

# Tax Incentives, Digital Transformation and Enterprise Innovation

-- Micro Evidence from Listed Manufacturing Companies

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**Abstract:** Taking China's A-share manufacturing listed companies from 2013 to 2020 as samples, this paper discusses and tests the impact of tax incentives and digital transformation on enterprise innovation, and further explores the moderating effect of digital transformation on the relationship between tax incentives and enterprise innovation. The research results show that tax incentives play a significant positive role in promoting enterprise innovation, and digital transformation can effectively promote enterprise innovation and positively regulate the innovation incentive effect of tax incentive policies, indicating that enterprise digital transformation is conducive to the play of tax incentive policies, so that enterprise innovation can be better promoted and promoted. The results of heterogeneity test show that the promoting effect of tax incentives and digital transformation on enterprise innovation is more obvious in state-owned enterprises and non-high-tech enterprises, while the moderating effect of digital transformation on the incentive effect of tax incentives is more prominent in high-tech enterprises.

**Keywords:** Tax Benefits, Digital transformation, Innovation of Enterprises, Manufacturing.

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## 1. Introduction and Review of Related Literature

As a micro subject of the macro economy, manufacturing enterprises are the main force to implement the innovation-driven strategy and achieve high-quality development. However, weak innovation ability and lack of core technologies have long been one of the chronic problems of China's "big but not strong" manufacturing industry. The wide application of today's digital technology not only brings the social and economic development into the era of digital economy represented by artificial intelligence, block chain, big data and cloud computing, but also plays an important role in promoting the quality of manufacturing development[1]. The Government Work Report of 2021 pointed out that "digital development should be accelerated, new advantages of digital economy should be created, and digital industrialization and industrial digital transformation should be promoted jointly", which pointed out the direction of manufacturing transformation in the era of digital economy at the level of top-level design. Driven by digital technology, more and more manufacturing enterprises join the wave of digital transformation and strive to realize the micro transformation of the deep integration of digital technology and production and management[2][3]. At the critical stage of the transition from old to new growth drivers, promoting the transformation of traditional manufacturing to a digital system can not only effectively mitigate the major impact of COVID-19 on "Made in China", but also provide a strong driving force for the improvement of manufacturing innovation capacity.

As an important part of the government's public policies, tax incentives play an important role in guiding corporate investment and influencing corporate decision-making[4], and also have a significant impact on corporate R&D and innovation. Many studies have found that tax preference has a strong incentive effect on enterprise innovation[5][6]. The

implementation of various tax preference policies in our country also plays an objective role in promoting independent innovation and promoting enterprise transformation. However, with the development of digital economy, under the realistic background of deep integration of manufacturing and digitalization, how can tax incentives play a role? What is the specific effect on the innovation of manufacturing enterprises? Can the digital transformation of manufacturing industry improve the effect of tax incentives on enterprise innovation? The exploration and answers to the above questions can not only provide ideas for the evaluation of the effect of tax incentives on the innovation of manufacturing enterprises under the background of digital economy, but also provide policy suggestions for how to improve the innovation ability of manufacturing enterprises.

As for how tax incentives affect enterprise innovation, although some literatures believe that the government's "adverse selection" and enterprise's "moral hazard" under the condition of information asymmetry will lead to little effect of tax incentives in the process of enterprise innovation[7], the inefficiency of government intervention will also distort the allocation of innovation resources and inhibit the improvement of innovation ability[8][9]. However, most studies still believe that tax incentives have an incentive effect on enterprise R&D and innovation, and demonstrate it from both theoretical and practical levels[10][11]. Some studies further believe that tax incentives can promote enterprise innovation by reducing enterprise costs and easing capital constraints [12].

In terms of how digital transformation affects enterprise innovation, domestic and foreign scholars analyze it from the theoretical and empirical levels. In terms of theoretical research, scholars believe that the application of digital tools in product design will improve design efficiency, reduce R&D risk (Vial, 2019)[109], and enhance the efficiency of design innovation in manufacturing industry. Digital transformation can also integrate information technology into the production links of manufacturing enterprises, and promote process

innovation in manufacturing industry through the creation of new quality control procedures and management processes (Liu Xielin et al., 2020)[17] and technical training of employees in production (Shi Ai et al., 2018)[18]. At the level of empirical research, Wang Jinjie et al. (2018) [19] and Wang Wenna et al. (2020)[20] used the survey data of the World Bank to prove the positive impact of Internet-based R&D on manufacturing innovation. Another scholar constructed enterprise digital transformation index and found that the digitalization level of Chinese enterprises was positively correlated with the innovation ability through the data inspection of listed companies (Chen Qingjiang et al., 2021; Huang Jiegen et al., 2021) [15][12] and drew a conclusion that digital transformation can significantly improve enterprises' total factor productivity (Zhao Chenyu et al., 2021)[16].

