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Research article

How does technological innovation affect the fiscal decentralization of local governments? Evidence from China

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ABSTRACT

Technological innovation is a pivotal driver of high-quality economic development, and China's distinctive fiscal decentralization model stands out as a crucial institutional factor behind the country's economic growth miracle. Despite its significant academic and practical implications, there is a noticeable scarcity of literature on examining government fiscal decentralization through the lens of technological innovation. This paper addresses fundamental research questions regarding the relationship between technological innovation and fiscal decentralization. Leveraging balanced panel data from 30 provinces in China spanning 2005 to 2020, our findings indicate that technological innovation positively impacts the fiscal decentralization of local governments. Specifically, for each standard deviation increase in technological innovation, there is a corresponding 0.1508 standard deviation in fiscal decentralization. The mechanism driving this relationship lies in technological innovation's ability to enhance enterprise profit levels, increasing tax and non-tax revenues for local governments. Importantly, when non-tax revenue at the central government level surpasses tax revenue, the resulting augmentation in local government revenue contributes to an elevated level of fiscal decentralization. In conclusion, this paper offers valuable insights into the government's endeavors to promote scientific and technological innovation while enhancing local fiscal decentralization. These insights contribute to an improved quality of economic development.

1. Introduction

Innovation is a pivotal driver for promoting high-quality economic development [1]. Under the new normal, making technological innovation the sole path to achieving high-quality economic development [2]. While steering the high-quality development of China's economy, technological innovation also can reshape the financial structure between central and local governments, influencing fiscal decentralization. Fiscal decentralization, in turn, generates effective competition and a demonstration imitation effect among regions, motivating local governments to pursue high-quality economic development through institutional innovation and policy adjustments. This optimization in the allocation structure of social resources provides robust support for the rapid development of the national economy [3,4], rendering fiscal decentralization conducive to high-quality economic development. So, technological innovation and fiscal decentralization are both key to high-quality economic development. Sorting out the relationship between technological innovation and fiscal decentralization facilitates the introduction of policies to promote high-quality economic development. To this

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end, this paper studies the impact of technological innovation on the fiscal decentralization of local governments and its underlying mechanisms.

Extensive literature underscores that Chinese-style fiscal decentralization is a critical institutional factor explaining China's economic growth miracle [5,6]. Given China's multi-tiered government system, effectively incentivizing grassroots governments to promote innovation remains a significant challenge for both central and local authorities. The inherent long-term and uncertain nature of innovation activities makes it challenging for the government to realize substantial results in the short term. In pursuing economic growth, grassroots governments may opt for a simplistic development model to meet short-term targets, potentially neglecting the encouragement and cultivation of innovation activities.

Since the founding of new China, intergovernmental tax sharing has proven effective as higher-level governments incentivize lower-level counterparts to bolster local economies by entering tax-sharing contracts and sharing tax revenues. Despite existing literature highlighting the direct impact or moderating effect of fiscal decentralization on technological innovation, few studies delve into government fiscal decentralization from the perspective of technological innovation. As technological innovation levels increase, adjustments to government taxation may ensue, such as innovations reducing transportation and communication costs, potentially intensifying fiscal competition among governments and limiting their tax enforcement capabilities. Unfortunately, the specific mechanism through which technological innovations affect fiscal decentralization remains unclear.

On these bases, this paper aims to address several key research questions concerning the relationship between technological innovation and fiscal decentralization. Specifically, the study investigates the existence of a connection between technological innovation and fiscal decentralization. Furthermore, it seeks to explore the direct and indirect impacts of technological innovation on fiscal decentralization. Lastly, the research delves into the underlying mechanisms of technological innovation that influence fiscal decentralization. To answer these questions, this study first introduces the development level of technological innovation into the production function of representative enterprises and constructs the partial equilibrium model of technological innovation and government fiscal decentralization. Based on the derivation of the partial equilibrium analysis model, in terms of the direct impact, we hypothesize that technological innovation can increase the level of fiscal decentralization of local governments; regarding the indirect impact, we hypothesize that technological innovation also increases the level of fiscal decentralization of local governments by increasing the local government's tax revenues and non-tax revenues. Then, according to the measured technological innovation level and using balanced panel data of 30 provinces in China from 2005 to 2020, this study also examines the effect of technological innovation on fiscal decentralization. Finally, based on the theoretical derivation results, this study takes tax and non-tax revenue as intermediary variables for mechanism analysis.

