-1.029)	0.001 (0.444)	0.021 (1.299)	-0.008 (-0.297)	0.002 (0.501)	0.021 (1.248)	-0.021 (-0.931)	0.003 (1.017)
Age	0.000 (0.009)	-0.002 (-0.106)	0.011*** (3.318)	-0.001 (-0.078)	-0.011 (-0.570)	0.010*** (2.881)	-0.001 (-0.159)	0.005 (0.326)	0.009*** (2.729)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	717	310	407	717	310	407	717	310	407
R^2	0.712	0.813	0.549	0.736	0.892	0.553	0.742	0.918	0.563
Adj. R^2	0.702	0.800	0.524	0.726	0.884	0.528	0.732	0.911	0.537

Note: t values are in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

After Model 2 adds government subsidies, the full-sample Gov coefficient is -1.060 but not significant, indicating that the average direct effect of government subsidies is not stable. The grouped results have more explanatory meaning: the Gov coefficient of state-owned enterprises is -2.068 and significant at the 1% level; the Gov coefficient of non-state-owned enterprises is 0.371 but not significant. This result is inconsistent with the simple judgment that 'subsidies necessarily promote innovation'. For state-owned resource-based enterprises, subsidies may more enter safety production, employment stabilization, environmental governance or existing project budgets, and may not be transformed into current R&D input; for non-state-owned enterprises, the subsidy direction is positive but significance is insufficient, indicating that obtaining subsidies alone does not necessarily change R&D budgets. Only when competition pressure exists at the same time, subsidies are more likely to be used by enterprises for innovation activities.

After Model 3 adds the interaction term of competition and subsidy, the results change obviously. The full-sample Comp coefficient increases to 0.106 and is significant at the 1% level; the Comp coefficient of non-state-owned enterprises increases to 0.128 and is significant at the 1% level; the Comp coefficient of state-owned enterprises is 0.094 but still not significant. In terms of interaction terms, the full-sample coefficient is 0.281 but not significant, the interaction term of state-owned enterprises is 0.613 and significant at the 1% level, and the interaction term of non-state-owned enterprises is 1.195 and significant at the 10% level. This result indicates that although government subsidies do not show stable direct effects, they can strengthen the effect of competition pressure on innovation input. The policy value of subsidies is not only reflected in giving enterprises 'more money', but more reflected in reducing the capital concerns and external uncertainty of enterprises when they add R&D input under a competition situation.

The results of control variables also provide auxiliary explanation. In Table 5, Size basically keeps positive significance in all models and grouped models, indicating that resource-based enterprises with larger asset scale are easier to form R&D input capacity. Lev is negative in some models, especially in SOE group Model 3, it is -0.044 and significant at the 5% level, showing that debt pressure may compress enterprise innovation budgets. ROA keeps positive significance in the non-SOE group, and the coefficient of Model 3 is 0.019 and significant at the 1% level, indicating that profitability is more important for R&D input of non-state-owned enterprises. Age is positive and significant in the non-SOE group, reflecting that the business accumulation of non-state-owned resource-based enterprises may improve their R&D organization capacity. The above control variables do not change the core conclusion, but help to explain that innovation input is affected by scale, financial pressure and profitability at the same time.

Figure 6 draws the three-dimensional response surface according to the core coefficients of Model 3, as shown in Figure 6.

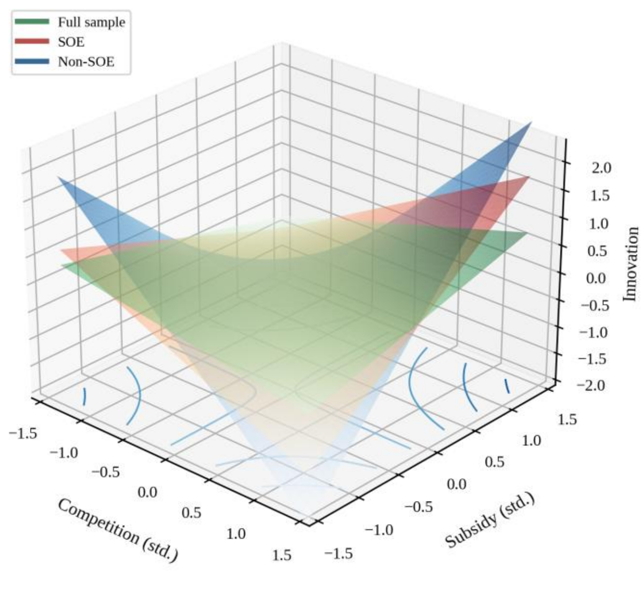

Figure 6: Three-dimensional Surface of Competition, Subsidy and Innovation Response

