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Research on the Impact of Tax Incentives on the Digital Transformation of Manufacturing Enterprises

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Abstract: *Tax preference is an important policy tool to drive the digital transformation of manufacturing enterprises. Using Chinese A-share manufacturing listed companies in Shanghai and Shenzhen as samples, this paper examines the impact and mechanism of tax incentives on the digital transformation of manufacturing enterprises based on the intermediary effect model.The results shows that preferential tax policies can effectively promote the digital transformation of manufacturing enterprises. Tax incentives positively affect the digital transformation of manufacturing enterprises by encouraging them to increase their investment in innovation and human capital. The incentive effect of preferential tax policies on the digital transformation of manufacturing enterprises is heterogeneous, with a greater incentive effect on the data-driven transformation of medium and large manufacturing enterprises, as well as medium and low growth manufacturing enterprises. The research in this paper provides empirical evidence and policy enlightenment for the implementation of tax incentives to promote the digital transformation of enterprises.*

Keywords: *Tax preference; Digital transformation; Mechanism analysis; Mediating effect*

1. Introduction

At present, the rapid development of a new generation of information technology has promoted the deep integration of digital technology and real economy. Chinese 14th Five-Year Plan puts forward that it is necessary to implement the action of "going to the cloud to use numbers to give wisdom" to promote the digital and intelligent development of manufacturing industry. Building a digital power and promoting digital transformation of enterprises has become an important strategic measure to empower China's high-quality economic development.Under the background of digital economy, manufacturing enterprises, as the main microeconomic entities, should actively promote digital transformation, enhance their competitiveness, and respond to the impact and challenges of digital transformation. However, according to the "Research on Digital Transformation Index of China Enterprises in 2022" released by Accenture, the average score of Chinese enterprises' digital transformation index is only 52 points, which is far from the ideal level. Digital transformation is in the primary stage and there is still a lot of room for improvement. The digital transformation of enterprises is a systematic innovation and change, which has the characteristics of long cycle (Hui Li and Dandan Liang, 2020)[1], high risk (Shepherd et al., 2017)[2], high failure rate and positive externalities (Xinyu Tu and Xiaoling Yan, 2022)[3], and many enterprises have problems such as "not being able to transfer", "unwilling to transfer", and "afraid to transfer"(Shuchun Liu et al., 2021)[4]. There is market failure in the process of digital transformation, which requires the government to intervene (Zhiyuan Zhang and Yongfan Ma, 2023)[5], implement incentive policies, and drive enterprises to carry out digital transformation and reform.

In recent years, China has introduced many tax incentives to correct market failures in enterprise data-driven transformation, encouraging enterprises to actively promote the development of digital transformation.How to use tax incentives to help enterprises in their data-driven transformation has attracted the attention of scholars. Scholars have empirically tested the impact of tax incentives on the digital transformation of enterprises from the perspectives of R&D expenses plus deduction and tax reduction (Qiongwen Cheng and Hongyi Ding, 2022)[6], accelerated depreciation policy of fixed assets (He Chen et al., 2022)[7] and forward-looking effective tax rate (Hao Zeng, 2022)[8]. Their research shows that the preferential tax policies do have a positive impact on the digital transformation of enterprises. Some scholars also believe that the government is not a real market subject and cannot effectively grasp the trajectory of digital transformation and evolution (Fei Wu et al., 2021)[9]. The existing literature or analysis samples only focus on traditional resource-based enterprises, or only analyze the impact of some

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preferential tax policies on enterprise digital transformation, such as R&D expenses plus deduction, tax reduction and exemption, tax rate, etc., and the research on the theoretical logic and mechanism of the impact of preferential tax policies on enterprise digital transformation is still insufficient. Manufacturing enterprises are the most important market players in promoting the national strategy of digital transformation, and their digital transformation is typical and representative. Exploring how to effectively promote the data-driven transformation and upgrading of manufacturing enterprises through tax incentives is of great theoretical and practical significance for China's implementation of the digital economy strategy. Therefore, this paper takes the listed manufacturing companies of China's A-share in Shanghai and Shenzhen as samples, and investigates the influence and mechanism of tax incentives on digital transformation based on the intermediary effect model. The possible marginal contributions of this paper are as follows: firstly, taking innovation investment and human capital investment as intermediary variables, the conduction path of tax preferential policies to promote enterprise digital transformation is investigated, and the mechanism of tax preferential policies to enterprise digital transformation is revealed. Secondly, it empirically examines the impact of tax incentives on the digital transformation of manufacturing enterprises, and provides empirical evidence for the implementation of tax incentives to effectively promote the digital transformation of manufacturing enterprises. Thirdly, from the perspective of enterprise scale and growth, this paper investigates the heterogeneity of the impact of tax incentives on the digital transformation of manufacturing enterprises, so as to effectively capture the differential driving role of tax incentives on the digital transformation of manufacturing enterprises and provide direction guidance for the improvement of subsequent tax incentives.

