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Research on the impact of tax incentives on enterprise innovation activities: Based on the life cycle of enterprises

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ABSTRACT
There is limited research exploring the relationship between tax incentives and enterprise innovation activities from a dynamic perspective. This article examines the impact of tax incentives on enterprise innovation activities using samples of A-share listed companies in the Shanghai and Shenzhen stock exchanges from 2014 to 2020. Multiple econometric models are constructed to empirically test the effect of tax incentives on enterprise innovation activities from the perspective of the enterprise lifecycle. The empirical results demonstrate that tax incentives have a positive effect on enterprise innovation, but this effect varies significantly with the stage of the enterprise's life cycle. The effect is only significant when the enterprise is in the mature stage. There is also a nonlinear relationship between tax incentives and enterprise innovation activities. When tax incentives exceed a certain threshold, the impact is significantly enhanced. This threshold effect varies significantly among enterprises with different ownership structures. Moreover, there exists a long-term stable interaction between enterprise innovation activities and tax incentives, and this interaction also varies significantly with the stage of enterprise's life cycle . This study provides important guidance for enhancing enterprise innovation activities and improving the top-level design of tax incentives.

KEYWORDS
Tax Incentives; Enterprise Innovation; Enterprise Life Cycle; Heterogeneity Effect; Interaction Mechanism.

1 Introduction and Literature Review

Innovation is the core driving force for the sustained development of a country and is crucial for shaping international competitiveness. Implementing a strategy of technological innovation is the effective way to overcome technological bottlenecks and promote high-quality economic development in China. As the main actors in the micro-market economy, enterprises need to enhance their autonomous innovation capabilities to push up transformating and upgrading the industrial structure[1]. In July 2020, General Secretary Xi Jinping pointed out at an entrepreneurs' symposium that innovation activities by entrepreneur is the key to driving enterprise innovation. Thus, engaging in innovation activities is crucial for enterprises to enhance competitiveness, to survive and achieve sustainable development.. However, innovation is a high-risk and high-investment activity with no short-term results. The long-term financing constraints faced by enterprises hinder innovation activities further and greatly reduce their enthusiasm. The government is motivated to intervene in and support enterprise innovation investment to achieve better resource distribution and promote technological innovation[2].

Taxation is a crucial tool for macroeconomic regulation and government intervention. On the one hand, through taxation, the government secures funds to provide basic public services. On the other hand, through tax incentives, various preferential tax treatments are given to taxpayers to lighten their tax burden, thereby subsidizing specific taxpayers and their activities, promoting and supporting economic development[3]. Specific preferential tax policies include tax exemptions, preferential tax rates, immediate tax refunds, deferred tax refunds, accelerated depreciation of fixed assets, and deductible expenses[4]. It not only requires their own efforts but also relies on policy support, to mproving enterprise innovation capabilities. Therefore, tax policy, as an important tool for

promoting economic development and stimulating market vitality, has become a hot topic in academic research regarding its impact on micro-enterprise innovation activities.For example, Hall & Van Reenen (2000) argue that tax incentives have a sustained stimulating effect on enterprises' autonomous innovation[5]. Tang et al. (2013) and Tang & Li (2020) found a positive correlation between tax incentives and enterprise innovation investment through their studies on listed companies on the Growth Enterprise Market[6-7]. Yuan & Jiang (2014), Wei & Xiao (2021)hold the same view[8-9]. Wang & Zhang (2015), using high-tech enterprises as samples, found that for every unit increase in the amount of tax incentives, the direct and indirect effects on internal R&D expenditure growth were 0.74 units and 0.32 units, respectively[10]. Feng & Li (2017) discovered that tax incentive policies significantly promote enterprises' patent inventions and the development of new products[11].

Some scholars have found from different perspectives that tax incentives can distort the distribution of innovation resources and be detrimental to enterprise innovation. For example, Mansfield (1986) found that some poorly designed incentive policies may lead to companies manipulating research and development costs rather than actually increasing investment, and the impact on innovation output is also minimal [12]; Lokshin et al. (2012) argue that tax incentives have limited incentives for enterprise R&D investment [13]; Li Weian et al. (2016) found that companies with political connections did not effectively invest tax incentives in innovation activities. The income tax incentives for high-tech enterprises have become a "tax shield" for these companies to avoid taxes to a large extent. Therefore, the effect of tax incentives on the innovation performance of high-tech enterprises is not significant; Wang Chunyuan and Ye Weiwei (2018) constructed a double difference model and found that a double tax incentive has a restraining effect on enterprise innovation [15]; Li Xiangju and Yang Huan (2019) found from the perspective of information asymmetry that the reverse incentive effect of tax incentives may lead to manipulating the true level of innovation investment [16].

Through literature review, it is found that existing research only stays at the static level in studying the impact of tax incentives on enterprise innovation activities, and it is hard to reach consensus on the relationship between tax incentives and enterprise innovation activities. It is well known that the life cycle is an important characteristic of companies. Anthony and Ramesh, (1992), Bens et al. (2002), DeAngelo et al. (2006) argue that the enterprise life cycle plays an important role in the company's investment, financing, distribution, and other behaviors[17-19]. Liang et al. also believe that there are significant differences in investment decisions, financing decisions, dividend decisions, strategic deployments, and asset pricing at different life cycle stages of the company, and companies in different life cycle stages have different levels of innovation intensity and innovation needs[20]. Therefore, from the perspective of the enterprise life cycle, dynamically studying the impact of tax incentives on enterprise innovation activities is of great practical significance. When companies are at different life cycle stages, their willingness or motivation for innovation is significantly different, which may affect the policy effectiveness of tax incentives.

