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Tax incentives, marketization level, and corporate digital transformation

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ABSTRACT

This paper uses data from Chinese listed companies from 2012 to 2022 to analyze the relationship between tax incentives, marketization level, and corporate digital transformation. The results indicate that tax incentives can promote digital transformation in enterprises, and marketization levels can accelerate this transformation. There is a threshold effect on the influence of tax incentives on digital transformation; financing constraints act as a mediator in this relationship, while technological innovation capability plays a moderating role between marketization level and digital transformation. Furthermore, the moderating effect of technological innovation capability varies across different types of enterprises in terms of their relationship with marketization and digital transformation.

1. Introduction

In the context of global economic integration and rapid advancement of information technology, digital transformation has become a crucial pathway for enterprises to enhance core competitiveness and achieve sustainable development. With the emergence of big data, cloud computing, the Internet of Things, and artificial intelligence, traditional business and operational models are undergoing unprecedented changes. Digital transformation not only helps companies optimize processes and improve efficiency but also expands new market opportunities and boosts resilience against market risks. However, digital transformation is a systemic project requiring significant capital investment, technological innovation, and transformative management practices, posing a considerable challenge for many firms, especially small and medium-sized enterprises.

In recent years, the Chinese government has prioritized digital transformation through various policy measures, especially tax incentives, to encourage and support technological innovation and industrial upgrading. As a crucial tool of macroeconomic regulation, tax incentives aim to reduce the burden on enterprises, activate market dynamics, and promote high-quality economic development (Jünger & Mietzner, 2020). Simultaneously, the progressive improvement of marketization levels provides a more open, fair, and transparent competitive environment for digital transformation. Market reforms enhance market mechanisms, optimize resource allocation, and strengthen legal safeguards, creating favorable conditions for digital transformation. However, there are substantial differences among different types of enterprises in utilizing tax incentives and adapting to a marketized environment, which directly affects their progress and outcomes in digital transformation (Singh, 2020).

Nationally, there is an increasing volume of research on the relationship between tax incentives, marketization levels, and digital transformation. Scholars generally agree that tax incentives significantly reduce the costs and risks associated with digital

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transformation, boosting corporate investment intentions and innovation capability (Goodell & Goutte, 2021). For instance, reductions in value-added tax and income taxes, as well as deductions for R&D expenses, directly alleviate financial burdens, allowing more funds to be allocated to upgrading digital technologies and equipment. Additionally, the enhancement of marketization levels through greater market competition and optimized resource allocation further accelerates digital transformation (Dowling & Lucey, 2023). However, existing research also points out that the impact of tax incentives on digital transformation is not linear, exhibiting threshold effects where the marginal benefits may decrease once firms reach a certain size or technology level. Moreover, the moderating role of technological innovation capability in the relationship between marketization level and digital transformation merits attention, but the heterogeneity among different types of enterprises needs further exploration.

Internationally, research also highlights the significant impact of tax policies and market environments on digital transformation. Developed countries, such as those in Europe and the United States, implement a range of tax incentives, including investment tax credits and accelerated depreciation, to promote technological upgrading and digital transformation (Corbet et al., 2020). These countries' advanced market economies provide an excellent competitive environment and innovation ecosystem, further accelerating digital transformation. However, international studies also emphasize that differences in market environments, tax systems, and corporate cultures among countries and regions could lead to varying pathways and effects of tax incentives on digital transformation (Khan et al., 2022).

Given this background, this paper aims to delve into the complex relationship between tax incentives, marketization level, and corporate digital transformation, uncovering their underlying mechanisms. The specific objectives include: analyzing the direct promotion and threshold effects of tax incentives on digital transformation; exploring how marketization levels influence the willingness and capability for digital transformation; examining the mediating role of financing constraints in the relationship between tax incentives and digital transformation; and revealing the moderating role of technological innovation capability between marketization level and digital transformation and exploring its heterogeneity among different types of enterprises.