According to the existing literature, relevant researches are only theoretical and empirical analysis on how digital transformation affects enterprise innovation, and how tax incentives affect enterprise innovation is also divorced from the realistic background of digital transformation. At present, there is still a lack of a unified analytical framework at home and abroad to reveal the relationship between tax incentives, digital transformation and manufacturing enterprise innovation, and there is no in-depth analysis of whether digital transformation and tax incentives have a moderating effect on the specific impact of enterprise innovation. Therefore, this paper uses the data of A-share manufacturing listed companies, and on the basis of theoretical analysis, focuses on the impact mechanism of tax incentives and digital transformation on the innovation of manufacturing listed companies, and further examines the adjustment effect of digital transformation on the impact of tax incentives.

## 2. Theoretical Analysis and Research Hypothesis

### 2.1. Tax incentives and Enterprise innovation

Although some studies believe that the preferential tax policies formulated by the government are characterized by strong subjectivity and weak marketability, which may lead to the problems of over-incentive and resource distortion, resulting in low innovation efficiency (Bennie et al, 2006; Lee et al., 2016).[9][10] However, the characteristics of innovation activities such as long cycle, high risk and large amount of capital make external incentive become a necessary condition to promote enterprise innovation. The incentive effect of tax incentives on enterprise innovation is mainly reflected through the following three channels: First, tax incentives can ease the financial constraints of enterprises in R & D innovation and enhance the enthusiasm and initiative of enterprises in innovation. Innovation activities need more initial capital investment, coupled with a longer time and higher risk, financial constraints have become an important reason to restrict innovation. Preferential tax policies can indirectly increase the innovation funds of enterprises, alleviate the financial constraints of enterprises, and enable enterprises to innovate with a more proactive attitude (Czarnitzki et al., 2010; Chu et al., 2017)[6][7]. Second, tax incentives can send positive signals to the outside world and enhance the innovative financing ability of enterprises. Under the current preferential tax policies, not all enterprises can enjoy the "welfare" of tax reduction. In this case, tax incentives can play a role in the information transmission of credit identification and implicit guarantee.

Tax incentives for enterprises can convey a "positive signal" reflecting their market competitiveness to the outside world, so that they can obtain convenience in credit financing, and ease the financing constraints on R&D and innovation of enterprises. Third, tax incentives can stabilize enterprises' expectations of R&D innovation and reduce innovation risks. In the R&D stage, accelerated depreciation, additional deduction and other policies can reduce the R&D costs of enterprises and share the innovation risks of enterprises. In the stage of technology transformation, policies such as patent box and preferential treatment of transformed achievements will directly affect the finished products brought by technological innovation of enterprises, increase the expected benefits of innovation achievements, and make R&D investment more attractive (Li Juxiang and He Na, 2019)[8]. In conclusion, although tax incentives have the possibility of crowding out effect in the process of enterprise innovation, the incentive effect is greater than the crowding out effect. Based on this, theoretical hypothesis H1 is proposed:

H1: On the premise that other conditions remain unchanged, tax incentives have a positive promoting effect on enterprise innovation. That is, tax incentives can promote enterprise innovation.

### 2.2. Digital transformation and Enterprise innovation

With the wide application of digital technology, the decision-making mode and operation process of enterprises have changed greatly. By empowering traditional industries through digital transformation, enterprises can be endowed with stronger capabilities in resource integration, information acquisition and data analysis, and realize the optimization of enterprise innovation system and innovation mode. The role of digitalization in manufacturing enterprise innovation mainly focuses on two aspects: product innovation and process innovation. First, product innovation in the process of digital transformation can effectively reduce innovation costs and risks, and improve enterprise innovation efficiency. Product innovation is mainly embodied in design innovation, and design innovation must be market-oriented. The application of digital technology in the new economy era can improve the information collection and processing ability of enterprises in the process of product innovation (Chen Qingjiang et al., 2021).[12] The application of digital tools in product design will improve the design efficiency and reduce the innovation risk (Vial, 2019)[13]. The self-growth and recombination of digital technologies and other characteristics accelerate the modular trend of innovation activities, reduce the cost of innovation (Liu Xiaolin et al., 2020)[17], and improve the efficiency of product innovation of manufacturing enterprises. In addition, the application of Internet business model in the context of digital economy brings customers into the product innovation of enterprises. Consumers can participate in the whole process of industrial design and value creation more extensively, which makes innovation more market-oriented and shortens the time for new products to enter the market (Manesh et al., 2021).[14] Second, digital transformation can promote enterprise innovation through the creation of new quality control procedures and management processes, as well as the optimization of human capital structure. According to the study of Zhao Chenyu et al. (2021),[16] a one-sided focus on technological innovation rather than organizational management reform will inevitably lead to inefficient