2. Theoretical Analysis and Research Hypothesis

Digital transformation is an innovative process for enterprises to use digital technology (Amit and Bala, 2020)[10]. The essence of the process of digital transformation of manufacturing enterprises is the transformation from "industrialized management mode" to "digital management mode" (Shuchun Liu et al., 2021)[4]. By deepening the digital application of R&D, production, management and market service, the data is deeply integrated with other production factors, so that the R&D design of enterprises tends to be efficient and the production management tends to be intelligent (Frynas et al., 2018)[11], and enhance enterprise core competitiveness. However, the digital transformation of enterprises is a systematic transformation project, and manufacturing enterprises are often not motivated to transform because of insufficient resources and capabilities. First of all, a series of technical support such as big data and cloud computing are needed in the process of digital transformation. Manufacturing enterprises often lack digital transformation technology and talents, do not have all the conditions for digital transformation, and face the problem of "unable to turn". Secondly, the digitalization of enterprises is uncertain and the risk of transformation is high, which leads many enterprises to be in a state of "dare not turn". Third, the digital transformation of manufacturing enterprises needs to invest a lot of money to purchase the software and hardware facilities needed for digital transformation. The transformation cost is too high and the transformation motivation is insufficient, so enterprises are "unwilling to transfer". Therefore, the level of independent investment in digital transformation of enterprises will be lower than the optimal level of society, and the government needs to adopt incentive policies to make up for the lack of investment in digital transformation. Preferential tax policies have strong universality and policy orientation. By encouraging manufacturing enterprises to increase investment in innovation and human capital, they can effectively solve the problems of "unable to turn", "afraid to turn" and "unwilling to turn" in the process of digital transformation of manufacturing enterprises, and promote the digital transformation of enterprises.

Preferential tax policies can encourage manufacturing enterprises to increase investment in innovation, form innovative output and promote the digital transformation of enterprises. Digital transformation of manufacturing enterprises is a systematic process of applying digital technology to carry out intelligent and digital transformation. It is necessary to promote equipment networking, digital connection of production links, production data penetration, manufacturing flexibility and intelligent management. Technical factors are very important for digital transformation of enterprises, and technical input is an important factor to promote digital transformation (Yu Tong, 2022)[12]. The digital transformation of enterprises needs to invest a lot of resources to buy software, information technology and automation equipment, and use digital technology to rebuild existing processes and systems. Therefore, it is necessary to build platforms and systems through innovative investment in order to achieve the goal of digital transformation of enterprises. The impact of tax incentives on enterprise innovation investment is mainly due to the decline of marginal cost of R&D investment brought by tax incentives, and the marginal cost curve moves down to get a higher level of balanced R&D investment

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(Genqiang Lei and Yue Guo, 2018)[13]. From the current preferential tax policies, policy tools such as technology transfer reduction and exemption, preferential tax rate for high-tech enterprises, additional deduction of R&D expenses and accelerated depreciation of fixed assets can directly reduce R&D costs of enterprises, reduce innovation risks, increase after-tax profits of enterprises, increase endogenous financing, and encourage enterprises to increase investment in innovation funds. Sufficient innovation investment is a necessary input factor for enterprises to carry out digital technology reform (Song Tang et al., 2022)[14]. With the increase of innovation investment, manufacturing enterprises can have sufficient funds to purchase the software and hardware equipment needed for digital transformation, and provide the necessary software and hardware basic conditions for digital transformation. At the same time, innovation investment can improve the digital innovation output of enterprises, enhance the digital innovation strength, form innovative achievements such as digital products, processes, business models, supply chain collaborative models and intelligent management, and drive the digital transformation of manufacturing enterprises. Therefore, preferential tax policies can encourage manufacturing enterprises to increase their investment in innovation, and to a great extent solve the problems such as "unable to turn", "afraid to turn" and "unwilling to turn", thus effectively promoting the digital transformation of manufacturing enterprises.