In Figure 6, the slope of the non-SOE surface is the largest, especially in the area where subsidy level and competition intensity increase at the same time, innovation response rises faster; the SOE surface is relatively gentle, but when subsidy and competition jointly strengthen, it still appears lifted; the full-sample surface is between the two. This figure transforms the interaction term in Table 5 into a spatial relationship, clearly showing that competition and subsidies do not affect innovation input in isolation. For non-state-owned enterprises, the stronger the competition pressure, the easier subsidies are transformed into R&D input; for state-owned enterprises, the innovation incentive of subsidies needs to appear together with external competition constraints.

Figure 7 further shows the coefficients and confidence intervals of Model 3, as shown in Figure 7.

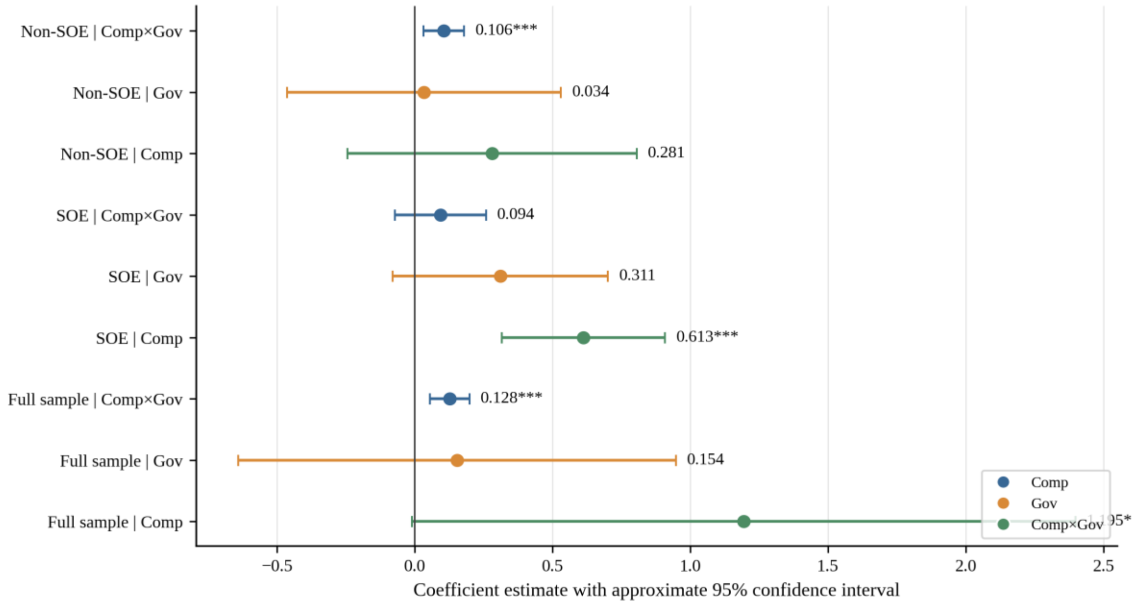

Figure 7: Core Coefficients and Confidence Intervals of Model 3

In Figure 7, the Comp coefficient of the non-SOE group is 0.128, and the confidence interval obviously tends to the positive direction; the Comp coefficient of the SOE group is 0.094, but the interval crosses around zero. Gov coefficients do not form stable positive evidence in the three groups, among which the SOE group is 0.311 but its significance is insufficient. The difference of interaction terms is the most prominent. The interaction term 0.613 of the SOE group has a relatively concentrated confidence interval, while the interaction term 1.195 of the non-SOE group has a wider interval, but the direction is still positive. This result indicates that ownership structure affects not only subsidy scale, but also the way subsidies and competition pressure jointly play a role.