This study introduces several innovative aspects. Firstly, unlike prior research focusing on the economic consequences of technological innovation, this study pioneers an investigation into the effect and mechanism of technological innovation on local government fiscal decentralization, presenting a novel research problem. Secondly, while previous studies extensively evaluate the level of fiscal decentralization, there is a gap in the literature concerning the factors influencing fiscal decentralization. Our empirical testing, rooted in theoretical derivations from the perspective of technological innovation, fills this gap, providing a fresh outlook on the effect of technological innovation on local government fiscal decentralization. Thirdly, building on theoretical derivations, this study employs the intermediary effect analysis method to scrutinize the mechanism from the angles of both tax and non-tax revenue, offering a unique exploration into how technological innovation influences the level of local government fiscal decentralization.

The subsequent sections of this paper are organized as follows. Section 2 delves into theoretical analysis and introduces the formulated hypotheses. Following that, Section 3 outlines the research design, while Section 4 covers the empirical analysis and robustness tests. Section 5 focuses on the mechanism test, presenting an innovative examination. Lastly, Section 6 conducts a threshold effect test, summarizes the paper, and concludes with insightful policy implications.

2. Literature review and theoretical analysis

2.1. Literature review

In the realm of technological innovation, prevailing studies posit that it plays a pivotal role in enhancing total factor productivity by facilitating the spillover of technology and knowledge, thereby fostering economic growth [7–10]. Following the Asian financial crisis and the 2008 global financial crisis, a heightened level of technological innovation emerged as the primary driver in mitigating distortions in factor capital allocation and improving the overall efficiency of capital allocation. Consequently, technological innovation has been identified as a catalyst for enhancing the efficiency of capital allocation post-financial crises, leading to improved economic growth [11,12]. Moreover, the positive impact of technological innovation extends to alleviating resource and environmental constraints in regional development, diminishing negative outputs of economic growth, and elevating the intensity of economic development to foster the sustainable growth of regional economies [13]. This continuous effect of technological innovation yields a spillover effect, constituting a competitive advantage for a country or region [14].

Turning to the domain of fiscal decentralization, financial and monetary instruments are deemed mutually replaceable within the framework of local economic growth. It is imperative to acknowledge that fiscal decentralization inherently influences financial decentralization [15]. Notably, fiscal decentralization has been identified as a catalyst for promoting economic growth in China [16]. Numerous studies highlight that under the Chinese-style fiscal decentralization system, local governments wield the authority to deploy public policy tools, such as subsidies and tax cuts, to enhance production efficiency and establish a micro sustainable local economic growth mechanism [17]. However, divergent perspectives exist, with some studies suggesting that fiscal decentralization in developing countries might exert a negative impact on economic growth [18]. Analyzing provincial panel data, Zhang and Zou [19] discovered a negative correlation between China's fiscal decentralization and economic growth. Furthermore, Zhan and Liu [17] conducted a simulation analysis using a general equilibrium model within a multi-level government framework, revealing that the effects of fiscal decentralization in China on actual economic growth, economic growth objectives, and unplanned growth are not synchronous but exhibit regional variations.

As for the relationship between technological innovation and fiscal decentralization, the current body of literature primarily focuses on illustrating the direct or moderating impacts of fiscal decentralization on technological innovation [20,21]. However, there is a notable dearth of articles examining government fiscal decentralization from the vantage point of technological innovation. Remarkably, heightened levels of technological innovation may prompt fresh adaptations in government taxation. For instance, innovations that diminish transportation and communication costs could conceivably amplify fiscal competition among governments, thereby limiting their capacity to enforce taxes [22]. Regrettably, the precise mechanisms through which technological innovations influence fiscal decentralization remain unclear. Based on this background, this study introduces the development level of technological innovation into the production function of representative enterprises and constructs the partial equilibrium model of technological innovation and government fiscal decentralization in the following subsection.

2.2. Model setting

Consider a hypothetical scenario where the economy comprises both the government and enterprises, with the government further divided into central and local governments. Enterprises are responsible for undertaking technological innovation and conducting production and operations accordingly. The government, in turn, imposes taxes on the production and operations of enterprises, with the resulting tax revenue being shared between the central and local governments. Additionally, both levels of government generate non-tax revenue. To facilitate theoretical analysis, we establish the following model. The assumptions of representative enterprises and governments are as follows.

(1) Representative enterprises

Assumption 1. Referring to the practices of Dai et al. [23] and Gong and Cao [24], the production function of representative enterprises is set as the Cobb-Douglas production function, that is, $y = AN^{\alpha}K^{\beta}$, where y is output; A is the comprehensive technical level, that is, the total factor productivity; N is the labour input; K represents invested capital. Where A>0、$0 < \alpha < 1$、$0 < \beta < 1$.

Assumption 2. Technological innovation can improve total factor productivity [8–10]. If the technological innovation level of representative enterprises is L, that is, $\partial A/\partial L > 0$, with improvements in the technological innovation level, the total factor productivity of representative enterprises will increase. Therefore, considering the level of technological innovation, the output of representative enterprises is $y = A(L)N^{\alpha}K^{\beta}$.