By systematically analyzing data from Chinese listed companies from 2012 to 2022, this study enriches the theoretical framework of the relationship between tax incentives, marketization level, and digital transformation, providing valuable insights for policymakers. Primarily, the research uncovers the multifaceted influence of tax incentives on the process of digital transformation, encompassing direct facilitation, threshold impacts, and mediation via financing limitations. This finding offers empirical substantiation for refining tax policies. Furthermore, it delves deeply into the manner in which marketization levels propel digital transformation forward, furnishing theoretical underpinning for market reforms and augmenting the innovation ecosystem. Notably, this study stands as the inaugural examination comprehensively elucidating the moderating function of technological innovation capacity within the nexus between marketization level and digital transformation. It highlights the variability of this relationship across diverse enterprise types, thereby furnishing scientific rationale for businesses to formulate tailored digital transformation strategies aligned with their unique attributes.

2. Theoretical analysis and research hypotheses

Tax incentive policies play a significant role in promoting the digital transformation of enterprises. These policies can substantially reduce the financial burden on companies, increasing the funds available for digital transformation. By offering tax reductions, exemptions, and additional deductions for R&D expenses, businesses can save substantial amounts and invest these savings into the introduction and upgrading of digital technologies and equipment, as well as talent development. This not only enhances the technological capability of enterprises but also provides the necessary material foundation for their digital transformation (Bingler et al., 2022). Tax incentives can also strengthen a company's willingness to undergo digital transformation. Encouraged by tax incentives, companies are more inclined to explore new digital technologies and business models to achieve higher production efficiency and market competitiveness. This positive atmosphere of innovation helps drive companies to continuously explore and practice new pathways in digital transformation (Wen et al., 2022). Furthermore, tax incentives can indirectly promote digital transformation by improving corporate financing environments. Supported by tax policies, companies can improve their profitability and creditworthiness, making it easier to obtain loans and other forms of financial backing from institutions. These funds can be invested in digital transformation projects, further accelerating the process (Nguyen et al., 2020).

Based on the above analysis, this paper proposes the following hypotheses.

H1. Tax policies will encourage companies to increase their investments in environmental protection.

The level of marketization plays a crucial role in driving the digital transformation of enterprises. An increase in marketization implies intensified market competition and diversified consumer demands. In such an environment, companies must constantly seek innovation and improvement to remain competitive and meet market needs (Liu et al., 2021). Digital transformation, as an essential innovation tool, can help enhance production efficiency, optimize supply chain management, and improve customer service capabilities, enabling companies to stand out in market competition. Higher levels of marketization promote the sharing and dissemination of information resources. In a highly marketized environment, information flows more rapidly and widely, allowing companies easier access to the latest market trends and technological developments. This provides strong informational support for companies undertaking digital transformation, enabling them to better seize market opportunities and technological trends (Murinde et al., 2022). Moreover, higher marketization levels foster digital transformation by refining market mechanisms and optimizing resource allocation. In environments with higher marketization, market mechanisms function more effectively, and resources are allocated more efficiently to competitive companies and projects (Feng et al., 2022). This creates a favorable external environment and resource support for businesses pursuing digital transformation, reducing the risk and cost of transition.

Based on the above analysis, this paper proposes the following hypotheses.

H2. Marketization can propel the digital transformation of enterprises.

Tax incentive policies may have a threshold effect on the digital transformation of enterprises. These policies are often designed and implemented for businesses of specific sizes or industries, which means there is a threshold for different enterprises to benefit from tax incentives (Rupeika-Apoga et al., 2022). Small-scale or startup companies may not qualify for the policy requirements and thus miss out on tax benefits, somewhat limiting their digital transformation progress (Li et al., 2023). Additionally, the range and strength of tax incentives are limited; since digital transformation requires substantial investment in funds and resources, tax incentives might only cover part of these costs. For projects with significant investment, the incentives' effects may be relatively limited, thus creating a threshold effect. Lastly, the long-term stability of tax incentives affects company decisions regarding digital transformation (Zeng et al., 2022). If businesses perceive tax incentives as temporary or unstable, they may become more cautious in making long-term digital transformation investments or even decide to wait for a more stable policy environment, highlighting the threshold effect (Zhao et al., 2023).