Preferential tax policies can encourage manufacturing enterprises to increase human capital investment, promote the upgrading of human capital of digital skills and drive the digital transformation of enterprises. Enterprise digital transformation is a complex system change that involves the full participation of all employees in various aspects such as technology, business, processes, management, and systems (Yi Pan and Jinchang Zhang, 2023)[15], which requires digital technical talents. The existing personnel structure of manufacturing enterprises is not enough to support and implement the digital strategy, so it is necessary to cultivate and introduce high-quality professionals with digital technology background to support the digital transformation of enterprises. Preferential tax policies can effectively encourage enterprises to increase investment in human capital (Qiren Liu and Can Zhao, 2020)[16]. First of all, digital talents are scarce talents with high wage costs. Tax incentives such as preferential tax rates for high-tech enterprises, tax reductions, and additional deductions for research and development expenses can increase the after tax profits of enterprises, provide them with sufficient funds, enable them to have the ability and conditions to cultivate and introduce digital technical talents, and increase the investment in human capital for digital talents. Secondly, Tax incentives enable manufacturing enterprises to have the ability and conditions to purchase software and hardware equipment required for digital transformation, and investment in digital facilities can promote the upgrading of digital skills and human capital. Classical theory and empirical research on digital technology and human capital find that they are complementary. Qiren Liu and Can Zhao (2020)[16] studied the path and mechanism of upgrading human capital in enterprises based on tax policies. They believe that tax policies, while incentivizing enterprises to add fixed assets, will promote an increase in the relative employment ratio of skilled labor and improve the structure of human capital. Acemoglu and RestRepo (2018)[17] found that the application of digital technologies such as artificial intelligence will increase the demand for highly skilled talents matching this digital technology. Therefore, preferential tax policies can encourage manufacturing enterprises to increase investment in human capital, enhance human capital of digital skills, effectively solve the problem that enterprises can't turn, and promote the digital transformation and development of enterprises.

Based on the above analysis, the following three assumptions are put forward:

H1: Tax incentives have a positive impact on the digital transformation of manufacturing enterprises.

H2: Tax incentives positively affect the digital transformation of manufacturing enterprises by encouraging enterprises to increase their investment in innovation.

H3: Tax incentives positively affect the digital transformation of manufacturing enterprises by encouraging enterprises to increase their investment in human capital.

3. Research Design

3.1. Sample Selection and Date Source

This paper selects manufacturing listed companies in the Shanghai and Shenzhen of A-shares of China as the sample, with a time span of 2017-2022, and conducts the following processing on the sample: (1) The samples that cannot obtain complete data are excluded; (2) Eliminate enterprises with missing required indicators; (3) Eliminate the abnormal companies operated by ST.. After the above processing,

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13,449 data observations from 2,967 listed manufacturing enterprises were selected as the research samples. The relevant data in this paper comes from CSMAR database. In order to avoid the influence of extreme values in the analysis process on the empirical results, all continuous variables are truncated at the quantiles of 1% and 99%, and the extreme values are eliminated

3.2. Selection and Definition of Variables

3.2.1. Independent Variable

Tax preference (TAX) is used as independent variable. This paper uses "0.25-income tax expense/total profit" to measure the strength of tax preference.

3.2.2. Dependent Variable

The degree of digitization (DT) is taken as the dependent variable. In this paper, the digital transformation index from the CSMAR database is selected to measure the degree of digitalization, which is calculated by "0.3472* strategic leading score +0.162* technology driving score +0.0969* organizational empowerment score +0.0342* environmental support score +0.2713* digital achievement score +0.0884* digital application score".