3.3 Robustness, Explanation Boundary and Governance Meaning

Outside the main results, it is necessary to test whether the conclusions are affected by model setting and variable scale. The original manuscript adopts the robustness test of replacing the explained variable, replacing R&D expenditure with the ratio of R&D expenditure to operating revenue. This treatment can reduce the influence that large-scale enterprises naturally have higher R&D expenditure. The direction of the robustness test is consistent with the benchmark results, showing that the positive effect of market competition and the moderating effect of subsidies are not only caused by differences in enterprise scale. This treatment is consistent with the test logic in public R&D subsidy additionality, crowding-out effect and exploratory innovation research [17-21]. At the same time, this paper still keeps cautious interpretation of result boundaries: the existing sample only covers listed resource-based enterprises from 2014 to 2020, and cannot directly infer the behavior of unlisted enterprises, small mine enterprises and enterprises in the period of violent fluctuation of resource prices after the epidemic.

Figure 8 is used to explain how government subsidies change the marginal effect of competition, as shown in Figure 8.

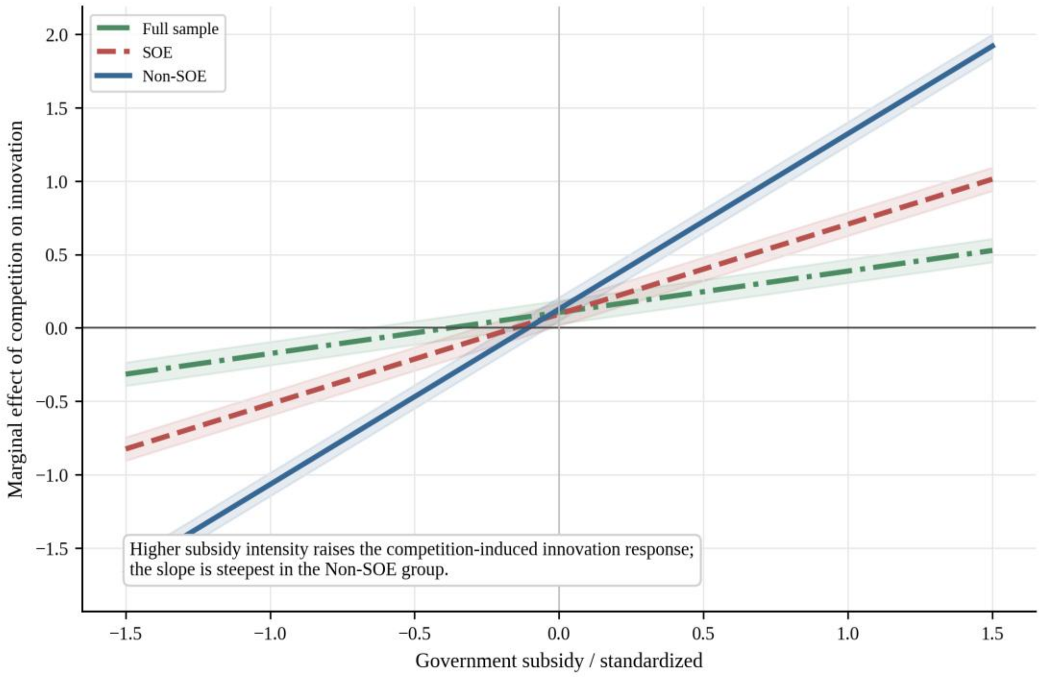

Figure 8: Change of Competition Marginal Effect under Government Subsidy Intensity

In Figure 8, the horizontal axis is the standardized subsidy intensity, and the vertical axis is the marginal influence of competition on innovation input. As subsidy intensity increases, the three curves all move upward, among which the non-SOE group has the highest slope, the SOE group is second, and the full sample is the lowest. This figure is consistent with the interaction term results in Table 5, indicating that the amplification effect of subsidies on competition incentives is stronger in non-state-owned enterprises. The reason is that financing constraints and project uncertainty of non-state-owned enterprises are higher, and after subsidies are in place, the cash flow pressure of R&D input can be reduced; although state-owned enterprises have larger subsidy scale, their budget arrangement and project objectives are more complicated, and subsidies may not immediately form additional R&D.