Based on the above reasons, the possible marginal contributions of this paper are: (1) From the

perspective of the enterprise life cycle, this paper dynamically discusses the impact of tax incentives on enterprise innovation activities in different life cycle stages, enriching the relevant research perspectives. (2) While the government aims to stimulate enterprise innovation activities through tax incentives, the relationship between the two is not simply linear. This paper further explores the non-linear relationship between them by constructing threshold regression models, and discusses the heterogeneity of the impact of tax incentives on innovation in state-owned and non-state-owned enterprises, providing relevant theoretical explanations. (3) Tax incentives can influence enterprise innovation. If companies engage in innovation activities over the long term, will government policies be more favourable for them? This paper empirically tests the long-term stable interaction between enterprise innovation activities and tax incentives in different stages of enterprise life cycles, as well as their differences, by constructing panel vector autoregressive models.

2 Theoretical Analysis and Research Hypotheses

2.1 Tax Incentives and Enterprise Innovation

Knowledge products have certain non-competitiveness and non-exclusivity. The process of technological innovation by enterprises generates spillover effects, leading to a phenomenon of "market failure" where although R&D investment increases social marginal benefits, it cannot be fully converted into enterprise marginal benefits[22]. Therefore, management inevitably reduces the input of innovation factors such as human resources and material resources. Tax incentives, as common "ex-ante incentives" policy tools, can promote enterprises to engage in innovation activities. First, by adopting measures such as tax exemptions, preferential tax rates, tax refunds, accelerated depreciation, and tax offsets, the government allows a portion of the tax payable to be waived to taxpayers, helping to conserve internal cash flow and alleviate financial pressures on enterprises[23]. Endogenous growth theory suggests that technological innovation is the source of economic growth. When the government lowers its own R&D costs through tax incentives, enterprises are more willing to engage in activities such as technology and product development, thereby improving product quality and production efficiency and ensuring enterprises gain a larger market share. Second, tax incentives help enterprises obtain more investment and financing opportunities, assisting them in accessing more credit resources. When an enterprise receives more tax incentives, it indicates better prospects for its development, sending positive signals to the market and attracting external investors' attention. Fu. (2014) found that tax incentives stimulate enterprise investment[24], conenterpriseing this point. Therefore, tax incentives can mitigate information asymmetry between internal and external stakeholders, enhance external investors' and creditors' support for enterprise R&D activities, enabling enterprises to have sufficient funds and strong willingness to engage in R&D innovation activities, thus increasing R&D investment[25]. Third, tax incentives can to some extent compensate for potential losses incurred by R&D innovation activities, increasing the level of risk-taking[26]. Innovation activities are characterized by high risk and uncertainty. Enterprises engaging in innovation activities face the burden of potential failure, but tax incentives reduce this burden, thereby stimulating management to engage in innovation activities.

Tax incentives, like government subsidies, can also lead to moral hazard. Excessive tax incentives may lead to managerial rent-seeking behavior. When managers obtain higher tax incentives through rent-seeking activities, they may perceive this as profits earned by the enterprise, which may weaken the incentive for technological innovation. Based on the above analysis, the following hypotheses are proposed:

H1: Tax incentives can stimulate enterprise innovation activities to a certain extent.

H2: There is a certain non-linear relationship between tax incentives and enterprise innovation activities.

2.2 The regulatory role of enterprise life cycle

Enterprise life cycle refers to the cyclic characteristics of repeated stages in sequence, and is a reference model for analyzing the dynamic development process of an enterprise over a period of time [27]. The common ways of dividing the enterprise cycle are start-up, growth, maturity and decline [20,28-29]. Adizes (1988) pointed out that enterprises are significantly different in scale, profitability, growth, investment and financing strategies, R&D and innovation intention, etc. at different development stages [30], and R&D investment has diverse influences on the improvement of enterprises' comprehensive capabilities at different growth stages [31]. Considering that the sample of the text research is listed enterprises, which have basically passed the initial stage, only the differences of tax incentives on enterprise innovation activities in the growth, maturity and decline stages are considered.

Enterprises in the growth stage have the following characteristics: First, they face greater financing constraints. When the enterprise is in the growth stage, its own funds can not meet the production of the enterprise, the enterprise must borrow funds from the outside, the enterprise may need to find additional capital to invest in new equipment, technology, personnel and other aspects. De Ang e lo (2007) also points out that the capital investment used by enterprises in the growth stage is more from external financing [33]. The resulting increase in external financing needs has invisibly increased financial risks [34]. Second, it faces greater survival risks. When enterprises are in the growth stage, their risk bearing capacity is low [35] and their operating risk is high. External investors rarely choose to invest in enterprises in the growth stage, which increases the financing difficulty of enterprises in this stage [28]. Although the government can reduce some financing constraints through tax incentives, enterprise management also tends to adopt a conservative attitude and invest funds in businesses with predictable returns due to risk, thus reducing investment in innovation.

Enterprises in the mature stage have the following characteristics: First, all aspects are relatively stable. When an enterprise enters the mature stage, its product production and market demand reach a relatively steady state, its own market share and sales are also stable, its free cash flow and retained earnings are relatively abundant [12], internal funds can meet its activity needs, external financing is greatly reduced, and financial risks are also reduced [36]. Second, there are sufficient factors for innovation. At this time, the organizational structure of the enterprise has been quite complete, with relatively rich human, material and financial resources [27], and the company often has a clear development strategy and future planning [37]. Enterprises are more willing to develop new products and research new technologies to further capture market share and make themselves more durable competitiveness in the market. In the mature stage, enterprises themselves have stronger innovation willingness, and under the incentive of preferential tax policies, they will further enhance innovation activities.