3.2.3. Mediator Variables

Mediator variables are innovation investment (RD) and human capital investment (LABOR). Innovation investment is generally measured by R&D investment (RD). At present, most scholars measure innovation investment by R&D investment intensity or logarithm of R&D investment. In this paper, the innovation investment of enterprises is measured by "R&D investment/operating income". For the measurement of human capital investment in enterprises, there are indicators such as salary payable to employees, employee welfare funds, cash paid to employees and cash paid for employees. This paper selects "the logarithm of the ratio of cash paid to employees and for employees to the number of employees" to reflect the intensity of human capital investment in enterprises.

3.2.4. Control Variables

In addition to the above independent variables and intermediary variables, the digital transformation of enterprises is also affected by many factors. In order to alleviate the interference caused by missing variables, this paper refers to the practices of relevant scholars and selects seven variables as control variables, including asset liability ratio (LEV), revenue growth rate (GROW), cash flow (CASH), fixed asset ratio (PPE), enterprise size (SIZE), equity concentration (CR), and ownership type (OWN). Specific definitions of variables are listed in Table 1:

Table 1: Definition of each variable.

Variable	Name	Symbol	Variable Definition Description
Dependent variable	Degree of digitization	DT	0.3472* strategic leading score +0.162* technology driving score +0.0969* organizational empowerment score +0.0342* environmental support score +0.2713* digital achievement score +0.0884* digital application score
Independent variable	Tax preference	TAX	0.25 minus total income tax expense divided by the profit
Mediator variable	Innovation investment	RD	Research and development expenses divided by sales revenue
	Human capital investment	LABOR	Logarithm of the ratio of cash paid to employees and for employees to the number of employees
Control variable	Cash ratio	CASH	Cash plus cash equivalents divided by current liabilities
	Debt asset ratio	LEV	Total liabilities divided by total assets
	Fixed asset ratio	PPE	Fixed assets divided by total assets
	Revenue growth rate	GROW	Growth in operating revenue/total operating revenue of the previous year
	Ownership type	OWN	1 for state-owned enterprises and 0 for non-state-owned enterprises
	Concentration ratio of shares	CR	The shareholding ratio of the largest shareholder
	The scale of enterprises	SIZE	Natural logarithm of total assets at the end of the period

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3.3. Empirical Model Selection

In order to examine the impact of tax incentives on digital transformation and the mediating effect of innovation investment and human capital investment between the two, that is, to test whether H1, H2, and H3 are valid, the following model is constructed based on the discussion of mediating effects by scholars such as Zhonglin Wen and Baojuan Ye (2014)[18]:

$$DT_{it} = \alpha_0 + \alpha_1 TAX_{it} + \alpha_2 \sum_{K=1}^{7} Controls_{it} + \varepsilon_{it} \quad (1)$$

$$MED_{it} = \beta_0 + \beta_1 TAX_{it} + \beta_2 \sum_{K=1}^{7} Controls_{it} + \varepsilon_{it} \quad (2)$$

$$DT_{it} = \gamma_0 + \gamma_1 TAX_{it} + \gamma_2 MED_{it} + \gamma_3 \sum_{K=1}^{7} Controls_{it} + \varepsilon_{it} \quad (3)$$

Among them, DT_{it}, TAX_{it} and MED_{it} respectively represent the degree of digitization, tax preference and Mediator variable of the I-th sample in the T-th period, $Controls_{it}$ represents the control variables shown in Table 1, and ε_{it} represents the error term.The specific approach is: firstly, verify the coefficient of α_1 in model (1). If the result is significantly positive, it indicates that the greater the tax incentives, the higher the degree of digital transformation. Secondly, the coefficient of β_1 in model (2) is verified. If the result is significantly positive, it shows that increasing the intensity of tax incentives will encourage enterprises to increase investment in innovation and human capital. Finally, the coefficient of γ_2 in model (3) is verified. If the coefficient is significant and regular, it proves the existence of intermediary effect, which shows that tax incentives positively affect the degree of digital transformation through intermediary variables.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

Table 2 shows the descriptive statistical analysis results of all variables. The average degree of digital transformation is 36.35, and the measurement range is between 22.502 and 63.567, which shows that many manufacturing enterprises have undergone digital transformation, and the degree of transformation of different enterprises is different. The average tax preference is 0.117, which shows that most enterprises have enjoyed the benefits of government tax preference policies. The minimum value is -0.528 and the maximum value is 0.841. The positive and negative values in the measured value may be affected by deferred income tax. The average value of innovation investment is 5.092, the maximum value is 25.370, the minimum value is 0.052, and the maximum value is more than 80 times of the minimum value, which reflects that the intensity of innovation investment of different enterprises is quite different. The average value of human capital investment is 11.664, the maximum value is 12.826, and the minimum value is 10.851, which shows that there is little difference in human capital investment among enterprises. The results of control variables are consistent with the existing literature, and will not be repeated here.