Assumption 3. The market of the products produced by representative enterprises is a perfectly competitive market, in which they are price receivers, and the product price is p.

Assumption 4. The labour and capital markets faced by representative enterprises are also completely competitive markets, and they are price recipients in these markets. Let the price of labour be w and the price of capital be r.

According to assumption 1-4, the profit of an enterprise is $\pi = py - wN - rK$.

(2) Government

Assumption 5. The government levies taxes on enterprises at the tax rate τ. Following Fu and Zhao [25], the tax revenue obtained by the government is $T = \tau\pi = \tau(py - wN - rK)$. In addition to tax revenue, according to the notice of the Ministry of Finance on strengthening the management of government non-tax revenue, the government can also obtain non-tax revenue O. Therefore, tax revenue and non-tax revenue are sources of government revenue [26,27].

Assumption 6. Tax revenue T is shared by the central government and local governments, of which the proportion obtained by local governments is β. Therefore, the tax revenue obtained by representative local governments is $T_l = \beta T = \beta\tau(py - wN - rK)$.

According to the notice of the Ministry of Finance on strengthening the management of government non-tax revenue, non-tax revenue includes income from the operation of state-owned capital. The operating income of state-owned capital is related to the production and operation of enterprises, so it is related to its scientific and technological innovation level L. The higher the scientific and technological innovation level L, the more the operating income of state-owned capital may be. Therefore, if the non-tax income of the representative local government is O_l and that of central government is O_c, then $\partial O_l/\partial L > 0$, $\partial O_c/\partial L > 0$.

Income from state-owned capital operation is related to the production and operation of state-owned enterprises. Technological innovation is different between state-owned enterprises and private enterprises [28], but it is homogeneous among state-owned enterprises. For this purpose, let $\partial O_l/\partial L = \partial O_c/\partial L$.

To sum up, the fiscal revenue of representative local governments is $F_l = O_l + T_l = O_l + \beta\tau(py - wN - rK)$, while the fiscal revenue of central and representative local governments is $F = O_c + O_l + T = O_c + O_l + \tau(py - wN - rK)$.

2.3. Model analysis

China's fiscal decentralization system grants local governments a defined level of income autonomy and expenditure responsibility, empowering them to independently determine the scale and structure of budget expenditures [17]. Consequently, the fiscal decentralization of local governments primarily manifests in the proportion of their fiscal revenue, symbolizing their capacity to allocate fiscal resources [15]. Drawing from insights provided by He and Miao [15], Shen and Fu [29], Xu [30], and other relevant sources, the level of fiscal decentralization for representative local governments is quantified by the ratio of local government revenue to the aggregate revenue of both central and local governments.

$$fiscd = \frac{F_l}{F} = \frac{O_l + T_l}{O_c + O_l + T} = \frac{O_l + \beta\tau(py - wN - rK)}{O_c + O_l + \tau(py - wN - rK)} \tag{1}$$

The numerator of Equation (1) is the fiscal revenue of representative local governments, including non-tax revenue O_l and tax revenue T_l shared with the central government; The denominator is the sum of the fiscal revenue of the representative local government and that of the central government, including the non-tax revenue O_l of the representative local government, the non-tax revenue O_c of the central government and the shared tax revenue T of the two levels of government.

According to the hypothesis, the non-tax revenue of the central and representative local governments is a function of the technological innovation level L of representative enterprises, while the shared tax revenue is a function of the profits of representative enterprises, and the profits are a function of the technological innovation level L of representative enterprises. Therefore, the shared tax income is also a function of the technological innovation level L of representative enterprises. Thus, the fiscal decentralization level *fiscd* of representative local governments is a function of the technological innovation level L of representative enterprises. To solve for the influence of the technological innovation level of representative enterprises on the financial decentralization level of representative local governments, we first find the first-order partial derivative of the technological innovation level L of representative enterprises on both sides of Equation (1), and get:

$$\frac{\partial fiscd}{\partial L} = \frac{(O_c - O_l)\frac{\partial O_l}{\partial L} + p\tau(\beta(O_c + O_l) - O_l)N^{\alpha}K^{\beta}\frac{\partial A}{\partial L} + (1 - 2\beta)\tau\pi\frac{\partial O_l}{\partial L}}{\left(O_c + O_l + \tau(py - wN - rK)\right)^2} \tag{2}$$

The denominator of Equation (2) is positive, and its sign depends on the numerator. If the numerator is greater than zero, the improvement of the technological innovation level of representative enterprises can increase the financial decentralization level of representative local governments; if it is less than zero, the opposite is true.