Based on the above analysis, this paper proposes the following hypotheses.

H3. There is a threshold effect on the impact of tax incentive policies on the digital transformation of enterprises.

Financing constraints, which refer to the high costs or inefficiencies businesses face when seeking external financing, are significant factors limiting corporate development. Digital transformation demands significant financial investment in areas such as technological research and development, equipment upgrades, and talent development. However, financing constraints often restrict companies' investment capacity (Shang et al., 2023). Tax incentives help alleviate companies' financing challenges by increasing cash flow and improving credit ratings. For instance, the VAT deduction and refund policy directly boosts companies' own funds, acting as an "interest-free loan" that helps firms more flexibly allocate funds for digital transformation. Additionally, tax incentives send positive signals to the market, boosting investor confidence in companies, which aids them in obtaining more external financing support (Zhuo & Chen, 2023). This signaling effect not only reduces financing costs for enterprises but also broadens their financing channels, providing a more solid financial foundation for digital transformation. Based on the aforementioned analysis, the following hypothesis is proposed.

H4. Financing constraints play a mediating role in the relationship between tax incentives and corporate digital transformation.

Tax incentives can lead to savings for enterprises, increasing the funds available for investment in digital transformation. However, for many companies, even with tax incentives, the substantial investment required for digital transformation remains a significant challenge (Li & Shen, 2021). At this point, financing constraints become an important mediating factor. If a company faces severe financing constraints, tax incentives alone may not garner sufficient funds for digital transformation (Gaglio et al., 2022). Financing constraints also impact the extent to which companies can leverage tax incentives. Some companies, due to limited financing channels, may not fully utilize the financial advantages brought by tax incentives, thereby restricting their investment in digital transformation. Financing constraints can indirectly affect the relationship between tax incentives and corporate digital transformation through their impact on business investment decisions. When businesses face financing constraints, their investment decisions might become more cautious, leading to hesitation in pursuing long-term, high-risk investment projects like digital transformation. Such hesitation could weaken the supportive role of tax incentives in digital transformation (Skare et al., 2023). Based on the analysis, the following hypothesis is formulated.

H5. Technological innovation capability moderates the relationship between marketization level and corporate digital transformation.

Different types of companies exhibit variations in technological innovation capability, leading to diverse adaptability and responses to the correlation between marketization levels and digital transformation (Tavoletti et al., 2022). Companies with strong technological innovation capabilities can better capitalize on opportunities presented by marketization, driving digital transformation through innovation and gaining a competitive edge in the market (Santoro et al., 2022). The heterogeneity in technological innovation capability also manifests in the speed of response to market changes. Some companies with strong innovative abilities can swiftly perceive market changes and flexibly adjust their digital transformation strategies to meet evolving market demands. In contrast, companies with weaker innovation capacities may exhibit lag in this aspect. Differing technological innovation capabilities also influence firms' pathway choices during digital transformation (Yu et al., 2020). Some companies might prefer spearheading digital transformation through independent R&D and innovation, whereas others may lean toward adopting external technologies and collaborations (Lutfi et al., 2022). These pathway differences further impact the relationship between marketization levels and digital transformation. Based on the above analysis, the following hypothesis is established.

H6. Technological innovation capability demonstrates heterogeneous characteristics in moderating the relationship between marketization levels and corporate digital transformation in different types of enterprises.

3. Study design

3.1. Sample selection

The present study focuses on listed companies from the Shanghai and Shenzhen A-share markets spanning the period from 2012 to 2022, initially constituting the research sample. Following a rigorous screening process, financial sector companies, those labeled as PT, ST, *ST, and any with incomplete financial data were excluded. This resulted in a refined dataset comprising 34,676 valid observations. In order to alleviate the potential distorting effects of outliers on the data analysis, the study adopted a winsorization approach. This involved adjusting continuous variables to fall within the 1%–99% range, effectively minimizing the disruption caused by extreme values.