Table 2: Descriptive Statistical Results.

VarName	Obs	Mean	SD	Median	Min	Max
DT	13449	36.350	10.022	34.507	22.502	63.567
TAX	13449	0.117	0.155	0.115	-0.528	0.841
RD	13449	5.092	4.184	4.090	0.052	25.370
LABOR	13448	11.664	0.385	11.626	10.851	12.826
LEV	13449	0.378	0.184	0.368	0.059	0.846
GROW	13449	0.184	0.327	0.132	-0.468	1.830
CASH	13449	0.055	0.066	0.052	-0.130	0.249
PPE	13449	0.210	0.126	0.188	0.015	0.588
SIZE	13449	22.062	1.167	21.904	20.025	25.677
CR	13449	33.152	14.074	30.880	9.050	73.190

4.2. Benchmark Regression Analysis

In order to investigate the impact of tax incentives on the digital transformation of enterprises, the model (1) was regressed and the benchmark regression results in Table 3 were obtained. Column (1) is the regression result of single explanatory variable of tax preference and digital transformation, and column (2) is the regression result after adding control variables, with tax preference coefficients of 4.794

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and 4.816 respectively, which are significantly positive at 1% level, indicating that tax preference has a significant promotion effect on digital transformation of manufacturing enterprises. The regression results verify the theoretical analysis and research hypothesis H1 above, and the tax incentives can effectively solve the problems such as "unable to turn", "afraid to turn" and "unwilling to turn" in the process of digital transformation of manufacturing enterprises, and positively affect the digital transformation of manufacturing enterprises.

Table 3: Benchmark Regression Analysis.

VarName	(1) DT	(2) DT
TAX	4.794*** (8.60)	4.816*** (9.30)
LEV		5.662*** (10.77)
GROW		-1.708*** (-6.97)
CASH		-5.124*** (-3.99)
PPE		-21.139*** (-32.36)
SIZE		2.020*** (24.10)
CR		-0.071*** (-12.31)
OWN		-0.942*** (-4.56)
Constant	35.788*** (331.08)	-3.317* (-1.89)
Observations	13,449	13,449
R^2	0.005	0.155
F statistics	74.00***	308.2***

Note: ***, **, and * represent significant (double-tailed) at 1%, 5%, and 10% levels respectively, with t values in brackets.

4.3. Robust Test

4.3.1. Replace the Independent Variable Measurement

Referring to the method of Guangqiang Liu (2016) [19], after changing the measurement index of tax preference to "tax refund/(tax refund+various taxes paid)", the benchmark regression model is regressed. The test results are shown in column (2) of Table 4, and the regression coefficient of tax preference is still positive and significant at the level of 1%, indicating that the result of benchmark regression is robust.

4.3.2. Adjust the Sample Period

In view of the newly emerging concept of digital transformation, the process of digital transformation of enterprises is faster in recent years. This paper shortens the sample period to 2018-2022, and regresses the sample again. The regression results are shown in column (3) of Table 4. The sign and significance of tax preference regression coefficient are the same as those of the original benchmark regression model, and the sign and significance of control variables are basically the same as those of the original model, which shows that the benchmark regression result is robust.

4.3.3. Independent variables lag by one period

To alleviate endogeneity issues that may arise from causal reverse effects, a regression was performed between the lagged explanatory and control variables and the degree of digital transformation. The results are shown in column (4) of Table 4. Except for the difference in coefficient values, the sign and significance of tax preference coefficient are the same as those of the original benchmark regression model, which confirms the robustness of the benchmark regression results.