Enterprises in recession have the following characteristics: First, they face higher risks. When an enterprise is in a period of recession, its market share and market share will decrease, and the emergence of a large number of new products will lead to the impairment of its products. As a result, the capital turnover of the enterprise will be hindered due to the sales obstruction, the threat of alternative products, the overstocking of inventory, and the decline of gross profit margin, etc., the sales income and free cash flow will be greatly reduced, and even the loss will occur [38]. In addition, during the recession, the external reputation of enterprises will be greatly reduced,

creditors will be over-supervised, the possibility of bankruptcy will increase, and the financial risk of enterprises will be greatly increased [39]. Second, the enterprise management is not willing to innovate. On the one hand, poor management affects the realization of the compensation incentive of the management, and suffers from the pressure of the shareholders and the board of directors and occupational safety threats; On the other hand, failure to achieve performance expectations is concerned by analysts and the media, which affects the trust of investors and creditors in the company and management, reduces their financial support for the company, and affects the availability of financing [40]. In the recession period, the technological innovation ability of enterprises decreases, and the future development is full of high uncertainty. In addition, the management is in a situation of "self-insurance". In the case of tax incentives, although there is a better business plan, it is difficult to implement, and innovation activities are in a state of risk aversion.

H3: The impact of tax incentives on enterprise innovation will vary due to the different life cycle of enterprises, that is, the life cycle of enterprises will regulate the innovation impact of tax incentives.

H3a: When enterprises are in the mature stage, tax incentives have a strong incentive effect on enterprise innovation.

H3b: When enterprises are in the growth stage and recession stage, tax incentives have no significant incentive effect on enterprise innovation.

3 Research design

3.1 Data selection and data sources

This paper selects A-share listed enterprises in Shanghai and Shenzhen from 2014 to 2020 as research samples. In order to ensure the reliability of the data, this paper excluded ST, *ST, financial, listed enterprises with serious missing data and R&D investment of 0, and finally got 1003 sample enterprises. Enterprise innovation input comes from WIND database, and the remaining financial data comes from Guotai 'an CSMAR database. Of the 1,003 companies, 436 are state-owned and 567 are non-state-owned.

3.2 Variable design

3.2.1 Explained variables

Enterprise Innovation（Innovation）. Some scholars use patent number to measure enterprise innovation. X.H.Qian et al. believe that the use of patent number to measure the innovation level of enterprises has certain drawbacks [41]. For example, some enterprises are reluctant to apply for patents for innovation output due to their own development strategies and other reasons, which may lead to underestimating the innovation level of such enterprises. Research and development costs directly reflect the enterprise's innovation willingness and innovation effort, which can be a better enterprise innovation activities. Referring to the existing literature, this paper uses innovation input to measure the innovation level of enterprises [42]. In order to avoid the problem of heteroscedasticity caused by a large numerical gap, the natural logarithm is applied to the innovation input of enterprises.

3.2.2 Explanatory variables

tax benefits (tax). Enterprise value-added tax, turnover tax, income tax and other taxes reflect the

tax burden of enterprises. If the tax is too large, it is not conducive to enterprises to carry out innovation activities and reduce the enthusiasm of enterprises to innovate. Therefore, it is necessary to give play to the auxiliary role of the "visible hand" of the government and adopt certain preferential tax policies for enterprises. Based on the practice of Tang Hongxiang and Li Yinchang, this paper adopts the following methods to calculate the enterprise tax incentives[7].

3.2.3 Core grouping variables

Enterprise life cycle（cycle）. The life cycle of an enterprise is measured based on the scores of four variables: sales revenue growth rate, retention rate of return, capital expenditure rate and company age. This method is the most common way to divide the life cycle of an enterprise in academic circles. When the enterprise is in the growth stage, the value is 1, when the enterprise is in the maturity stage, the value is 2, and when the enterprise is in the decline stage, the value is 3.

3.2.4 Control variables

In order to ensure the scientific results of the research, the following variables are also controlled in this paper: (TobinQ), enterprise Size, asset-liability ratio (Lev), net profit rate on total assets (ROA), return on equity (ROE), and the shareholding ratio of the largest shareholder (Top1), as shown in Table 1.

Table 1 Variable definitions

Variable type	Variable name	Symbolic representation	Calculation formula
Dependent variable	Enterprise Innovation	Innovation	The natural logarithm of innovation input
Independent variable	Tax Benefits	tax	Basic VAT rate and turnover tax rate
Core grouping variable	Enterprise life cycle	cycle	Composite scoring
Control variable	Tobin Q	Tobin Q	(Market value of tradable shares + number of non-tradable shares * Net assets per share + book value of liabilities)/Total assets
	Enterprise scale	Size	The natural log of total assets
	Asset-liability ratio	Lev	Total liabilities/Total assets
	Net profit rate on total assets	ROA	Net profit/Total assets
	Return on equity	ROE	Net profit/shareholders' equity
	The proportion of the largest shareholder	Top1	Number of shares held by the largest shareholder/Total number of shares

3.3 Model construction

In order to explore the impact of tax incentives on enterprise innovation activities, this paper constructs the following econometric model:

$$Innovation_{it} = \beta_0 + \beta_1 tax_{it} + \beta_2 controls + \varepsilon_{it} \#(1)$$

In order to explore the moderating effect of enterprise life cycle on the impact of tax incentives

and enterprise innovation activities, the following econometric model is constructed:

$$Innovation_{it} = \beta_0 + \beta_1 tax_{it} + \beta_2 tax_{it} * cycle_{it} + \beta_3 cycle_{it} + \beta_4 controls + \varepsilon_{it} \#(2)$$

The i represents different listed enterprises, the t represents different years, tax_{it} represents the tax incentives of the i th enterprise in the t year, $Innovation_{it}$ represents the innovation input of the i th enterprise in the t year, and controls represents a series of control variables, which are random disturbance terms.