innovation results. The digital transformation of the production process can have a subversive impact on the original enterprise management process, forcing enterprises to form a good atmosphere to attach importance to innovation and encourage innovation, and integrate innovation into every link of production. In addition, the application of digital technology will increase the employment demand of enterprises for highly educated talents, optimize the human capital structure of enterprises, integrate knowledge capital and human capital into the innovation process, and enhance the innovation ability of enterprises through the diffusion effect of technology. Based on this, theoretical hypothesis H2 is proposed:

H2: On the premise that other conditions remain unchanged, digital transformation has a positive promoting effect on enterprise innovation. That is, digital transformation can promote enterprise innovation.

### 2.3. Tax incentives, Digital Transformation and Enterprise innovation

As "digital economy" has become the latest development trend of the current information technology revolution, the evaluation of the effect of tax incentives on enterprise innovation under the background of digital transformation should be paid attention to and attached importance to. Whether there is a regulatory effect of digital transformation on the incentive effect of tax incentives has also become an important research content in the era of digital economy. The adjustment mechanism of digital transformation on tax incentive is mainly focused on the following three points: First, under the realistic background of the government's active support for digital economy and intelligent manufacturing, enterprises promoting digital transformation will get more fiscal and tax policy support and more preferential policies in terms of tax, which will further reduce the cost and risk of innovation of enterprises and promote enterprise innovation. Secondly, Chinese manufacturing enterprises have the phenomenon of tax concealment without substantive innovation. The introduction of digitalization and information technology can make the information of enterprises in the research and development and production stage more transparent, restrain the rent-seeking behavior of enterprises in "strategic" innovation (Li Wenjing and Zheng Manni, 2016)[21], and boost the effect of tax incentives. Finally, the digital transformation of manufacturing enterprises accelerates the possibility of information sharing, connects the government's tax incentives with the market's R&D and innovation, improves the accuracy of decision-making and planning, and gives better play to the incentive role of tax incentives for innovation. Based on this, theoretical hypothesis H3 is proposed:

H3: On the premise that other conditions remain unchanged, digital transformation can significantly improve the incentive effect of tax incentives on enterprise innovation.

## 3. Study Design

### 3.1. Selection of variables

1. Enterprise innovation performance. The explained variable is firm innovation performance (Inn). According to the analysis of existing studies, patent output can better reflect the level and quality of enterprise innovation. This paper refers to the research of Li Wenjing and Zheng Manni et al. (2016) [21] based on the perspective of innovation motivation, and uses the number of invention patent applications representing the substantive innovation of enterprises as the measurement index of enterprise innovation output level. At the same time, considering that it takes a certain amount of time for enterprises to change from R&D input to patent output, the natural logarithm of the number of invention patent applications of sample enterprises in the next year plus 1 is finally selected as the explained variable.

2. Tax incentives. The explanatory variable in this paper is tax incentives (Etr). Referring to the practice of Yang Xudong (2018) [23] and Chen Hong et al. (2019), [24] this paper divided the enterprise's income tax by its EBIT to represent the effective income tax rate borne by the enterprise, and deducted the enterprise's effective income tax rate by 1 to represent the tax incentives and exemptions enjoyed by the enterprise. The specific calculation formula is: tax benefit = 1 - corporate income tax / (net profit + corporate income tax + interest expense).

3. Degree of digital transformation. Digitization transformation index (Dig) was used as an explanatory variable and a moderating variable. Drawing on previous research ideas (Wu Fei et al.; 2021; Li Qi et al., 2021) [3][22] divided enterprise digital transformation into "basic technology" and "practical application", among which "basic technology" included artificial intelligence technology, blockchain technology, cloud computing technology and big data technology. Python was used to mine the digital transformation information involved in the annual report of listed companies. The number of keywords about digital transformation in the annual reports of listed companies is taken as the index to measure the digital transformation of enterprises, and the natural logarithm is taken after adding 1.