4.3.4. Quantile Regression

Conventional regression estimation methods may affect the results if there are abnormal extreme

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values in the samples. Therefore, Koenker and Bassett put forward the method of "quantile regression", which adopts the method of multiple quantile regression, and its test results are more robust and can effectively reduce the interference of extreme values. In order to describe the whole picture of the conditional distribution of the explained variables more comprehensively, this paper further adopts the "quantile regression" method for regression. The estimated regression results in columns (5), (6) and (7) of Table 4 are 0.25, 0.5 and 0.75 respectively. It can be seen that the tax preference coefficient is significantly positive at the level of 1%, but it shows a gradual upward trend with the increase of quantile, indicating that the degree of tax preference has a positive impact on the digital transformation of manufacturing enterprises. The greater the tax preference policy, the greater the promotion of digital transformation. We should increase the tax preference to promote the digital transformation of manufacturing enterprises more effectively.

Table 4: Robustness test.

	(1) the original model	(2) substitution variables	(3) adjust the sample period	(4) Explanatory variables lag by one period	(5)q25	(6)q50	(7)q75
Variable	DT	DT	DT	DT	DT	DT	DT
TAX	4.816*** (9.30)		4.460*** (7.49)		3.635*** (5.35)	5.395*** (7.76)	6.763*** (8.08)
TAX1		4.999*** (12.58)					
L.TAX				0.533** (2.27)			
CVs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.317* (-1.89)	-1.857 (-0.96)	-2.105 (-1.03)	-15.171*** (-3.57)	-6.556*** (-4.04)	-9.109*** (-3.74)	-3.926 (-1.43)
Obs	13,449	11,033	9,735	10,386	13,449	13,449	13,449
R^2	0.155	0.167	0.160	0.058			
F statistics	308.2***	275.7***	231.5***	32.10***			

Note: ***, **, and * represent significant (double-tailed) at 1%, 5%, and 10% levels respectively, with t values in brackets.

4.4. Mechanism Inspection

The above analysis shows that tax incentives can drive the digital transformation of manufacturing enterprises. The mechanism test will analyze the intermediary path of tax incentives affecting the digital transformation of manufacturing enterprises, that is, whether tax incentives promote the digital transformation of enterprises by increasing investment in innovation and enhancing investment in human capital?

Firstly, the model (1), model (2) and model (3) are empirically tested by the traditional stepwise regression test method, and the regression results are shown in Panel A in Table 5. Column (1) is the influence of tax incentives on the degree of digitalization, which is consistent with the benchmark regression part and reflects the total effect of tax incentives on the digital transformation of enterprises. Column (2) is the influence of tax incentives on innovation investment, with a coefficient of 4.081 and significant at the level of 1%, indicating that tax incentives can encourage enterprises to increase innovation investment. Column (3) shows the influence of tax incentives and innovation investment on the digital transformation of enterprises, and the innovation investment coefficient is 0.535, which is significant at the level of 1%, indicating that the improvement of innovation investment intensity is beneficial to the digital transformation of enterprises, and the tax incentives coefficient has decreased from 4.816 to 2.633, but it is still significant. The regression results of columns (1), (2) and (3) show that the preferential tax policies positively affect the digital transformation of enterprises by encouraging enterprises to increase innovation investment, and innovation investment plays a partial intermediary role between tax incentives and digital transformation, that is, H2 is verified. Column (4) reflects the impact of tax incentives on human capital investment, and the coefficient is 0.217, which is significant at the level of 1%, indicating that tax incentives are conducive to promoting the increase of human capital investment of enterprises. Column (5) reflects the impact of tax incentives and human capital investment on the digital transformation of enterprises, and the coefficient of human capital investment is 2.921, which is significant at the level of 1%, indicating that the promotion of human capital investment has effectively promoted the digital transformation of enterprises, and the coefficient of tax incentives has dropped from 4.816 to 4.182 and is still significant. The regression results of columns (1), (4) and (5)

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show that the preferential tax policies promote the digital transformation of enterprises by encouraging enterprises to increase the input of human capital, and the input of human capital plays a partial intermediary role between tax incentives and digital transformation, that is, H3 is verified. Column (6) reflects the influence of tax preference, innovation investment and human capital investment on the digital transformation of enterprises. After including two intermediary variables, the coefficients of the three variables are all positive and significant at the level of 1%, and the coefficient of tax preference is reduced from 4.816 to 2.509. The conclusion that innovation investment and human capital investment play an intermediary effect is still valid.