In order to study the nonlinear relationship between tax incentives and enterprise innovation activities, this paper adopts the panel threshold model proposed by Hansen (1999) :

$$Innovation_{it} = \alpha_0 + \alpha_1 * x_{it} * I(q_{it} \le \gamma) + \alpha_2 * x_{it} I(q_{it} > \gamma) + \varepsilon_{it} \#(3)$$

The $q_{it}$is the threshold variable, which can be a part of the explanatory variable x_{it} and γ is the threshold value to be estimated. The I(.) is an indicator function. 3.3.4. In order to explore the interaction mechanism of enterprise innovation activities on tax incentives, the following panel vector autoregression (PVAR) model is constructed:

$$Y_{it} = \sum_{l=1}^{p} \Phi_{i1}(l) Y_{1,t-l} + \ldots + \sum_{l=1}^{p} \Phi_{iN}(l) Y_{N,t-l} + \sum_{l=0}^{p} \Psi_{i1}(l) X_{1,t-l} + \ldots$$

$$+ \sum_{l=0}^{p} \Psi_{iN}(l) X_{1,t-l} + Y_i + \mu_{ti} \#(4)$$

The X_{ti} representing M*1 strict exogenous variables of individual i in period t, the Y_i representing G unobserved individual fixed effects of individual i, $\Phi_{ij}(l)$and $\psi_{ij}(l)$are respectively the vectors after period l $Y_{j,t-l}$and $X_{1,t-l}$ the short-term influence coefficients on the vectors.

3.4 Descriptive statistical collinearity diagnosis

3.4.1 Descriptive statistics

Table 2 shows the descriptive statistics of the main variables. The average value of enterprise innovation input is 17.847, and the minimum value and maximum value are 7.601 and 22.863 respectively, indicating that there are great differences in innovation activities carried out by enterprises. The average value of tax incentives is 0.076, and the maximum value is quite different, indicating that the government gives different tax incentives to different enterprises. Differentiated innovation inputs and tax incentives lay a good foundation for the following analysis in this paper.

Table 2 Descriptive statistics of main variables

Variable	Obs	Mean	Std.dev.	Min	Max
Innovation	5,595	17.847	1.481	7.601	22.863
tax	5,595	0.076	0.032	-0.027	0.160
TobinQ	5,595	2.911	4.249	0.000	76.820
Size	5,595	22.588	1.735	18.611	28.257
Lev	5,595	0.536	0.247	0.038	1.650
ROA	5,595	0.014	0.120	-0.762	0.464
ROE	5,595	0.048	0.308	-2.685	0.872
Top1	5,595	0.308	0.128	0.091	0.771

3.4.2 Collinearity diagnosis

Table 3 shows the collinearity diagnosis results of the main variables. The variance inflation factor (VIF) of the main variables are all less than the threshold value of 10, indicating that there is no multicollinearity problem between the variables in this paper, which provides a good guarantee for the reliability of the empirical results.

Table 3 collinear diagnosis

Variable	VIF	1/VIF
ROA	1.85	0.540
Lev	1.66	0.601
Size	1.57	0.639
TobinQ	1.43	0.698
ROE	1.3	0.769
Top1	1.13	0.885
tax	1.08	0.925

4 Empirical results and analysis

4.1 Analysis of benchmark results

This paper uses STATA17.0 statistical software analysis tool and equation (1) to carry out regression. In order to ensure the robustness of the results, a panel random effect model and a panel fixed effect model are constructed. Table 4 shows the results of baseline regression. In the random effects model, the coefficient of enterprise tax incentives is 2.883, which is significant at the 5% significance level; in the fixed effects model, the coefficient of enterprise tax incentives is 13.21, which is significant at the 1% level. In conclusion, no matter the random effect model or the fixed effect model, tax incentives have a significant positive correlation with enterprise innovation activities, H1 is established.

Table 4 Baseline regression results

Variable	Innovation(随机)	Innovation(固定)
tax	2.883**	13.21***
	(2.25)	(4.97)
TobinQ	-0.0143***	-0.0138***
	(-4.44)	(-4.22)
Size	0.135***	0.162***
	(11.08)	(12.52)
Lev	-0.770***	-0.859***
	(-10.34)	(-11.13)
ROA	-0.932***	-1.097***
	(-7.34)	(-8.44)
ROE	-0.00627	0.00262
	(-0.19)	(0.08)
Top1	-0.212*	-0.217*
	(-1.86)	(-1.85)
_cons	14.93***	13.77***
	(52.03)	(40.49)
N	5595	5595
R^2	0.075	0.0781

*p<0.1, **p<0.05, ***p<0.01, the t value in parentheses, the same below.

4.2 The adjustment effect of enterprise life cycle

Equation (2) is used to test the moderating effect of enterprise life cycle on the impact of tax incentives and enterprise innovation activities (Table 5). In the random effects model, the interaction term between tax incentives and enterprise life cycle is significantly negative, indicating that there are significant differences in the impact of tax incentives on enterprise innovation in

different enterprise life cycles. In the fixed effects model, the interaction term between tax incentives and enterprise life cycle is also significantly negative.

To sum up, enterprise life cycle can affect the effect of tax incentives on enterprise innovation activities, and H3 is established.