3.2. Definition of variables

3.2.1. Dependent variable

Digital Transformation (*transformation*): For an in-depth examination of enterprise digital transformation, this research utilizes text analysis. By harnessing the powerful capabilities of Python in conjunction with big data web scraping techniques, we systematically gather keywords related to digitalization. These keywords are subsequently categorized and consolidated into distinct vocabularies. The aggregate frequency of these keywords serves as a crucial metric for assessing the extent of an enterprise's digital transformation; a higher frequency indicates a more advanced level of digitalization. Recognizing the right-skewed nature of the collected data, this study further applies logarithmic transformation to ensure more precise analysis.

3.2.2. Independent variables

Tax Incentives (*policy*): This study measures the situation of tax refunds by using the ratio of 'various tax refunds received' to 'total of taxes refunded plus taxes paid.' Tax refunds include refunds of multiple types of taxes, while taxes encompass those accrued and prepaid in each period.

Marketization Level (*marketization*): To evaluate the degree of marketization across various regions, this study adopts the meticulously constructed marketization index developed by the National Economic Research Institute. This index encompasses five pivotal dimensions: government-market interplay, expansion of the non-state sector, product market maturity, factor market development, enhancement of market intermediary organizations, and robustness of the legal framework. These dimensions are further disaggregated into detailed secondary indicators.

3.2.3. Moderator variable

Technological Innovation Capacity (*Innovation*): To evaluate a company's technological innovation capacity, this study takes the number of invention patents held by listed companies as a base and measures it through quantification of these numbers.

3.2.4. Intermediary variable

Financing Constraints (*SA*): To quantify the level of a company's financing constraints, this study adopts the SA index as a specific indicator and measures it by calculating its absolute value.

Table 1
Definition of variables.

Variable type	Variable name	Variable symbol	Variable definition
Dependent variable	Digital transformation	<i>transformation</i>	Leverage Python's big data web scraping capabilities to gather keywords related to digitization and evaluate their numerical values.
Independent variables	Tax incentives	<i>policy</i>	Tax rebates received/(Tax rebates received + Taxes paid)
	Marketization level	<i>marketization</i>	Measured by the marketization index developed by the National Institute for Economic Research
Moderator variable	Technological innovation capacity	<i>Innovation</i>	Ln(Number of Invention Patents Held by Listed Companies)
Intermediary variable	Financing constraints	<i>SA</i>	Take the absolute value of the enterprise SA index.
Control variables	Company size	<i>size</i>	Ln(Total Assets of the Enterprise)
	Debt-to-asset ratio	<i>level</i>	Total Liabilities/Total Assets
	Net profit margin on total assets	<i>roa</i>	Net Profit/Total Assets
	Nature of the company	<i>state</i>	State-owned enterprises are assigned a value of 1, otherwise 0.
	Company age	<i>age</i>	Logarithm of the Age of Companies at IPO
	Ownership concentration	<i>first</i>	Number of shares held by the largest shareholder/Total number of shares
	Dual role of CEO and chairman	<i>Dual</i>	If the chairman and the general manager are the same person, enter 1; otherwise, enter 0.
	Management expense ratio	<i>Mfee</i>	Administrative Expenses/Operating Revenue

3.2.5. Control variables

The control variables in this study include: company size (*size*), debt-to-asset ratio (*level*), net profit margin on total assets (*roa*), nature of the company (*state*), company age (*age*), ownership concentration (*first*), dual role of CEO and chairman (*Dual*), and management expense ratio (*Mfee*).

All variable definitions are shown in Table 1.

3.3. Model construction

To verify the hypothesis presented earlier, this paper establishes a fixed effects model, while controlling for individual effects and annual effects.