To more rigorously verify the mediating path of tax incentives on corporate digital transformation, this paper adopts a structural equation model of mediating effects for further testing. Panel B in Table 5 provides the corresponding empirical results. The results show that the mediating effect coefficient of innovation investment is 2.183, with a confidence interval of [1.904, 2.463], excluding 0. The mediating effect coefficient of human capital investment is 0.635, with a confidence interval of [0.486, 0.783], excluding 0. This indicates that both innovation investment and human capital investment are mediating pathways for tax preferential policies to promote the digital transformation of manufacturing enterprises. Hypotheses H2 and H2 have been verified: tax preferential policies do indeed stimulate enterprises to increase innovation investment and human capital investment to promote digital transformation.

Table 5: Mechanism Test.

Panel A:stepwise regression test						
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	DT	RD	DT	LABOR	DT	DT
TAX	4.816*** (9.30)	4.081*** (18.58)	2.633*** (5.15)	0.217*** (10.92)	4.182*** (8.09)	2.509*** (4.91)
RD			0.535*** (27.00)			0.501*** (24.07)
LABOR					2.921*** (13.09)	1.208*** (5.26)
CVs	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.317* (-1.89)	11.70*** (15.73)	-9.576*** (-5.56)	10.221*** (151.67)	-33.174*** (-11.56)	-21.524*** (-7.55)
Obs	13,449	13,449	13,449	13,449	13,449	13,449
R^2	0.155	0.128	0.198	0.156	0.166	0.200
F statistics	308.2***	246.7***	369.8***	311.4***	296.4***	336.1***
Panel B:intermediary effect test of structural equation						
The project	coefficient		Bootstrap Std. Err		BC interval 95%	
Direct effect	1.998		0.511		1.632	3.634
Mediating effect: innovation investment	2.183		0.143		1.904	2.463
Mediating effect: human capital investment	0.635		0.076		0.486	0.783
Overall Mediating effect	2.818		0.511		1.508	3.510
Total effect	4.816		0.518		3.801	5.831

Note: ***, **, and * represent significant (double-tailed) at 1%, 5%, and 10% levels respectively, with t values in brackets.

4.5. Heterogeneity Analysis

4.5.1. Heterogeneity of Enterprise Scale

According to the scale of enterprise assets, listed manufacturing companies are divided into three groups: small, medium and large. From Table 6, it can be found that the tax preferential coefficient of small manufacturing enterprise group is not significant, while that of medium-sized and large-sized

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enterprises is significant at the level of 5% and 1% respectively, indicating that tax preferential policies have the greatest promotion effect on the digital transformation of large manufacturing enterprises, and the promotion effect on the digital transformation of medium-sized manufacturing enterprises is also significant, but the impact on the digital transformation of small manufacturing enterprises is not obvious. There are two possible reasons: First, the digital transformation of enterprises needs to invest a lot of money to buy software and equipment, and use information technology to rebuild existing processes and systems. Medium and large manufacturing enterprises have abundant funds and resources to provide the necessary material and hardware conditions for digital transformation, while small manufacturing enterprises provide relatively insufficient conditions for manufacturing transformation. Second, the digital transformation of enterprises is a complex system engineering, which involves the participation of all employees in all links and positions of enterprises and requires a large number of digital technical talents. Large and medium-sized manufacturing listed companies can provide generous treatment and introduce high-quality professionals with digital technology background to support the digital transformation of enterprises, while small manufacturing listed companies provide relatively insufficient conditions for attracting digital technology talents. Therefore, preferential tax policies have a significant role in promoting the digital transformation of large and medium-sized manufacturing enterprises, but have a limited impact on the digital transformation of small manufacturing enterprises.