Table 5 Regulatory effects of enterprise life cycle

Variable	Innovation(Random)	Innovation(Fixed)
tax	3.372***	13.28***
	(2.59)	(5.00)
tax*cycle	-0.392**	-0.398**
	(-2.13)	(-2.15)
cycle	-0.0101	-0.00497
	(-0.50)	(-0.25)
TobinQ	-0.0147***	-0.0142***
	(-4.56)	(-4.32)
Size	0.139***	0.166***
	(11.33)	(12.79)
Lev	-0.775***	-0.866***
	(-10.42)	(-11.22)
ROA	-0.952***	-1.121***
	(-7.50)	(-8.61)
ROE	-0.00539	0.00362
	(-0.16)	(0.11)
Top1	-0.216*	-0.222*
	(-1.89)	(-1.89)
_cons	14.91***	13.75***
	(51.24)	(40.12)
N	5595	5595
R^2	0.0772	0.082

Table 6 shows the regression results of tax incentives and enterprise innovation in different life cycles. When the enterprise is in the growth stage, the coefficient of tax incentives is positive, but does not pass the minimum significance level test (10%); when the enterprise is in the maturity stage, the coefficient of tax incentives is significantly positive at the level of 1%; when the enterprise is in the recession stage, the coefficient of tax incentives is negative, and still does not pass the minimum significance level test (10%).

To sum up, the positive effect of tax incentives on enterprise innovation activities is significant only when enterprises are in the mature stage. Enterprises in the mature stage will use the funds provided by tax incentives to increase their investment in research and development, and H3a and H3b are established. In this regard, according to the enterprise life cycle theory, when an enterprise is in the growth stage, its organizational structure becomes more complex, and it still faces many external threats and unstable factors. If an enterprise wants to carry out innovation activities, it needs a leader who can overcome all opinions and make quick decisions [43].

However, in this state, managers should consider their own interests. They are not willing to try innovative activities that may face failure. Therefore, tax incentives for enterprises in the growth stage have relatively limited incentives for enterprises to carry out innovative activities. When the enterprise from the mature period to the decline period, due to the shortage of internal resources, although managers have the intention to win the market share through technological innovation, the role of managers is greatly restricted, that is, "make bricks without straw".

Table 6 Effects of tax incentives in different enterprise life cycles

Variable	Innovation(growth stage)	Innovation(mature stage)	Innovation(recession period)
tax	2.445	51.26***	2.248
	(1.33)	(4.18)	(1.49)
Tobin Q	-0.0111	-0.0152*	-0.0159***
	(-1.35)	(-1.80)	(-3.99)
Size	0.121***	0.123***	0.0849***
	(4.34)	(4.05)	(5.36)
Lev	-0.958***	-0.345*	-0.598***
	(-5.27)	(-1.84)	(-6.22)
ROA	-1.126***	-0.195	-0.738***
	(-3.63)	(-0.61)	(-4.33)
ROE	0.0436	-0.0201	-0.000797
	(0.58)	(-0.27)	(-0.02)
Top1	-0.0126	0.0132	-0.360**
	(-0.05)	(0.05)	(-2.35)
_cons	15.51***	11.41***	16.03***
	(24.45)	(10.32)	(43.88)
N	1235	1757	2603
R^2	0.1193	0.0549	0.0708

4.3 Robustness analysis

In order to ensure the reliability and scientificity of the benchmark regression results, the following robustness tests are carried out in this paper. First, the endogenous problem will affect the reliability of the empirical results. Considering that the explanatory variables are delayed by one stage, if the results are consistent with the baseline regression, it indicates that the above results are robust. Second, missing variables will also affect the reliability of empirical results, and control variables will be added to mitigate the impact of missing variables.

4.3.1 Robustness analysis considering endogeneity

Table 7 shows the empirical results of delaying tax incentives for one period. In the random effects model, the coefficient of tax incentives lagging one period is 2.251, which is significant at the 10% level; in the fixed effects model, the coefficient of tax incentives lagging one period is 8.993, which is significant at the 1% level. The above results show that the results of baseline regression are robust.

4.3.2 Consider adding robustness tests for control variables

Table 8 shows the regression results with added control variables. The number of directors and Dual will affect the innovation activities of enterprises, so the increased two variables re-examine the effect of tax incentives on the innovation activities of enterprises. Among them, the number of directors (Board) is calculated by taking the natural logarithm of the number of directors; Dual: When the chairman and general manager are the same, the value is 1, and when they are not, the value is 0.

In the random effects model, the coefficient of tax incentives is 2.590, which is significant at the 5% level, and in the fixed effects model, the coefficient of tax incentives is 13.21, which is significant at the 1% level. The above results show that the results of baseline regression are robust.

Table 7 Robustness test with one-phase lag

Variable	Innovation(Random)	Innovation(Fixed)
L.tax	2.251*	8.993***
	(1.76)	(3.74)
TobinQ	-0.0244***	-0.0239***
	(-7.54)	(-7.25)
Size	0.0741***	0.0970***
	(5.32)	(6.45)
Lev	-0.375***	-0.436***
	(-4.96)	(-5.56)
ROA	-0.636***	-0.719***
	(-4.58)	(-5.10)
ROE	-0.00138	-0.000263
	(-0.04)	(-0.01)
Top1	0.0372	-0.0324
	(0.31)	(-0.26)
_cons	16.26***	15.42***
	(50.72)	(41.64)
N	4538	4538
R^2	0.0582	0.0605