According to the provisions of China's tax law, value added tax, enterprise income tax and individual income tax are the main shared taxes. The central government and local governments will allocate 50 % of the value-added tax levied by non-customs agencies. The central government and local governments will allocate 60 % and 40 % of the corporate income tax paid by enterprises other than central enterprises, local banks, foreign banks and non-bank financial enterprises, railway departments, bank headquarters and insurance companies. The central government and local governments will allocate 60 % and 40 % of individual income tax respectively. According to the central and provincial fiscal and tax revenue data from 2005 to 2020 released by the National Bureau of statistics, the local fiscal revenue of Guangdong Province is the highest over the years, reaching 988.195 billion yuan in 2020, but it only accounts for 12 % of the central fiscal revenue of 7964.423 billion yuan in 2020. Thus, (1-2β) is always greater than 0.

The symbol of numerator in Equation (2) is closely related to the non-tax income O_c and O_l of the central and representative local governments, respectively. From China's reality, the non-tax revenue of the central government is significantly greater than that of the local government, $O_c > O_l$. According to the data from 2005 to 2020, the non-tax revenue of the central government increased from 49.672 billion yuan in 2005 to 312.649 billion yuan in 2020; the average non-tax income of 31 provinces increased from 7.658 billion yuan in 2005 to 82.178 billion yuan in 2019. The non-tax revenue of local governments is always far less than that of the central government.

Therefore, from the actual situation in China, $O_c > O_l$. Thus, the first term of numerator in Equation (2) is positive. Combined with (1-2β) $\geq$0, it can be seen that the second term of numerator in Equation (2) is also positive. Therefore, we have:

$$\frac{\partial fiscd}{\partial L} > 0 \tag{3}$$

2.4. Research hypotheses

Equation (3) shows that if other conditions are unchanged, with improvements in the technological innovation level of representative enterprises, the financial decentralization level of representative local governments will increase. Therefore, we put forward the following hypotheses.

Hypothesis 1. (H1): Technological innovation can improve the level of fiscal decentralization of local governments.

The second item $p\tau(\beta(O_c + O_l) - O_l)N^{\alpha}K^{\beta}\partial A/\partial L$ of numerator in Equation (2) is the increase in the representative local government's tax revenue, which increases its level of fiscal decentralization. Sum of the first items 1 and 3 $[O_c - O_l + (1 - 2\beta)\tau\pi]\frac{\partial O_l}{\partial L}$ of numerator in Equation (2) is the increase in the non-tax revenue of representative local governments resulting from improvements in the technological innovation level of representative enterprises. The increase in non-tax revenue enhances the fiscal decentralization level of representative local governments.

Therefore, we put forward the following hypotheses on the mechanism of technological innovation to improve the level of fiscal decentralization of local governments.

Hypothesis 2. (H2): Technology innovation has the tax effect as it promotes the local government's tax revenue to enhance the local government's financial decentralization level.

Hypothesis 3. (H3): Technology innovation has the non-tax effect as it promotes the local government's non-tax revenue to enhance the local government's financial decentralization level.

2.5. Research design

2.5.1. Sample selection and data sources

Considering that the latest provincial panel data is 2020 and the availability of data, provincial panel data from 2005 to 2020 is selected for an empirical test. The data of local fiscal revenue, local fiscal expenditure, the number of patent applications, and the number of patent applications for inventions in various provinces are obtained from the National Bureau of Statistics of the People's Republic of China (https://www.stats.gov.cn/sj/ndsj/), the land area data are from Baidu (https://zhidao.baidu.com/question/930384489837332579.html), and the other data are taken from the National Bureau of Statistics of the People's Republic of China and People's Bank of China(www.pbc.gov.cn). To eliminate the effect of outliers, winsorize is used to reduce the tail of continuous variables by 1 %.

2.6. Model design

(1) Model design of hypothesis H1

To test hypothesis H1, the following time and individual two-way fixed effect models were designed:

$$fiscd_{it} = \alpha_0 + \beta_1 * inlev_{it} + \eta_j * X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{4}$$

In Equation (4), $fiscd_{it}$ represents the level of fiscal decentralization of i province in t year, and the greater the value, the higher the level of fiscal decentralization; α_0 is the intercept, the individual effect of i province, λ_t is the annual effect of t year, and ε_{it} is the random error.

$inlev_{it}$ is the key explanatory variable, that is, the level of technology innovation of i province in t year, and β_1 is its coefficient. If β_1 is significantly positive, the level of fiscal decentralization can be improved by technological innovation.

Table 1
Variable definitions.