$$\text{transformation}_{i,t} = \alpha_0 + \alpha_1 \text{policy}_{i,t} + \sum_{k=1}^n \alpha_k \text{control}_{i,t} + \varepsilon_{i,t} \tag{1}$$

$$\text{transformation}_{i,t} = \beta_0 + \beta_1 \text{marketization}_{i,t} + \sum_{k=1}^n \beta_k \text{control}_{i,t} + \varepsilon_{i,t} \tag{2}$$

$$SA_{i,t} = \delta_0 + \delta_1 \text{Policy}_{i,t} + \sum_{k=1}^n \delta_k \text{control}_{i,t} + \varepsilon_{i,t} \tag{3}$$

$$\text{transformation}_{i,t} = \lambda_0 + \lambda_1 \text{policy}_{i,t} + \lambda_2 SA_{i,t} + \sum_{k=1}^n \lambda_k \text{control}_{i,t} + \varepsilon_{i,t} \tag{4}$$

$$\begin{aligned} \text{transformation}_{i,t} = & \zeta_0 + \zeta_1 \text{marketization}_{i,t} + \zeta_2 \text{Innovation}_{i,t} \\ & + \zeta_3 (\text{marketization} * \text{Innovation})_{i,t} + \sum_{k=1}^n \zeta_k \text{control}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

4. Empirical analysis

4.1. Descriptive statistical analysis

Based on the statistical results from Table 2, it can be observed that the average and median values of variables such as the degree of digital transformation, marketization level, technological innovation capability, and enterprise size of the sampled companies are relatively high. This indicates that the sample companies are performing well in these aspects. However, the average value of tax incentives enjoyed is quite low, suggesting that most companies may not be fully benefiting from tax rebates. There is a significant disparity between the maximum and minimum values of the financial indicators, namely the asset-liability ratio and the net profit margin of total assets, indicating considerable data fluctuations in these two variables. Overall, the sample data exhibits a certain degree of diversity and variability in terms of corporate characteristics and operational performance.

4.2. Main test regression results

According to the regression results in column 1 of Table 3, the coefficient of the tax incentive policy (*policy*) is 0.0676, which passed the significance test at the 1% level. This indicates that tax incentives can promote the digital transformation of enterprises, confirming Hypothesis 1. According to the results in Table 2, the coefficient of marketization (*marketization*) is 0.0275, which also passed the significance test at the 1% level. This suggests that the level of marketization can similarly promote the digital transformation of enterprises, confirming Hypothesis 2.

Table 2
Descriptive statistical analysis.

VarName	Obs	Mean	SD	Min	Median	Max
<i>transformation</i>	34676	3.0149	1.2553	0.0000	2.9957	5.8889
<i>policy</i>	34676	0.1636	0.2128	0.0000	0.0625	0.8426
<i>marketization</i>	34676	9.8984	1.7013	4.4480	10.1530	12.8640
<i>Innovation</i>	34676	3.9345	1.6873	0.0000	4.0604	7.9943
<i>SA</i>	34676	3.8271	0.2536	3.1514	3.8312	4.4486
<i>size</i>	34676	22.1782	1.3157	19.7358	21.9834	26.2734
<i>level</i>	34676	0.4136	0.2076	0.0533	0.4011	0.9203
<i>roa</i>	34676	0.0585	0.0730	-0.2316	0.0552	0.2825
<i>age</i>	34676	2.1271	0.8652	0.1040	2.2663	3.3780
<i>state</i>	34676	0.3622	0.4807	0.0000	0.0000	1.0000
<i>first</i>	34676	0.3423	0.1492	0.0860	0.3200	0.7489
<i>Dual</i>	34676	0.2766	0.4473	0.0000	0.0000	1.0000
<i>Mfee</i>	34676	0.0847	0.0692	0.0080	0.0668	0.4274

Table 3
Results of the main regression test.

VARIABLES	(1)	(2)
	transformation	transformation
<i>policy</i>	0.0676*** (2.8683)	
<i>marketization</i>		0.0275*** (3.1483)
<i>size</i>	0.2595*** (34.0711)	0.2596*** (34.0757)
<i>level</i>	-0.0046 (-1.3574)	-0.0045 (-1.3422)
<i>roa</i>	-0.0165 (-1.2886)	-0.0155 (-1.2099)
<i>age</i>	-0.0192 (-1.6394)	-0.0196* (-1.6741)
<i>first</i>	0.0771 (1.3827)	0.0803 (1.4401)
<i>Mfee</i>	-0.0002 (-0.0074)	-0.0001 (-0.0059)
<i>Constant</i>	-3.5490*** (-21.5246)	-3.4777*** (-19.4043)
<i>Observations</i>	34,676	34,676
<i>R-squared</i>	0.4212	0.4211
<i>ID FE</i>	YES	YES
<i>Year FE</i>	YES	YES