Table 8 Robustness test results of added variables

Variable	Innovation(Random)	Innovation(Fixed)
tax	2.590**	13.21***
	(2.03)	(4.98)
TobinQ	-0.0132***	-0.0121***
	(-4.02)	(-3.63)
Size	0.141***	0.170***
	(11.28)	(12.85)
Lev	-0.791***	-0.893***
	(-10.37)	(-11.29)
ROA	-0.925***	-1.105***
	(-7.21)	(-8.41)
ROE	-0.0128	-0.00407
	(-0.38)	(-0.12)
Top1	-0.297**	-0.315***
	(-2.54)	(-2.62)
Board	-0.171***	-0.186***
	(-3.01)	(-3.21)
Dual	-0.0676**	-0.0889***
	(-2.40)	(-3.11)
_cons	15.25***	14.04***
	(47.02)	(38.08)
N	5595	5595
R^2	0.0795	0.0828

5 Further research

5.1 Regression analysis of the threshold of tax incentives for innovative activities

Before the parameter estimation of threshold regression, the significance test of threshold effect

and the authenticity test of threshold estimate are needed. The following results were obtained after 1000 times of bootstrap method.

First, whether the threshold effect is significant is tested. Table 9 shows the test results of threshold effect. The significance level of the single threshold effect passed the 1% significance test, while the double threshold effect did not pass the significance test. Therefore, tax incentives have a significant single threshold effect on enterprise innovation, and there is no double threshold effect.

Table 9 Threshold effect test (overall)

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Single	902.9357	0.2232	240.53	0	84.9099	99.4998	116.9189
Double	902.3476	0.223	2.64	0.567	8.9394	11.4656	19.1847

Then, the validity of the threshold value is tested. The maximum likelihood estimator was used to test the threshold value by Hansen, and the threshold value was 0.06. In order to directly reflect the results of threshold values, this paper draws a maximum likelihood graph (LR) curve. It can be seen from the LR curve that the lowest point of the given curve is 0.06, indicating that the threshold value is true and effective.

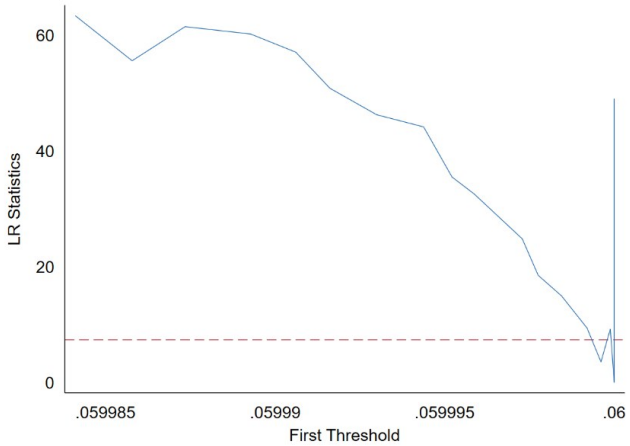


Figure 1 LR curve of threshold value

Threshold regression results. Table 10 shows the threshold regression results with tax preference as the threshold variable. When tax incentives do not cross the threshold value, the impact of tax incentives on enterprise innovation is 4.724, and it is significant at the level of 10%. When the threshold is crossed, this positive effect is significantly enhanced.

Table 10 Threshold regression results (overall)

Independent variable	**Threshold variable**	**coefficient**	**Standard error**	**T-value**	**p-value**
tax	tax≤0.06	4.724	2.716	1.74	0.082
	tax>0.6	5.988	2.704	2.21	0.027
	Control variable		Controls		
	R^2		0.1712		

5.2 Threshold regression analysis based on different equity properties

Preferential tax policy is a supportive policy of the government for enterprises. The impact of such policy will inevitably vary with the different ownership of enterprises, and the impact of

preferential tax policy on state-owned enterprises and non-state-owned enterprises is too different. Based on this, this part of the paper examines the effect of tax incentives on enterprise innovation activities under the background of different equity properties. Table 11 shows the threshold effect test results of different equity properties. Considering that the enterprise life cycle will affect the effect of tax incentives, the enterprise life cycle is included in the control variable in this part. As can be seen from the following table, the single threshold values of state-owned enterprises and non-state-owned enterprises pass the significance level of 10% and 1% respectively, and the double threshold values are significant at the significance level of 10%, both of which fail the three-threshold significance test. The above results show that tax incentives have a double threshold effect on both state-owned enterprises and non-state-owned enterprises.

Table 11 Threshold effect test (heterogeneity)

argument	State-owned enterprise		Non-state-owned enterprise	
Threshold	MSE	Prob	MSE	Prob
Single	0.1516	0.066	0.186	0.000
Double	0.1492	0.072	0.1847	0.097
Triple	0.1471	0.229	0.1845	0.913

The LR curve is drawn to reflect the result of the threshold value. As can be seen from FIG. 2 and FIG. 3, the lowest point of the single-threshold LR curve for state-owned enterprises is 0.06, and the lowest point of the dual-threshold LR curve is 0.0898, that is, the two values divide the tax incentives into three ranges, namely [tax0.06], [0.06<tax0.0898] and [tax>0.0898]. As can be seen from Figure 3 and Figure 4, the lowest point of LR for non-state-owned enterprises is 0.0599 for single threshold, and 0.06 for double threshold LR curve. Similarly, the two values of tax preference utilization are divided into three ranges, namely [tax0.0599], [0.0599<tax0.06] and [tax>0.06].