4. Other control variables. With reference to the setting of existing literature, the control variables in this paper include enterprise Size (Size), profit status (Roa), debt status (Lev), growth capacity (Gro), enterprise Age (Age), etc. In addition, the dummy variables of year and industry are also controlled in the empirical analysis. The specific Settings are shown in Table 1.

**Table 1.** Variable definition and description

Symbol of variable	Name of variable	Description of variables
Inn	Innovation performance (invention patent)	The natural logarithm of the number of invention patent applications is added by 1
Etr	Tax Benefits	1 minus the effective corporate income tax rate
Dig	Digital transformation	The number of keywords about "digital transformation" in the annual report is added by 1 and the natural logarithm is taken
Size	Size of Enterprise	The natural log of total assets
Roa	Position of profit	Return on equity
Lev	Position of liabilities	Total liabilities to total assets
Gro	Ability to grow	Growth rate of main business income
Age	Age of enterprise	The natural logarithm is calculated by adding 1 to the difference between the observation year and the establishment year

### 3.2. Model setting

This paper aims to explore the impact of tax incentives and digital transformation on manufacturing enterprise innovation, and whether digital transformation has a moderating effect on tax incentives. Therefore, the following model is constructed:

$$Inn_{i,t+1} = \alpha_0 + \alpha_1 Etr_{it} + \alpha_2 Controls_{it} + \sum year + \sum ind + \varepsilon \quad (1)$$

$$Inn_{i,t+1} = \alpha_0 + \alpha_1 Dig_{it} + \alpha_2 Controls_{it} + \sum year + \sum ind + \varepsilon \quad (2)$$

$$Inn_{i,t+1} = \alpha_0 + \alpha_1 Etr_{it} + \alpha_2 Dig_{it} + \alpha_3 Etr_{it} \cdot Dig_{it} + \alpha_4 Controls_{it} + \sum year + \sum ind + \varepsilon \quad (3)$$

Where, *i* represents enterprise subscript, *t* represents year subscript; *Inn* represents enterprise innovation, which is measured by the number of enterprise invention patent applications. *Etr* refers to tax incentives, *Dig* refers to the degree of digital transformation of manufacturing enterprises; *Controls* are the control variables, including enterprise Size (Size), profitability (Roa), indebtedness (Lev), growth capacity (Gro), Age (Age), etc. Year and Ind represent control year effect and industry effect respectively. They are intercept terms and random interference terms.

### 3.3. Sample selection and data collection

The research sample of this paper is the A-share listed manufacturing enterprises in Shanghai and Shenzhen from 2013 to 2020. Refer to existing literature (Yang Xudong, 2018; Li Qi et al., 2021)[22][23] screens the sample data and makes the following processing: (1) Delete the enterprises lacking in the number of invention patent applications and tax incentives, and delete the enterprises with total owners' equity less than 0; (2) Samples of listed enterprises with missing or negative values such as operating revenue, total assets, total liabilities, net profit and date of establishment are excluded; (3)

Excluding the IPO of the current year; (4) Delete listed companies that issue A shares, B shares or H shares at the same time. After screening, 4966 research samples were finally obtained.

The patent application data and corporate financial data in this paper come from CSMAR database, and the data of digital transformation come from Python crawler statistics of the annual reports of listed companies. In order to eliminate the influence of extreme outliers, this paper carries out Winsorize processing of 1% and 99% quantile for all continuous variables.

## 4. Analysis of Empirical Results

### 4.1. Descriptive statistics

Table 2 shows the descriptive statistics of the variables. The average value of *Inn* of innovation output of enterprises is 1.6111, and the median value is 1.3836. It has been said that the number of invention patent applications of most enterprises is lower than the average value. The standard deviation of 1.5105 indicates that there are great differences in innovation output of different enterprises. The mean value of the tax incentive *Etr* is 0.8632, the median is 0.8371, the maximum value is 1, and the minimum value is 0, indicating that there are enterprises that do not enjoy the income tax incentive. The mean value of digitization transformation *Dig* is 1.8388 and the median value is 1.6094, indicating that the enterprises in the sample have a high degree of digitization transformation, which makes the mean value greater than the median value. The degree of digitization transformation varies greatly among different enterprises, which is proved by the maximum value of 5.4889 and the minimum value of 0.6931. As for the descriptive statistical results of other control variables, they are basically consistent with the existing studies.