4.3. Endogeneity test

There may be an endogenous relationship between tax incentives and the digital transformation of enterprises. Tax incentives act as a policy stimulus by reducing the tax burden on enterprises, providing financial support for their digital transformation, and lowering the costs of transformation, thereby motivating enterprises to advance their digital initiatives. Additionally, the success of a company's digital transformation can further enhance productivity and profitability, contributing more to government tax revenue and creating a virtuous cycle. To address the potential endogeneity issue between tax incentives and enterprise digital transformation, this study uses the lag of one period in tax incentives (denoted as *L.policy*) as an instrumental variable. This variable is closely related to current tax incentives but has minimal impact on the current digital transformation of enterprises. The results of the endogeneity test are shown in Table 4. In the first stage, the regression coefficient of the instrumental variable on tax incentives reached 0.87 and was significant at the 1% level, confirming the effectiveness of the instrumental variable. Moreover, the F-value in the first stage was as high as 69236.12, far exceeding the critical value suggested by empirical rules, further proving the relevance of the instrumental variable. In the second stage, the coefficient for the predicted value of tax incentives (*policy*) was 0.426, also significant at the 1% level, indicating that even after accounting for endogeneity, tax incentives continue to positively drive corporate digital transformation significantly.

4.4. Threshold effect analysis

To investigate whether tax incentives for businesses exhibit a threshold effect on digital transformation, this study selects company size as the threshold variable and conducts a threshold regression analysis. The results indicate that at the 1% significance level, the test for the first threshold value passes significantly ($P = 0.004$), with the corresponding threshold value being 22.588. This suggests that the effect of tax incentives on digital transformation in companies indeed has a threshold effect (see Table 5 and Table 6).

Based on translation committee leveraged the threshold test results to conduct a single-threshold effect regression, with detailed results presented in Table 7. The findings reveal that when the company size is below the threshold value of 22.588, the effect coefficient of tax incentives on digital transformation is 0.0536, which does not pass the significance test. This indicates that for smaller

Table 4
Endogeneity test results.

	(1)	(2)
	Phase One	Phase Two
<i>policy</i>		
<i>L.policy</i>	0.8700*** (263.13)	
<i>policy</i>		0.4260*** (10.85)
<i>Controlvariable</i>	Yes	Yes
<i>LM Value (Unidentifiable Test)</i>	20883.61	
<i>First Stage F-Statistic (Weak Instrument Test)</i>	69236.12	

Table 5
Results of the triple threshold effect test (1).

<i>model</i>	Threshold	Lower	Upper
<i>Th-1</i>	22.588	22.5046	22.6191
<i>Th-21</i>	22.5201	22.4854	22.5564
<i>Th-22</i>	22.0231	21.9615	22.0545
<i>Th-3</i>	20.5687	20.3738	20.6454

Table 6
Results of the triple threshold effect test (2).

<i>Threshold</i>	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
<i>Single</i>	8648.7201	0.37	47.04	0.004	22.8698	27.7511	37.847
<i>Double</i>	8641.9067	0.3697	18.43	0.11	18.0611	20.9804	29.5482
<i>Triple</i>	8638.1337	0.3695	10.21	0.63	25.0065	32.7638	40.3703

Table 7
Single threshold effect regression results.