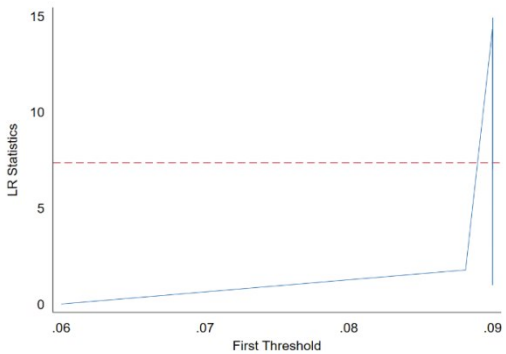


Figure 2 Single threshold value of state-owned enterprises

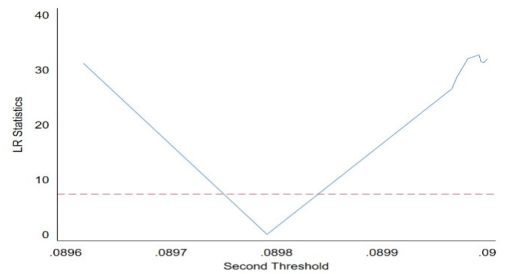


Figure 3 Double threshold value of state-owned enterprises

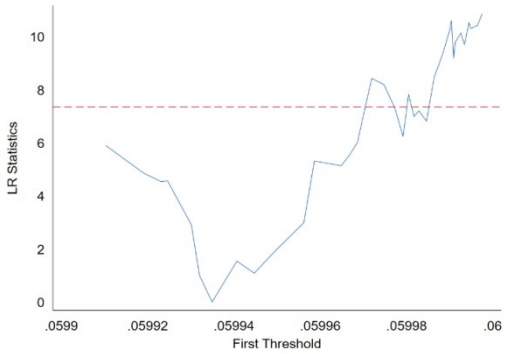


Figure 4 Single threshold value of non-state-owned enterprises

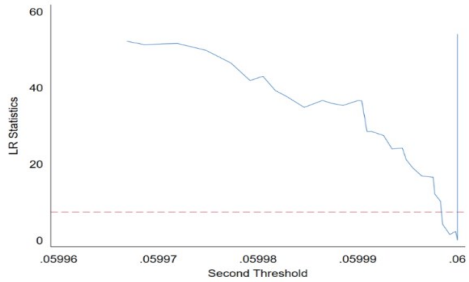


Figure 5 Double threshold value of non-state-owned enterprises

Table 12 shows the threshold regression results of firm nature heterogeneity. In state-owned enterprises, when tax incentives do not cross the single threshold, tax incentives can not promote enterprises to increase innovation activities; When the tax incentive is between the single threshold and the double threshold, the tax incentive significantly increases the enterprise innovation activities. When tax incentives cross the double threshold value, the promotion effect of tax incentives on enterprise innovation activities decreases significantly. In non-state-owned enterprises, when tax incentives do not cross the single threshold, tax incentives have a positive impact on enterprise innovation; When the tax incentive is between the single threshold and then the double threshold, the tax incentive has a positive impact on enterprise innovation, and this effect is significantly enhanced. When tax incentives cross the double threshold, the positive effect is further enhanced. To sum up, there is a nonlinear relationship between tax incentives and enterprise innovation activities. Although tax preference has double threshold effect in both state-owned enterprises and non-state-owned enterprises, its internal mechanism is different. The possible reason is that, compared with state-owned enterprises, non-state-owned enterprises pay more attention to the government's tax incentives for their own enterprises, which greatly mobilizes entrepreneurs' enthusiasm for innovation and helps to give play to entrepreneurship [1].And with the continuous enhancement of tax incentives, entrepreneurs are more active in innovation; On the contrary, in state-owned enterprises, excessive tax incentives may trigger rent-seeking behavior at the top, resulting in enterprises not actually implementing tax incentives, thus making innovation

1 Entrepreneurship provides the necessary conditions and motivation for innovation]. It encourages individuals or organizations to actively pursue new opportunities, take action, and face uncertainties and risks in the innovation process. Entrepreneurship therefore plays an important role in driving innovation and promoting economic development.

behavior exist on the surface.

Table 12 Threshold regression results (heterogeneity)

Independent variable	State-owned enterprise			Non-state-owned enterprise		
	Threshold variable	Coefficient	P	Threshold variable	Coefficient	P
tax	tax≤0.06	-43.043	0.811	tax≤0.0599	8.831	0.017
			-0.240			2.390
	0.06<tax≤0.0898	1529.167	0.000	0.0599<tax≤0.06	11.807	0.001
			3.770			3.190
	tax>0.0898	1497.956	0.000	tax>0.06	17.283	0.000
			3.730			4.760
	Sum of control Variables cycle			Controls		
	R^2	0.1495		0.2664		

Entrepreneurship provides the necessary conditions and motivation for innovation. It encourages individuals or organizations to actively pursue new opportunities, take action, and face uncertainties and risks in the innovation process. Therefore, entrepreneurship plays an important role in driving innovation and promoting economic development.

To sum up, there is a nonlinear relationship between tax incentives and enterprise innovation activities, and H2 is established. On the contrary, excessive tax incentives are not conducive to enterprises' innovation activities, and this effect is more obvious in state-owned enterprises.

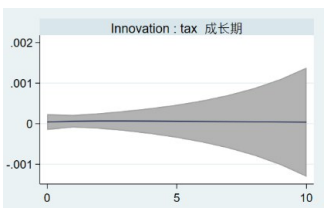
5.3 The interactive mechanism of enterprise innovation activities for tax incentives in different enterprise life cycles

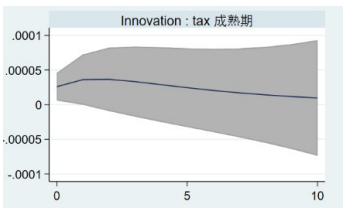
In the above analysis, there is a positive correlation between tax incentives and enterprise innovation activities. However, when enterprises continue to carry out innovation activities, will the government tilt the corresponding policy toward such enterprises, and then increase the tax incentives for such enterprises? To answer this question, this paper constructs a panel vector autoregressive model of equation (4). Through 200 Monte Carlo simulations, we can get the impulse response function of innovation input to tax incentives in the growth stage, the mature area and the recession stage. The results are as follows:

First, the system stability test. In the growth period, maturity period and recession period, there are two unit roots of enterprise innovation input and tax incentives, and the unit roots are in the unit circle, indicating that enterprise entrepreneurship and innovation activities and tax incentives have formed a stable interactive system.