**Table 2.** Descriptive statistics of major variables

Variable name	Mean	median	standard deviation	minimum	maximum	number of samples
<i>Inn</i>	1.6111	1.3863	1.5105	0.0000	8.6933	4966
<i>Etr</i>	0.8632	0.8371	0.1085	0.0000	1.0000	4966
<i>Dig</i>	1.8388	1.6094	1.0241	0.6931	5.4889	4966
<i>Size</i>	22.0083	21.8782	1.1947	18.9209	27.3074	4966
<i>Roa</i>	0.0499	0.0457	0.0665	-0.6089	0.9644	4966
<i>Lev</i>	0.3869	0.3802	0.1887	0.0111	0.9957	4966
<i>Gro</i>	0.2386	0.1285	1.2575	-0.8625	55.0444	4966
<i>Age</i>	1.8601	1.9460	0.8889	0.0000	3.3322	4966

### 4.2. Analysis of baseline regression results

Table 3 shows the benchmark regression results of this paper, verifying the impact of tax incentives and digital transformation on manufacturing enterprise innovation, as well as the moderating effect of digital transformation on tax incentives. As shown in columns (1) and (2) in the table, tax incentive *Etr* has a significant positive impact on enterprise innovation at the 1% level, that is, tax incentive plays a significant role in promoting the innovation of manufacturing enterprises. Hypothesis H1 is supported by empirical results. Columns (3) and (4) in the table reflect the impact of digital transformation on enterprise innovation. The coefficient of digitization transformation *Dig* is significantly positive at the level of 1%, indicating that digital transformation can promote enterprise innovation and has a positive incentive

effect on manufacturing enterprise innovation, which verifies the conclusion of hypothesis H2. Columns (5) and (6) in Table 3 reflect the impact of tax incentive *Etr*, DIGitization transformation *Dig* and their interaction terms on enterprise innovation. The regression results show that the regression coefficient of tax incentive and digitization transformation is still significantly positive at the level of 1%, and the coefficient of *Etr*×*Dig* is also significantly positive at the level of 1%. The regression results further prove that both tax incentives and digital transformation can promote enterprise innovation. Moreover, when the enterprise digital transformation degree is high, the incentive effect of tax incentives on innovation is stronger, and the digital transformation can significantly improve the incentive effect of tax incentives on enterprise innovation. The conclusion of

hypothesis H3 is supported by the empirical results. It can be found that tax incentives can increase R&D input and innovation output by sharing enterprise risks and increasing external financing. Digital transformation enables enterprises to enjoy the innovation dividends brought by digital technology and also improves the innovation ability of enterprises. At the same time, enterprises' own digital transformation has a strong positive moderating effect on the innovation effect of tax incentives, so that the policy effect of

tax incentives has been more fully played.

According to the regression coefficients of control variables in Table 3, the regression coefficients of enterprise size and profitability on innovation are significantly positive, the regression coefficients of debt and enterprise age on innovation are significantly negative, and the regression coefficients of growth ability on innovation are not significant, which is basically the same as the regression results of existing studies.

**Table 3.** The result of baseline regression

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Etr	0.7212*** (0.2027)	1.0077*** (0.2004)			0.5981*** (0.1944)	0.8216*** (0.1949)
Dig			0.1940*** (0.0215)	0.1844*** (0.0205)	0.1553*** (0.0208)	0.1606*** (0.0203)
Etr×Dig					2.1861*** (0.1708)	1.2013*** (0.1504)
Size		0.4990*** (0.0299)		0.4875*** (0.0297)		0.4309*** (0.0302)
Roa		1.7162*** (0.3684)		1.6666*** (0.3585)		1.7097*** (0.3612)
Lev		-0.4690*** (0.1367)		-0.4452*** (0.1348)		-0.4629*** (0.1349)
Gro		-0.0227 (0.0238)		-0.0315 (0.0222)		-0.0265 (0.0243)
Age		-0.2979*** (0.0286)		-0.3047*** (0.0285)		-0.2870*** (0.0284)
Constant	0.8207*** (0.2117)	-9.7468*** (0.6408)	1.1509*** (0.1217)	-8.8927*** (0.6019)	-5.3967*** (0.5132)	-11.7140*** (0.6915)
R2	0.0053	0.1135	0.0195	0.1235	0.0641	0.1383
Number of samples	4966	4966	4966	4966	4966	4966

Note: \*, \*\* and \*\*\* represent significant at the level of 10%, 5% and 1% respectively, and the brackets are robust standard error.