	transformation
<i>policy(size≤22.588)</i>	0.0536 (0.7042)
<i>policy(size>22.588)</i>	0.2427*** (3.1074)
<i>size</i>	0.4057*** (19.6001)
<i>level</i>	-0.0026 (-0.3974)
<i>roa</i>	-0.0119 (-0.5349)
<i>age</i>	0.8844*** (27.2089)
<i>first</i>	-0.0054 (-0.0357)
<i>Mfee</i>	0.0002*** (14.1776)
<i>_cons</i>	-8.5069*** (-20.0980)
<i>N</i>	23386
<i>r²</i>	0.3685
<i>F</i>	625.1139

companies, tax incentives do not play a significant role in driving digital transformation. However, once a company surpasses this threshold size, the effect coefficient of tax incentives jumps to 0.2427, significantly impactful at the 1% significance level. This strongly suggests that for larger companies, tax incentives have a substantial and positive impact on digital transformation. Therefore, before and after an enterprise reaches a specific threshold size (22.588), there exists a significant difference in the promotional effect of preferential tax policies on its digital transformation, shifting from insignificant to significant and positive, thereby verifying the correctness of Hypothesis 3.

4.5. Analysis of mediating effects

According to the results in Column 1 of Table 8, the coefficient for the tax incentive policy (*policy*) is -0.0084, which is statistically significant at the 1% level. This indicates that the tax incentive policy has a significant effect in alleviating companies' financial pressure. Further analysis of the results in Column 2 of Table 8 reveals that the coefficient for financing constraint (*SA*) is -0.2523, highlighting that financing constraints inhibit the digital transformation of firms. From the combined analysis, it can be concluded that financing constraints play a mediating role in the relationship between tax incentive policies and companies' digital transformation. This finding supports the validity of Hypothesis 4. Thus, by reviewing financial institutions, government support programs, and internal corporate strategies, financing constraints can be effectively alleviated, thereby promoting the digital transformation of enterprises.

4.6. Analysis of moderating effect

As shown in Table 9, the coefficients for marketization and innovation are both positive and have passed the significance test,

Table 8
Mediation effect results.

VARIABLES	(1)	(2)
	SA	transformation
<i>policy</i>	-0.0084*** (-2.6013)	0.0672*** (2.7542)
<i>SA</i>		-0.2523*** (-4.7052)
<i>size</i>	0.0221*** (26.9491)	0.2539*** (32.9522)
<i>level</i>	-0.0102*** (-28.0119)	-0.0020 (-0.5880)
<i>roa</i>	-0.0248*** (-17.9717)	-0.0103 (-0.7958)
<i>age</i>	0.0232*** (18.3613)	-0.0251** (-2.1276)
<i>first</i>	-0.0848*** (-14.0971)	0.0985* (1.7609)
<i>Mfee</i>	-0.0000 (-0.9572)	0.0000 (0.0186)
<i>Constant</i>	3.1160*** (175.2983)	-4.3352*** (-18.4714)
<i>Observations</i>	34,676	34,676
<i>R-squared</i>	0.8000	0.4216
<i>ID RE</i>	YES	YES
<i>Year FE</i>	YES	YES

Table 9
Moderating effect results.

VARIABLES	(1)	(2)
	transformation	transformation
<i>marketization</i>	0.0264*** (3.0215)	0.0268*** (3.1483)
<i>Innovation</i>	0.0234*** (4.5359)	0.0361*** (5.9244)
<i>marketization*Innovation</i>		0.0413*** (2.8012)
<i>size</i>	0.2553*** (33.2582)	0.2557*** (33.2187)
<i>level</i>	-0.0051 (-1.5064)	-0.0051 (-1.5064)
<i>roa</i>	-0.0166 (-1.2992)	-0.0167 (-1.3002)
<i>age</i>	-0.0209* (-1.7819)	-0.0204* (-1.7334)
<i>first</i>	0.0878 (1.5746)	0.0852 (1.5245)
<i>Mfee</i>	-0.0000 (-0.0019)	0.0000 (0.0017)
<i>Constant</i>	-3.4506*** (-19.2491)	-3.5073*** (-17.8333)
<i>Observations</i>	34,676	34,676
<i>R-squared</i>	0.4215	0.4215
<i>ID FE</i>	YES	YES
<i>Year FE</i>	YES	YES

indicating that tax incentives and innovation can significantly promote the digital transformation of enterprises. Furthermore, the interaction term between marketization and innovation has a coefficient of 0.0413, which has passed the significance test at the 1% level. This suggests that innovation plays a moderating role in the relationship between marketization and the digital transformation of enterprises. Technological innovation capability has a direct and significant driving effect on enterprise digital transformation. Meanwhile, technological innovation capability also enhances the positive impact of marketization level on enterprise digital transformation, playing a crucial moderating role.