Figure 9 reports model fit and multicollinearity diagnosis, as shown in Figure 9.

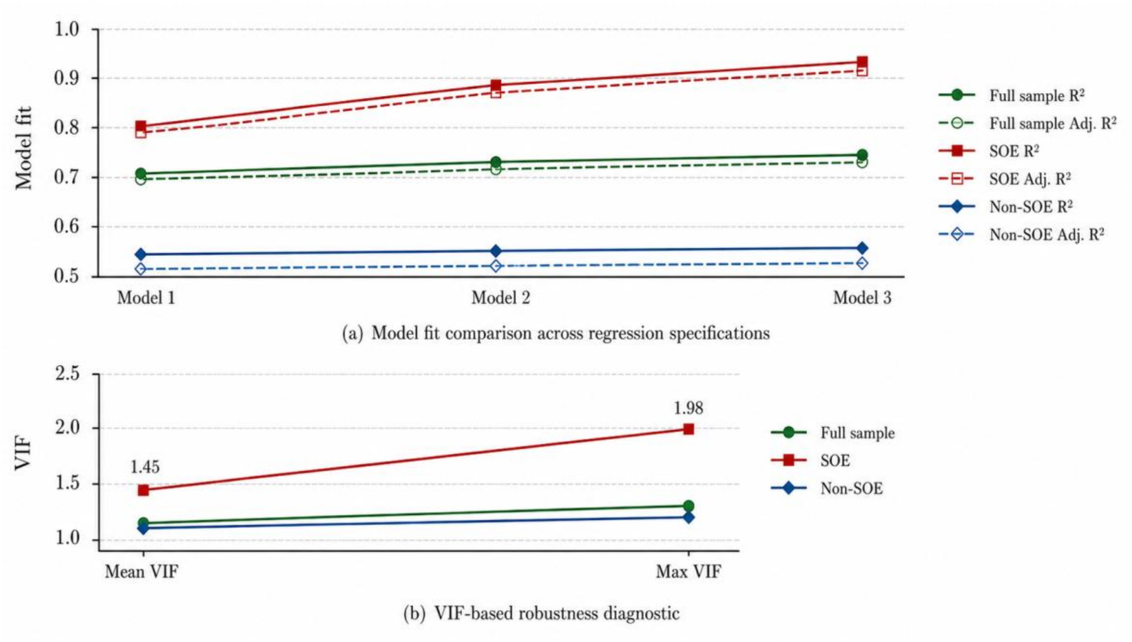

Figure 9: Model Fit and Multicollinearity Diagnosis

In Figure 9, the full-sample R2 increases from 0.712 in Model 1 to 0.742 in Model 3, and adjusted R2 increases from 0.702 to 0.732; SOE group R2 increases from 0.813 to 0.918, and adjusted R2 increases from 0.800 to 0.911; non-SOE group R2 increases from 0.549 to 0.563, and adjusted R2 increases from 0.524 to 0.537. Model explanatory power increases with the addition of variables, especially in the SOE group. The VIF mean value is 1.45, and the maximum value is 1.98, far lower than the commonly used warning line, indicating that multicollinearity among variables will not constitute the main problem. Model fit and VIF results jointly show that it is statistically acceptable for this paper to treat government subsidies as a moderating variable.

From the angle of hypothesis test, Hypothesis 1 is partially supported. Market competition is positive for innovation input in the full sample and is more stable in non-state-owned enterprises, but does not reach a significant level in state-owned enterprises. Hypothesis 2 is not sufficiently supported, because government subsidies do not form a stable positive effect in the full sample, and even show negative significance in state-owned enterprises. Hypothesis 3 obtains relatively strong support. The interaction terms are positive in both state-owned enterprises and non-state-owned enterprises, among which the coefficient of non-state-owned enterprises is higher. This combined result shows that the function of subsidy policy is closer to 'situation triggering', rather than simple 'capital increase'. Only when enterprises face relatively strong competition pressure, subsidies are more likely to become innovation input.