### 4.3. Robustness and endogeneity test

On the basis of baseline regression, the robustness and endogeneity tests were conducted in the following ways. In the robustness test process, the number of patent applications was used instead of the number of invention patent applications to measure enterprise innovation. Other Settings were consistent with the benchmark model. In the process of

endogeneity test, the practice of Chen Qingjiang et al. (2021)[12] is referred to, taking "year-industry average degree of digital transformation" as instrumental variable, and 2SLS method is applied for regression. The regression results in Table 4 are highly consistent with the baseline regression, indicating that the statistical inference of the baseline regression is relatively robust and there is no serious endogeneity problem.

**Table 4.** Robustness and endogeneity test results

Variable	Replace the explained variable				2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Etr	1.1187*** (0.2368)		0.9240*** (0.2297)	1.0100*** (0.1688)		0.8040*** (0.1634)
Dig		0.1853*** (0.0224)	0.1587*** (0.0224)		0.1149*** (0.0151)	0.0950*** (0.0148)
Etr×Dig			1.3340*** (0.1713)			1.7124*** (0.1131)
Size	0.5025*** (0.0330)	0.4904*** (0.0328)	0.4276*** (0.0337)	0.2991*** (0.0238)	0.2947*** (0.0238)	0.2212*** (0.0234)
Roa	0.8609** (0.4221)	0.8059** (0.4101)	0.8544** (0.4134)	1.7356*** (0.2640)	1.6589*** (0.2594)	1.6644*** (0.2596)
Lev	-0.4923*** (0.1594)	-0.4708*** (0.1579)	-0.4903*** (0.1575)	-0.4880*** (0.1067)	-0.4758*** (0.1062)	-0.4280*** (0.1060)
Gro	-0.0291 (0.0189)	-0.0386** (0.0167)	-0.0330* (0.0190)	-0.0015*** (0.0190)	-0.0015*** (0.0004)	-0.0014*** (0.0003)
Age	-0.4059*** (0.0333)	-0.4134*** (0.0332)	-0.3936*** (0.0331)	-0.2546*** (0.0233)	-0.2652*** (0.0232)	-0.2431*** (0.0229)
Constant	-9.0291*** (0.7104)	-8.0635*** (0.6643)	-11.2082*** (0.7537)	-5.7650*** (0.5112)	-4.9694*** (0.4817)	-8.8309*** (0.5573)
R <sup>2</sup>	0.0904	0.0975	0.1120	0.0605	0.0628	0.0940
Number of samples	4966	4966	4966	4966	4966	4966

Note: \*, \*\* and \*\*\* represent significant at the level of 10%, 5% and 1% respectively, and the brackets are robust standard error.

#### 4.4. Analysis of heterogeneity

In order to further demonstrate the robustness of the regression results and reveal the differences in influencing factors of different types of enterprises, this paper conducted group regression for the enterprises in the sample, and conducted heterogeneity analysis on the relationship between tax incentives, digital transformation and enterprise innovation.

First, grouping regression is carried out according to the nature of property rights. Table 5 shows the grouping regression of enterprises with different types of property rights. As can be seen from Table 5, the impact of tax incentives on the innovation of both soes and non-soes is significantly positive at the level of 1%, but the absolute value of the regression coefficient of soes is greater than that of non-soes, indicating that tax incentives have a greater promoting effect on the innovation of soes, mainly because soes are more favored by governments, especially local governments, in terms of tax incentives. However, when non-state-owned

enterprises enjoy preferential tax policies, they often encounter "revolving door" and "swing door", so the policy dividends brought by tax incentives are mostly used for daily operation, and less for R&D and innovation. Digital transformation has a significant positive incentive effect on both state-owned and non-state-owned enterprises. However, the absolute value of regression coefficient of state-owned enterprises is greater than that of non-state-owned enterprises, indicating that digital transformation has a greater role in improving the innovation of state-owned enterprises. The main reason for this result is that digital transformation of enterprises requires a large amount of technology and capital, and state-owned enterprises often have advantages in these aspects. The interaction terms between tax incentives and digital transformation are significantly positive in both state-owned enterprises and non-state-owned enterprises, and there is little difference in the regression coefficients, indicating that the moderating effect of digital transformation on the innovation effect of tax incentives is widespread in enterprises with different property rights.