	Variable name	Variable symbol	Variable definition	References
Dependent variable	Level of fiscal decentralization	*fiscd*	Fiscal revenue of provinces/National Revenue*100 collected from the National Bureau of Statistics	He and Miao [15]; Xu [30]
		rfiscd	Fiscal expenditure of provinces/National Expenditure*100 collected from the National Bureau of Statistics	Tan and Zhang [31]; Zhang and Gong [32]
Independent variable	Level of technological innovation	*inlev*	Number of patents applications/Total population collected from the National Bureau of Statistics	Zhang [33]
		rinlev	Number of applications for invention patents/Total population collected from the National Bureau of Statistics	
Intermediate variable	Tax Revenue Sharing	*stax*	Actual tax revenue/Total population (2005 base period) collected from the National Bureau of Statistics	New proposed
	Non-tax revenue	*ntax*	Actual non-tax revenue/Total population (2005 base period) collected from the National Bureau of Statistics	
Control variable	Level of economic development	*lnpgdp*	Ln (Real GDP per capita) collected from the National Bureau of Statistics	Ping et al. [34], Wang et al. [35]
	Level of industrial structure	*indstr*	1*Primary sector of the economy by province+2*Secondary sector of the economy by province+3*Tertiary sector of the economy by province collected from the National Bureau of Statistics	Ping et al. [34]
	Level of financial development	*fsize*	Loan Balance/GDP collected from the National Bureau of Statistics and the People's Bank of China	Wang and Li [36]
	Financial decentralization	*fd*	Local loan balance/National Loan Balance collected from the National Bureau of Statistics and the People's Bank of China	Lv et al. [37]
	Urbanisation Rate	*urbrate*	Urban population/Total population collected from the National Bureau of Statistics	Zhu [38]
	Population density	*pden*	Total population/Land area collected from the National Bureau of Statistics and Baidu	Yang et al. [39]
	Degree of government intervention	*gov*	Local expenditure/GDP collected from the National Bureau of Statistics	Guo [40]

X_{it} is the control variables designed for later.

(2) Model design of hypotheses H2–H3

$$fiscd_{it} = \alpha_0 + \beta_1 * inlev_{it} + \eta_j * X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{5}$$

$$med_{it} = \alpha_0 + \varsigma * inlev_{it} + \eta_j * X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{6}$$

$$fiscd_{it} = \alpha_0 + \beta_1 * inlev_{it} + \eta_j * X_{it} + \omega * med_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{7}$$

In Equations (5)–(7), med_{it} is the intermediary variable, which is tax revenue (*stax*) and non-tax revenue (*ntax*).

The test procedure is as follows: First, Equation (5) estimates that if the Coefficient β_1 of technological innovation level $inlev_{it}$ is significant, then technological innovation has an overall effect on the fiscal decentralization of local government, otherwise, it has a cloaking effect. Second, Equation (6) is regressed to judge the effect of technological innovation on intermediary variables. Third, if coefficient ς in Equation (6) and ω in Equation (7) are both significant, then the mediator effect exists. If β_1 in Equation (7) is significant, then the mediating variable plays a part of the intermediary effect. if β_1 in Equation (7) is not significant, then the mediating variable has a complete mediating effect. Fourth, if ς in Equation (6) and ω in Equation (7) have only one significant effect, the mediator effect should be tested by Sobel.

X_{it} in Equations (5)–(7) is the control variable.

2.6.1. Variable description

Based on the need to test the hypothesis and referring to the literature, the designed explanatory variables, key explanatory variables, and control variables are shown in Table 1.

The details are as follows:

(1) Dependent variable

The dependent variable in this study is the level of fiscal decentralization (*fiscd*) of local governments. Fiscal decentralization is divided into revenue decentralization and expenditure decentralization. Revenue decentralization is calculated based on fiscal revenue and expenditure decentralization is calculated based on fiscal expenditure. In this study, referring to He and Miao [15], we calculate revenue decentralization (*fiscd*) based on the fiscal revenue of provinces/national fiscal revenue; referring to Shen and Fu [29], the soundness of fiscal expenditure decentralization (*rfiscd*) is tested by the fiscal expenditure of provinces/national fiscal expenditure.

(2) Independent variable

The key explanatory variable in this study is the level of technological innovation (*inlev*): according to Zhang [33], the level of technological innovation is expressed by the number of patent applications divided by the total population. Although the application of invention patents is difficult [41], it is generally believed that invention patents can better reflect the level of technological innovation. In this study, we divide the number of patent applications by the total population to test the robustness of *rinlev*.

(3) Intermediate variable

Tax revenue (*stax*): As an intermediary variable, in this study, tax revenue is calculated by dividing the local government tax revenue by the total population.

Non-tax revenue (*ntax*): As another intermediary variable, non-tax revenue is calculated by dividing the local government's revenue minus the tax revenue by the total population.