These results have relatively clear meanings for the governance of resource-based enterprises. Recent studies on tax incentives, ESG investment, fiscal subsidies and green innovation also suggest that policy tools are more likely to form effective innovation output only when they are matched with market environment and enterprise constraints [22-25]. First, improving the degree of market-oriented competition can push enterprises to include technological transformation and R&D input into competition strategy, but competition policy needs to consider the safety production and supply stability constraints of resource-based industries. Second, government subsidies should not be allocated only according to enterprise scale or project quantity. For state-owned enterprises, subsidies should strengthen R&D use constraints and performance tracking, avoiding funds being absorbed into routine operating expenditures; for non-state-owned enterprises, subsidies can be used more to relieve early-stage

R&D capital pressure and project test risk. Third, the management of resource-based enterprises should regard subsidies as innovation capital arrangements under competition pressure, and should not regard them as short-term profit adjustment tools. Only when subsidies, competition and R&D project budgets form a consistent direction, policy funds can be more effectively transformed into innovation behavior.

4 Conclusion

Based on data of resource-based listed enterprises in Shanghai and Shenzhen A-share markets from 2014 to 2020, this paper examines the relationship among market competition, government subsidies and enterprise innovation input, and explains the moderating role of subsidies under ownership structure differences. The study shows that the innovation behavior of resource-based enterprises is jointly affected by market pressure and policy resources, and examining only the average effect of subsidies easily underestimates their situational role.

(1) In sample organization, this paper identifies 717 firm-year observations according to 12 types of resource-related industries, and controls the industry differences and time shocks of resource-based enterprises through industry and year fixed effects. Descriptive results show that R&D input and government subsidies have significant differences in ownership groups, non-state-owned enterprises have stronger competition pressure, and state-owned enterprises have higher resource scale.

(2) At the result level, market competition has a positive effect on innovation input, and this effect is more stable in non-state-owned enterprises. The direct effect of government subsidies is not sufficient, but it can strengthen the incentive of competition on innovation input. Especially when competition pressure and subsidy intensity increase at the same time, the innovation response of non-state-owned enterprises is more obvious.

(3) This paper still has limitations. The sample is limited to listed resource-based enterprises, and the innovation variable mainly uses R&D expenditure for measurement, without distinguishing green patents, invention patents and the quality of process transformation. Future research can combine patent texts, subsidy use details and post-epidemic data to further identify the actual flow of subsidy funds and the quality of innovation output.

About the Author

Mengjun Yang was born in Chengdu, Sichuan Province, P. R. China, in 1995. She is a lecturer and Intermediate Economist at Chengdu College of Arts and Sciences. She received the bachelor's degree from Chengdu University of Technology, and her master's degree from Chengdu University of Technology. Her research interest includes business management.

Tao Zhong was born in Chengdu, Sichuan Province, P. R. China, in 1981. He is an associate professor at Chengdu College of Arts and Sciences. He received the bachelor's degree from Sichuan Normal University, and his master's degree from Sichuan Normal University. His research interest includes business management.

References

[1] Zhou, W., Song, Y., Xu, D., et al. (2025). Government subsidies and industrial chain resilience: Evidence from Chinese resource-based enterprises. Resources Policy, 102, 105525.

[2] Ai, M., Yu, Y., & Bu, Y. (2025). The impact of digital transformation of resource-based enterprises on green innovation: Mechanism analysis based on TOE framework. Innovation and Green Development, 4(4), 100262.

[3] Zhao, Q., Guo, M., Feng, F., et al. (2024). Path analysis of digital development on the green industrial transformation of Chinese resource-based enterprises. Resources Policy, 93, 105085.

[4] Sun, J., Xue, J., & Qiu, X. (2023). Has the sustainable energy transition in China's resource-based cities promoted green technology innovation in firms? Socio-Economic Planning Sciences, 87(PA), 101330.