**Table 5.** Heterogeneity analysis based on property rights

Variable	State-owned enterprise			Non-state-owned enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
Etr	1.3404** (0.5200)		1.2760** (0.5048)	0.8952*** (0.2056)		0.6769*** (0.1993)
Dig		0.2578*** (0.0549)	0.2233*** (0.0546)		0.1645*** (0.0211)	0.1437*** (0.0209)
Etr×Dig			1.2697*** (0.3729)			1.2062*** (0.1622)
Size	0.5570*** (0.0553)	0.5416*** (0.0543)	0.4888*** (0.0562)	0.4157*** (0.0340)	0.4046*** (0.0338)	0.3448*** (0.0341)
Roa	3.2862*** (0.9535)	2.5970*** (0.9327)	2.7974*** (0.9214)	1.5436*** (0.3968)	1.5673*** (0.3890)	1.5964*** (0.3917)
Lev	-0.5882* (0.3176)	-0.6526** (0.3149)	-0.6454** (0.3139)	-0.3230** (0.1475)	-0.2920** (0.1456)	-0.3077** (0.1459)
Gro	-0.2670** (0.1051)	-0.2396** (0.0965)	-0.2590*** (0.0982)	-0.0109 (0.0210)	-0.0190 (0.0195)	-0.0144 (0.0211)
Age	-0.5533*** (0.0798)	-0.5596*** (0.0796)	-0.5380*** (0.0801)	-0.2925*** (0.0324)	-0.3033*** (0.0323)	-0.2848*** (0.0321)
Constant	-10.4583*** (1.3128)	-9.2412*** (1.1388)	-12.7559*** (1.4890)	-8.1495*** (0.7134)	-7.3969*** (0.6820)	-10.0312*** (0.7596)
R <sup>2</sup>	0.1673	0.1795	0.1916	0.0854	0.0952	0.1125
Number of samples	1169	1169	1169	3797	3797	3797

Note: \*, \*\* and \*\*\* represent significant at the level of 10%, 5% and 1% respectively, and the brackets are robust standard error.

Second, grouping regression is conducted according to whether high-tech enterprises or not. Table 6 reflects the grouping regression of high-tech enterprises or not. As can be seen from Table 6, the regression coefficient of tax incentives on enterprise innovation is significantly positive for both high-tech enterprises and non-high-tech enterprises, but the absolute value of the regression coefficient of non-high-tech enterprises is larger, indicating that tax incentives have stronger incentive effect on innovation of non-high-tech enterprises. The main reason is that the high R&D innovation of high-tech enterprises is higher than that of non-high-tech enterprises, so the marginal incentive effect of tax incentives on innovation of non-high-tech enterprises is stronger. By comparing the regression coefficient of digital transformation, it is found that the absolute value of the influence coefficient

of digital transformation on the innovation of non-high-tech enterprises is larger, that is, the promoting effect of digital transformation on the innovation of non-high-tech enterprises is stronger, indicating the necessity of improving the independent innovation and transformation and upgrading of non-high-tech enterprises through digital transformation. Further research finds that the interaction terms between tax incentives and digital transformation are significantly positive in both high-tech enterprises and non-high-tech enterprises. However, the regression coefficient of high-tech enterprises is larger than that of non-high-tech enterprises, indicating that the adjustment effect of digital transformation on the innovation incentive effect of tax incentives is more obvious in high-tech enterprises. The main reason is that high-tech enterprises generally have a higher degree of digital

transformation, which is easier to bring the innovation-driven effect of tax incentives into play.

**Table 6.** Heterogeneity analysis based on whether or not high-tech enterprises

Variable	High-tech enterprise			Non-high-tech enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
Etr	0.6236*** (0.2014)		0.4764** (0.1993)	1.6377*** (0.4506)		1.5096*** (0.4388)
Dig		0.1217*** (0.0215)	0.0998*** (0.0214)		0.1965*** (0.0399)	0.1733*** (0.0396)
Etr×Dig			1.2199*** (0.1769)			0.7336*** (0.2137)
Size	0.4061*** (0.0369)	0.4014*** (0.0366)	0.3384*** (0.0365)	0.6348*** (0.0425)	0.6189*** (0.0423)	0.5891*** (0.0436)
Roa	2.0293*** (0.4530)	1.9476*** (0.4259)	2.0402*** (0.4407)	4.8568*** (0.8038)	4.8161*** (0.8251)	4.5307*** (0.8015)
Lev	0.0583 (0.1568)	0.0828 (0.1539)	0.0731 (0.1545)	-0.0705 (0.2465)	-0.1151 (0.2488)	-0.1639 (0.2462)
Gro	-0.1545*** (0.0449)	-0.1649*** (0.0457)	-0.1523*** (0.0428)	0.0035 (0.0219)	-0.0090 (0.0169)	-0.0005 (0.0226)
Age	-0.1724*** (0.0349)	-0.1792*** (0.0347)	-0.1726*** (0.0345)	-0.4232*** (0.0428)	-0.4199*** (0.0432)	-0.4019*** (0.0432)
Constant	-7.6271*** (0.7694)	-7.1675*** (0.7425)	-9.5986*** (0.8350)	-13.8395*** (0.9759)	-12.3184*** (0.8646)	-14.9702*** (1.0290)
R <sup>2</sup>	0.0864	0.0924	0.1064	0.2142	0.2167	0.2283
Number of samples	3634	3634	3634	1890	1890	1890