(4) Control variable

At present, there is no literature on the level of fiscal decentralization of the local government as the explanatory variable. The following control variables are designed for this study.

a) The level of economic development (*lnpgdp*): Economic development will raise the price of industrial land [35]. The level of economic development is a key variable that determines the degree of dependence of local finance on real estate tax revenue [34], which may then affect the level of fiscal decentralization of the local government. Thus, in this study, we control for the level of economic development.
b) Industrial structure level (*indstr*): Industrial structure level is another key variable to determine the dependence of local finance on real estate tax revenue [34], which may affect the fiscal decentralization level of the local government. Therefore, in this study, we control for the industrial structure level.

c) Financial development level (*fsize*): The level of financial development has a non-linear effect on the business total factor productivity [36], which affects tax revenue; therefore, the level of financial development may affect the level of fiscal decentralization of local governments. Thus, we introduce the level of financial development and its second term as control variables.
d) Financial decentralization (*fd*): Financial decentralization can promote regional economic growth [37]. Economic growth will increase local government revenue, which may affect the level of local government fiscal decentralization. Hence, we control for financial decentralization.
e) Urbanisation rate (*urbrate*): There is a close relationship between urbanisation and fiscal revenue [38], and urbanisation may also affect the fiscal decentralization of local governments. Therefore, the urbanisation rate is controlled in this study.
f) Population density (*pden*): Population density has a positive effect on talent aggregation [39], as talent aggregation affects income which affects individual income tax, and may then affect the level of fiscal decentralization of local governments. Thus, we control for the population density.
g) Degree of government intervention (*gov*): Local government intervention has played a key role in rising housing prices in China in recent years [40]. Therefore, we control for the degree of government intervention.

3. Empirical analysis

3.1. Descriptive statistics

Table 2 presents the descriptive statistics for the main variables. The following is based on descriptive statistics. First, the average level of fiscal decentralization (*fiscd*) of local governments is 1.6391 %, the minimum is 0.0439 %, and the maximum is 5.7456 %. Second, the average level of technological innovation (*inlev*) is 0.0140, the maximum is 0.1161, and the minimum is only 0.0004, which is also in line with China's unbalanced development.

3.2. Benchmark regression

Equation (4) can be estimated using both the individual fixed effect model (FE) and the random effect model (RE). To choose between the two, the Hausmann test is employed in this study. The chi-square statistic for the Hausmann test is 91.35, with a p-value less than 0.0001. However, the Stata15.1 report mentioning "V_b-V_B is not positive definite" makes judgment challenging. Despite this, FE is favored for its ability to mitigate errors caused by missing variables.

Therefore, this study employs the FE estimation Equation (4) as the primary method, and the RE estimation is used to assess the robustness of the results. The FE estimation is utilized, and the gradual inclusion of control variables in Equation (4) is detailed in Table 3.

(1) Dependent variable

As indicated in Table 3, the coefficient of the technological innovation level (*inlev*) is positively significant at the 1 % level, affirming that the innovation level positively impacts the fiscal decentralization of local governments. Consequently, hypothesis H1 is supported. Further calculations, as presented in column (5) of Table 3 and in conjunction with Table 2, demonstrate that a 1 standard deviation increase in the level of technological innovation corresponds to a 0.1508 standard deviation increase in the fiscal decentralization level of local governments. This quantification underscores the substantial impact of technological innovation on enhancing fiscal decentralization.

Column (5) of Table 3 yields the following insights. Firstly, the coefficient of the economic development level (*lnpgdp*) is significantly positive at the 1 % significance level, indicating that economic development positively influences the fiscal decentralization of local governments. This effect may arise from increased industrial land prices, driven by economic development, consequently augmenting land revenue for local governments. Secondly, the coefficient of the level of industrial structure (*indstr*) is positively significant

Table 2
Descriptive statistics of major variables.

Variable	Observed value	Mean value	Standard deviation	Minimum value	Maximum value
fiscd	496	1.6391	1.3268	0.0439	6.5100
rfiscd	496	2.6529	1.3271	0.4588	7.2936
inlev	496	0.0140	0.0187	0.0004	0.1161
rinlev	496	0.0048	0.0079	0.0001	0.0663
stax	496	0.2997	0.3106	0.0245	1.9421
ntax	496	0.0883	0.0772	0.0037	0.6631
lnpgdp	496	1.0146	0.6021	−0.6538	2.4794
indstr	496	2.3589	1.3527	1.4563	2.8343
fsize	496	1.2769	0.4534	0.3745	2.9959
fd	496	3.0770	2.4646	0.0620	10.7249
urbrate	496	0.5423	0.1468	0.2230	0.8958
pden	496	0.4409	0.6648	0.0024	3.9492
gov	496	0.2651	0.1901	0.0869	1.3538

Table 3
FE regression results of Equation (4).