[5] Aghion, P., Bloom, N., Blundell, R., et al. (2005). Competition and innovation: An inverted-U relationship. The Quarterly Journal of Economics, 120(2), 701-728.

[6] Symeonidis, G. (2019). Competition, innovation and the use of innovations. The Journal of Industrial Economics, 67(3-4), 565-592.

[7] Canare, T., & Francisco, J. P. (2021). Does competition enhance or hinder innovation? Evidence from Philippine small and medium-sized enterprises. Journal of Southeast Asian Economies, 38(1), 24-50.

[8] Wan, Q., Ye, J., Zheng, L., et al. (2023). The impact of government support and market competition on China's high-tech industry innovation efficiency as an emerging market. Technological Forecasting and Social Change, 192, 122585.

[9] Zhang, H., Zhang, X., Zhang, X., et al. (2024). Government subsidies, market competition and firms' technological innovation efficiency. International Review of Economics & Finance, 96, 103567.

[10] Shao, K. C., & Wang, X. (2023). Do government subsidies promote enterprise innovation? Evidence from Chinese listed companies. Journal of Innovation & Knowledge, 8(4), 100436.

[11] Ren, Y., Zhao, W., Zhang, L., et al. (2024). R&D subsidy and corporate innovation: An integrated view of resource allocation and resource utilisation. Industry and Innovation, 31(6), 727-752.

[12] Luo, L., & Wang, J. (2025). The signaling role of government subsidies: Ambiguity reduction and corporate innovation in China. Finance Research Letters, 85(PB), 107969.

[13] Lyu, H., Ma, C., & Arash, F. (2024). Government innovation subsidies, green technology innovation and carbon intensity of industrial firms. Journal of Environmental Management, 369, 122274.

[14] Chen, Q., Tang, S., & Xu, Y. (2022). Do government subsidies and financing constraints play a dominant role in the effect of state ownership on corporate innovation? Evidence from China. Managerial and Decision Economics, 43(8), 3698-3714.

[15] Cao, X., Cumming, D., & Zhou, S. (2020). State ownership and corporate innovative efficiency. Emerging Markets Review, 44, 100699.

[16] Lin, C., Lin, P., Song, F. M., et al. (2011). Managerial incentives, CEO characteristics and corporate innovation in China's private sector. Journal of Comparative Economics, 39(2), 176-190.

[17] Zuniga-Vicente, J. A., Alonso-Borrego, C., Forcadell, F. J., et al. (2014). Assessing the effect of public subsidies on firm R&D investment: A survey. Journal of Economic Surveys, 28(1), 36-67.

[18] Dimos, C., & Pugh, G. (2016). The effectiveness of R&D subsidies: A meta-regression analysis of the evaluation literature. Research Policy, 45(4), 797-815.

[19] Bronzini, R., & Piselli, P. (2016). The impact of R&D subsidies on firm innovation. Research Policy, 45(2), 442-457.

[20] Marino, M., Lhuillery, S., Parrotta, P., et al. (2016). Additionality or crowding-out? An overall evaluation of public R&D subsidy on private R&D expenditure. Research Policy, 45(9), 1715-1730.

[21] Gao, Y., Hu, Y., Liu, X., et al. (2021). Can public R&D subsidy facilitate firms' exploratory innovation? The heterogeneous effects between central and local subsidy programs. Research Policy, 50(4), 104221.

[22] Hu, S., Zhou, X., & Li, P. (2025). Tax incentives, market competition, and corporate innovation. Finance Research Letters, 77, 107067.

[23] Ji, H., Yu, Z., Tian, G., et al. (2025). Market competition, environmental, social and corporate governance investment, and enterprise green innovation performance. Finance Research Letters, 77, 107057.

[24] Zhao, L., Chong, K. M., Gooi, L.-M., et al. (2024). Research on the impact of government fiscal subsidies and tax incentive mechanism on the output of green patents in enterprises. Finance Research Letters, 61, 104997.

[25] Wang, Y., Akhtar, R., Mu, W., et al. (2025). Government subsidy and enterprise green innovation: Evidence from Chinese enterprises. Polish Journal of Environmental Studies, 34(5), 5319-5336.