Note: \*, \*\* and \*\*\* represent significant at the level of 10%, 5% and 1% respectively, and the brackets are robust standard error.

## 5. Summary and Policy Recommendations

### 5.1. Summary

Taking China's A-share manufacturing listed companies from 2013 to 2020 as samples, this paper discusses and tests the impact of tax incentives and digital transformation on enterprise innovation, and further explores the moderating effect of digital transformation on the relationship between tax incentives and enterprise innovation. The research results show that tax incentives play a significant positive role in promoting corporate innovation, indicating that tax incentives can alleviate corporate financing constraints, reduce corporate innovation risks, increase corporate external financing, and play a positive role in promoting corporate innovation. Digital transformation can effectively promote enterprise innovation. The improvement of enterprise digital level in the era of digital economy is not only a requirement for high-quality economic development, but also an important means for enterprises to enhance innovation ability and enhance market competitiveness. The digital transformation has a positive moderating effect on the innovation incentive effect of tax incentive policies, indicating that the digital transformation of enterprises is conducive to the play of the role of tax incentive policies, so that enterprise innovation can be better promoted and promoted. The results of heterogeneity test show that the promoting effect of tax incentives and digital transformation on enterprise innovation is more obvious in state-owned enterprises and non-high-tech enterprises, while the moderating effect of digital transformation on the incentive effect of tax incentives is more prominent in high-tech enterprises.

### 5.2. Policy recommendations

This study expands the research on enterprise micro-innovation from the perspective of tax preferential policies,

and combines it with the internal governance of digital transformation to provide theoretical reference and practical guidance for solving the problem of insufficient innovation of Chinese enterprises. The research of this paper has the following policy implications:

First, we will deepen policies to cut taxes and fees to unleash the innovation vitality of market players. The externality of innovation is inevitable. Under the double pressure of economic downturn and the impact of the epidemic, enterprises' R&D and innovation activities are inevitably adversely affected by the shortage of funds and increased risks. In order to improve the innovation ability of manufacturing enterprises under the goal of high-quality development, the tax policy needs to be further exerted. Governments at all levels may further advance tax and fee reduction policies to ease the pressure on enterprises and unleash their innovation vitality through various tax measures. Preferential tax policies should be implemented in a diversified and precise way, and policies should be given to different types of enterprises to solve the worries of enterprise innovation. At the same time, a dynamic adjustment mechanism for policy benefits should be established. Enterprises with weak innovation or failing to achieve substantial innovation should be deprived of their right to enjoy tax incentives.

Second, increase tax incentives for enterprises with a high degree of digital transformation. The higher the degree of digital transformation of enterprises, the stronger the incentive effect of tax incentives. Therefore, according to the situation of enterprises' digital transformation, the government should give full play to the policy guidance role of taxation, encourage enterprises to speed up digital transformation, develop "digital manufacturing" with Chinese characteristics, and lay a solid foundation for high-quality economic development. In addition, for enterprises with a high degree of digital transformation, tax incentives can be increased to better play the innovation-driven effect of tax

incentives.

Third, we should emphasize fairness in tax incentives and focus on key industries and enterprises. For state-owned and non-state-owned enterprises, preferential tax policies should be the same, create a level playing field, effectively reduce the "swing door" and "revolving door" situation that non-state-owned enterprises encounter when applying for preferential tax policies, and significantly increase tax incentives for specialized and innovative private enterprises. While implementing tax incentives for high-tech enterprises, attention should also be paid to some non-high-tech enterprises that are actively engaged in digital transformation, and through tax means, they should be actively guided to transform from traditional production mode to digital production mode and from factor driven to innovation-driven transformation.

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