4.5.2. Heterogeneity of Enterprise Growth

According to the growth rate of enterprise sales revenue, listed manufacturing companies are divided into three groups: low growth, medium growth and high growth. As can be seen from Table 6, the tax preferential coefficients of the low-growth and medium-growth groups are significant at the level of 1%, while the high-growth group is not significant, indicating that the tax preferential policies have a significant role in promoting the digital transformation of low-growth and medium-growth manufacturing enterprises, but have insufficient influence on the digital transformation of high-growth manufacturing enterprises. The possible explanation comes from the theory of enterprise life cycle. Enterprises with medium or low growth tend to be mature or close to maturity, and have strong profitability and financial strength, which can provide sufficient hardware conditions for the digital transformation of enterprises and attract high-quality digital talents. Therefore, tax preferential policies can effectively promote the digital transformation of low-growth and medium-growth manufacturing enterprises. Most high-growth enterprises are located in the initial stage or growth stage, which may have high financing constraints, and the hardware conditions and human resources conditions provided for digital transformation are relatively insufficient. Therefore, the impact of tax incentives on the digital transformation of high-growth manufacturing enterprises is not significant.

Table 6: Heterogeneity Analysis —— Discussion Based on Enterprise Scale and Growth.

	Scale heterogeneity			growth heterogeneity		
	Small	medium	large	low	medium	high
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	DT	DT	DT	DT	DT	DT
TAX	0.364	0.926**	1.712***	1.286***	1.136***	0.859
	(0.99)	(2.51)	(4.02)	(3.90)	(2.97)	(1.61)
CVs	Yes	Yes	Yes	Yes	Yes	Yes
Constant	37.430***	38.617***	42.827***	-33.938***	-69.142***	-21.424***
	(46.32)	(43.21)	(43.21)	(-3.67)	(-7.84)	(-4.10)
Obs	4,483	4,483	4,483	4,483	4,483	4,483
R^2	0.093	0.058	0.035	0.054	0.137	0.154
F statistics	23.95***	14.63***	11.64***	17.01***	40.47***	34.45***

Note: ***, **, and * represent significant (double-tailed) at 1%, 5%, and 10% levels respectively, with t values in brackets.

5. Conclusion and policy implication

5.1. Conclusion

Manufacturing enterprises are the main market players in promoting the national strategy of digital technology transformation. It is of great theoretical and practical significance to study how to effectively promote the digital transformation and upgrading of manufacturing enterprises by using preferential tax policies for implementing the digital economy strategy. Therefore, this paper takes the listed companies

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of A-share manufacturing industry in Shanghai and Shenzhen as samples, and investigates the influence and mechanism of tax incentives on digital transformation based on the intermediary effect model. The research shows that: firstly, the preferential tax policies can effectively solve the problems of " unable to turn", "afraid to turn" and "unwilling to turn" in the process of digital transformation of manufacturing enterprises, and promote the digital transformation of manufacturing enterprises. The greater the intensity of preferential tax policies, the greater the promotion of digital transformation of enterprises. Second, tax incentives positively affect the digital transformation of manufacturing enterprises by encouraging them to increase their investment in innovation and human capital. Thirdly, the incentive effect of tax incentives on the digital transformation of manufacturing enterprises is heterogeneous, with a greater incentive effect on the data-driven transformation of medium and large manufacturing enterprises, as well as medium and low growth manufacturing enterprises

5.2. Policy Implication

This paper has the following policy implications: First, strengthen and improve the preferential tax policies to help the digital transformation of manufacturing enterprises. The research results show that tax incentives can effectively promote the digital transformation of manufacturing enterprises, and the greater the tax incentives, the greater the promotion. Therefore, we should build a long-term tax incentive mechanism oriented to the digital transformation of manufacturing enterprises, strengthen and improve the tax incentive system for the digital transformation of manufacturing enterprises, and maximize the digital transformation of manufacturing enterprises. Second, Tax incentive policies should be implemented with innovation investment and human capital investment as the focus. The research shows that tax incentives can effectively promote the digital transformation of manufacturing enterprises through the intermediary path of encouraging manufacturing enterprises to increase their investment in innovation and human capital. Therefore, the preferential tax policy should focus on encouraging manufacturing enterprises to increase investment in innovation and human capital, so as to promote the digital transformation of manufacturing enterprises more effectively. Third, Differentiated tax incentive policies should be implemented. The results show that the incentive effect of tax preferential policies on the digital transformation of different manufacturing enterprises is heterogeneous. Therefore, we should further refine the tax incentive policies and implement differentiated tax incentive policies for enterprises with different scales and different growth rates, so that all kinds of enterprises can be encouraged by tax preferential policies to carry out digital transformation, and then enhance the digital transformation of the overall manufacturing enterprises.

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