Second, impulse response analysis. The pulse response of enterprise innovation activities in different life cycles to tax incentives is as follows:

As can be seen from Figures 6, 7 and 8, there is a significant long-term interaction between





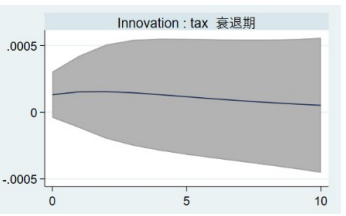


Figure 6Interactive effects during growthFigure7Interaction effect at maturityFigure 8Interactive effects during recession

investment in enterprise innovation activities and tax incentives, and this relationship varies with the change of enterprise cycle. When enterprises are in the growth stage, the interaction between enterprise innovation activities and tax incentives is relatively stable. When enterprises are in the mature stage, the overall pattern of enterprise innovation activities and tax incentives is inverted "√". In the short term, enterprise innovation activities have an upward impact on tax incentives, and in the long term, the impact of both will eventually stabilize. When enterprises are in the recession period, the impact of enterprise innovation activities on tax incentives is similar to that in the growth period, which is in a long-term stable state. To sum up, no matter the enterprise is in the growth stage, maturity stage or decline stage, enterprise innovation and tax incentives have formed a long-term interactive mechanism, that is, when the enterprise is willing to carry out innovation activities, the government will provide corresponding policy support to ensure the enterprise to carry out continuous innovation activities, which is consistent with the original intention of the formulation of tax incentive policies. It reflects the scientific nature of preferential tax policy from the side.

6 Research conclusions and policy recommendations

6.1 Research conclusions

Taking the data of China's Shanghai and Shenzhen A-share listed enterprises from 2014 to 2020 as research samples, A variety of econometric models are constructed to empirically test the impact, heterogeneity and interaction effects of tax incentives on enterprise innovation activities from the perspective of enterprise life cycle. The findings are as follows: (1) Tax incentives can significantly positively affect the innovation activities of enterprises, but the effect varies significantly depending on the life cycle of enterprises. When the enterprises are in the growth stage and the recession stage, the effect is not significant, and only when the enterprises are in the maturity stage, the effect is significant; (2) There is also a threshold effect between tax incentives and enterprise innovation activities. In state-owned enterprises, the impact of tax incentives on enterprise innovation activities shows no significant impact, positive impact and positive effect decrease; in non-state-owned enterprises, the impact of tax incentives on enterprise innovation activities shows an increasing effect; (3) There is a long-term and stable interaction between enterprise innovation activities and tax incentives, and this interaction will also have significant differences due to the different life cycles of enterprises. Only when enterprises are in the mature stage, enterprise innovation activities will have an upward impact on tax revenue, and the rest states are long-term and stable.

6.2 Policy suggestions

The visible hand of the government can directly play a regulatory role in the market, and if policy tools are properly used, it can encourage and guide enterprises to carry out various innovative activities. According to the empirical results, the following suggestions are obtained:

(1) Continue to deepen tax reform and reduce the tax burden on enterprises. At present, the domestic and foreign market environment is in a downward trend, and the development of enterprises is facing an increase of uncertain factors. The uncertain environment makes enterprises cautious about innovation activities that require long-term investment. Preferential tax policies can reduce the risk of enterprise research and development, reduce the cost of research and development, and then reduce the burden of enterprises, and re-stimulate the enthusiasm of enterprises to innovate. In preferential tax policies, the government also needs to flexibly combine the direct preferential way of enterprise income tax incentives with the indirect preferential way of

turnover tax incentives. Under the decisive role of the market in resource allocation, the government should promote the rational and effective allocation of resources as far as possible and help enterprises reduce the demand for innovative factors.

(2)Continue to optimize the external environment. First, we should appropriately simplify the application procedure, lower the application threshold, and relax the restrictive conditions so that more enterprises can enjoy preferential policies. In the study of this paper, the threshold effect of tax incentives on non-state-owned enterprises has been continuously enhanced. Therefore, tax support should be increased for non-state-owned enterprises, and certain tax rebates can be given on the basis of tax reduction and exemption, so as to better play the incentive role of policies on innovation of such enterprises. At the same time, for some state-owned enterprises with rent-seeking behavior, a certain tax preferential punishment mechanism is given, such as no longer giving tax preferential policies within the restricted years. Second, strengthen the protection of patent property rights, so that the innovation achievements of enterprises are guaranteed, and further strengthen the independent innovation activities, so that the innovation activities in the enterprise class form a virtuous circle.

(3) Differentiated preferential tax policies should be implemented according to the life cycle stage of enterprise development. In the growth stage, enterprises need a large amount of capital to meet their own development, and at this time, enterprises are faced with financial pressure brought by large financing constraints. Therefore, increasing the policy support for enterprises in the early stage can greatly alleviate their innovation pressure and financial pressure, so that enterprises have innovation impetus in a long life cycle and improve the success rate of innovation. Only in this way can we really solve the technical problems of the neck.

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