variable	(1)	(2)	(3)	(4)	(5)
	fiscd	fiscd	fiscd	fiscd	fiscd
inlev	6.588***	8.175***	7.977***	9.195***	10.70***
	(0.924)	(1.148)	(1.136)	(1.165)	(1.256)
lnpgdp		1.288***	0.693***	0.518***	0.678***
		(0.143)	(0.149)	(0.154)	(0.155)
indstr		0.206	0.265**	0.315***	0.378***
		(0.150)	(0.128)	(0.121)	(0.125)
fsize			−0.308*	−0.191	−0.417**
			(0.172)	(0.160)	(0.186)
fsize2			0.0337	0.00975	0.0381
			(0.0487)	(0.0447)	(0.0485)
fd			0.175***	0.139***	0.140***
			(0.0366)	(0.0334)	(0.0314)
urbrate				1.719***	1.922***
				(0.549)	(0.545)
pden					−0.0470
					(0.285)
gov					0.972***
					(0.181)
Constant	1.547***	0.621*	0.402*	−0.416	−0.664*
	(0.0153)	(0.343)	(0.241)	(0.354)	(0.399)
Individual effect	YES	YES	YES	YES	YES
Annual effect	NO	YES	YES	YES	YES
Observed value	496	496	496	496	496
Number of provinces	31	31	31	31	31
R^2	0.143	0.412	0.460	0.473	0.515

Note: ***, **, and * indicate significance levels of 1 %, 5 %, and 10 %, respectively. The robust standard error of dual clustering is shown in parentheses.

(2) Control variable

at the 10 % level. Enhancements in the industrial structure level prove beneficial for elevating the fiscal decentralization of local governments, as the level determines the reliance on real estate tax revenue, thus improving fiscal decentralization. Thirdly, the coefficient of the second term of financial development level (*fsize2*) is significantly positive at the 1 % level, while the coefficient of the first term (*fsize*) is significantly negative at the 1 % level. This signifies a positive U-shaped non-linear relationship between financial development and fiscal decentralization of local governments. This non-linear influence may be attributed to the impact of financial development on corporate total factor productivity and its subsequent effect on the fiscal decentralization level through corporate tax revenue transmission. Fourthly, the coefficient of financial decentralization (*fd*) is significantly positive at the 1 % level, indicating that financial decentralization positively affects the fiscal decentralization of local governments. This relationship may be attributed to financial decentralization promoting regional economic growth, thereby increasing the fiscal decentralization level. Lastly, both the urbanization rate (*urbrate*) and the degree of government intervention (*gov*) contribute positively to improving the fiscal decentralization of local governments. This positive impact is likely due to their facilitation of regional economic growth, consequently enhancing the fiscal decentralization level of local governments.

3.3. Robustness test

Mitigating the impact of autocorrelation and heteroscedasticity on statistical inference, Petersen [42] recommends adjusting standard errors through double clustering on individuals and time. In Models (1)–(5) of Table 3, we adopt dual clustering standard errors to enhance the reliability of the estimation results. It is noteworthy that the key explanatory variables in these models demonstrate significance at the 1 % level, underscoring the robustness of our findings.

To further bolster the robustness of our analysis, we conduct additional endogeneity tests. These tests involve the replacement of explanatory variables, substitution of key explanatory variables, consideration of fiscal decentralization inertia, and employing change estimation models. The robustness of our results is consistently upheld across these variations, affirming the resilience of our findings under different methodological considerations.

(1) Endogenous treatment

Theoretical analysis and empirical testing reveal a significant influence of technological innovation on the fiscal decentralization of local governments. Simultaneously, fiscal decentralization exerts an impact on regional innovation capacity [43] through the conduit of fiscal expenditure on technology, subsequently influencing the level of technological innovation. This interdependence establishes a two-way relationship between the level of technological innovation (*inlev*) and the fiscal decentralization of local governments, indicating that the level of technological innovation is endogenous.

To address potential endogeneity, Kim et al. [44] and Li et al. [45] employ the mean value of the annual technological innovation level in other provinces to derive *ivinlev*, which is then used as the instrumental variable for the re-estimation of Equation (4). The Cragg-Donald F statistic for the weak instrument variable test is 1.3e +04, significantly surpassing the critical value of 16.38 at a 10 % error rate. Using *ivinlev* as the instrumental variable, Equation (4) is estimated through the instrumental variable method, as presented in column (1) of Table 4. Repeating this process in columns (2) and (3) of Table 4, incorporating delayed control variables and robust standard error calculations, consistently supports the conclusion that the level of technological innovation positively impacts the fiscal decentralization of local governments. Consequently, the robustness of hypothesis H1 is affirmed in the absence of endogeneity.