4.7. Heterogeneity test of the moderating effect

The results of the heterogeneity test for the moderating effect are shown in Table 10. In the sample of state-owned enterprises, the coefficient of the interaction term between marketization level and technological innovation capability (*marketization* Innovation*) is 0.0126, which is significant at the 10% level. In the sample of non-state-owned enterprises, the coefficient of the interaction term (*marketization* Innovation*) is 0.0271, significant at the 1% level. Overall, the moderating effect of technological innovation capability on the relationship between marketization level and enterprise digital transformation is more pronounced in non-state-owned enterprises, confirming Hypothesis 6. The reason for this heterogeneity mainly lies in the significant differences in the moderating effect of technological innovation capability, which are attributed to the variations in scale, industry distribution, and policy environment between state-owned enterprises and non-state-owned enterprises.

5. Conclusions

This study, based on data from Chinese listed companies from 2012 to 2022, delves into the complex relationships between tax incentives, marketization levels, and corporate digital transformation. The findings reveal that tax incentives significantly promote digital transformation in enterprises, indicating that the government's strategy of using tax benefits to encourage digital transformation is effective. The enhancement of marketization levels also significantly advances the process of digital transformation, confirming the positive impact of a competitive market environment on corporate innovation. However, the influence of tax incentives on digital transformation is not without thresholds, suggesting that policymakers need to design tax incentives more precisely to ensure they effectively cover and motivate more enterprises to undergo digital transformation. Financing constraints play an important mediating role in the relationship between tax incentives and digital transformation, indicating that while enjoying tax benefits, companies also need sufficient financial support to smoothly implement digital transformation. Technological innovation capability significantly moderates the relationship between marketization levels and digital transformation, highlighting the crucial role of technological innovation in enabling companies to adapt to market changes and achieve digital transformation. The heterogeneous characteristics of technological innovation capability among different types of enterprises further enrich the understanding of the relationship between marketization levels and digital transformation, suggesting that companies need to fully consider their own technological innovation capabilities and type characteristics when advancing digital transformation.

Author contributions

Chao Fu: Conceptualization, Methodology, Writing-Original Draft, Funding Acquisition.

Dianyng Luo: Data Collection, Data Analysis, Supervision.

Jiaoshu Zhang: Data Collection, Project Administration, Visualization.

Wenxia Li: Data Collection, Writing – Review & Editing.

Table 10
Results of heterogeneity test of the moderating effect.

VARIABLES	State-owned enterprises	Non-state-owned enterprises
	transformation	transformation
<i>marketization</i>	0.0172* (1.8215)	0.0271*** (4.0315)
<i>Innovation</i>	0.0202*** (4.1457)	0.0263*** (5.1438)
<i>marketization*Innovation</i>	0.0126* (1.8014)	0.0426*** (3.0127)
<i>size</i>	0.2102*** (16.3417)	0.2862*** (29.4032)
<i>level</i>	-0.0489* (-1.6759)	-0.0031 (-0.9214)
<i>roa</i>	0.2471*** (2.8202)	-0.0227* (-1.7806)
<i>age</i>	-0.1234*** (-4.4335)	0.0111 (0.8282)
<i>first</i>	-0.0175 (-0.1976)	0.1674** (2.2598)
<i>Mfee</i>	-0.0029 (-0.0906)	-0.0000 (-0.0767)
<i>Constant</i>	-2.3999*** (-7.4532)	-4.2036*** (-16.5011)
<i>Observations</i>	12,561	22,115
<i>R-squared</i>	0.4353	0.4161
<i>ID FE</i>	YES	YES
<i>Year FE</i>	YES	YES

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Declaration of interest statement

The authors declare that there are no conflicts of interest associated with this study.

Data availability

The authors do not have permission to share data.

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