The level of technological innovation (*rinlev*) is quantified by the number of patent applications per capita. We employ the FE re-estimation Equation (4) for our analysis, and the outcomes are presented in column (1) of Table 5. In column (2) of Table 5, we substitute the interpreted variable with expense-weighted *rfiscd* and conduct a re-estimation using the FE model. Fiscal decentralization favors technological innovation through fiscal technology spending [43]. In this way, there will be a two-way causal relationship between fiscal decentralization and technological innovation. For this reason, we employ the dynamic panel estimation Equation (4) based on the difference GMM. The results, derived under the condition of a three-period lag in the explained variable, are detailed in column (3) of Table 5, having successfully passed both the autocorrelation and Sagan tests. Addressing the mentioned considerations, we perform a re-estimation of Equation (4) using the RE approach, and the findings are outlined in column (4) of Table 5.

From column (1)–(4) of Table 5, we find that the level of technology innovation can improve the level of fiscal decentralization of local governments. Therefore, the conclusion that hypothesis H1 holds is robust.

4. Mechanism test

4.1. Tax effect

Employing revenue decentralization (*fiscd*) as the dependent variable and tax revenue (*stax*) as the intermediate variable, we utilized the FE estimation Equations (5)–(7), yielding path A, path B, and path C in Panel A of Table 6. Simultaneously, for expenditure decentralization (*rfiscd*) as the dependent variable and tax revenue (*stax*) as the intermediary variable, FE estimation models (5)–(7) were applied, resulting in path A, path B, and path C in Panel B of Table 6. In another scenario where expenditure decentralization (*fiscd*) is the dependent variable and tax revenue (*stax*) is the intermediary variable, we replaced the independent variable with *rinlev* and employed FE estimation Equations (5)–(7), leading to path A, path B, and path C in Panel C of Table 6.

The findings in Table 6 affirm the existence of a tax effect stemming from technological innovation. Thus, the robustness of hypothesis H2 is substantiated, emphasizing the consistency of this conclusion across various model specifications.

4.2. Non-tax effect

Utilizing revenue decentralization (*fiscd*) as the dependent variable and non-tax revenue (*ntax*) as the intermediate variable, we applied the FE estimation Equations (5)–(7), resulting in path A, path B, and path C in Panel A of Table 7. Similarly, for expenditure decentralization (*rfiscd*) as the dependent variable and non-tax revenue (*ntax*) as the intermediary variable, FE estimation Equations (5)–(7) were employed, producing path A, path B, and path C in Panel B of Table 7. In a variation where expenditure decentralization (*fiscd*) is the dependent variable and non-tax revenue (*ntax*) is the intermediary variable, we replaced the key explanatory variable with *rinlev* and used FE estimation Equations (5)–(7), yielding path A, path B, and path C in Panel C of Table 7.

The outcomes presented in Table 7 affirm the presence of a non-tax effect resulting from technological innovation. Consequently, the robustness of hypothesis H3 is confirmed, underscoring the consistency of this conclusion across different model specifications.

Table 4
Results of the robustness test (I) for Equation (4).

Variable name	(1)	(2)	(3)
	fiscd	fiscd	fiscd
inlev	10.99***	10.99***	10.00***
	(1.087)	(1.248)	(1.328)
Control variable	YES	YES	YES
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Observed value	496	496	465
N	31	31	31
R^2	0.515	0.988	0.987

Note: * * *, * *, and * indicate significance levels of 1 %, 5 %, and 10 % respectively, with robust standard errors in parentheses. Except for column (1)。.

(2) Other robustness tests

Table 5
Results of the robustness test (II) for Equation (5).

Variable name	(1)	(2)	(3)	(4)
	fiscd	rfiscd	fiscd	fiscd
inlev		10.02***	2.036**	8.439***
		(1.520)	(0.973)	(1.343)
rinlev	21.80***			
	(3.297)			
Control variable	YES	YES	YES	YES
Individual effect	YES	YES	YES	YES
Annual effect	YES	YES	YES	YES
Observed value	496	496	372	496
N	31	31	31	31
R^2	0.500	0.575	–	–
AR(1)	–	–	0.0073	–
AR(2)	–	–	0.2093	–
Chi-square statistics of Sagan test	–	–	381.7547	–
Sagan test P value	–	–	0.1029	–

Note: Robust standard error in parentheses. Based on GMM and RE estimates, outreg2 does not output R2 or R2.

Table 6
Estimates of the tax effect.

Panel A			
Variable name	pathA	pathB	pathC
	fiscd	*stax*	*fiscd*
inlev	10.70***	2.761***	6.915***
	(1.256)	(0.463)	(1.053)
stax			1.370***
			(0.151)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.515	0.898	0.603
Panel B			
Variable name	pathA	pathB	pathC
	rfiscd	*stax*	*rfiscd*
inlev	10.02***	2.761***	7.848***
	(1.520)	(0.463)	(1.456)
stax			0.786***
			(0.174)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.575	0.898	0.592
Panel C			
Variable name	pathA	pathB	pathC
	fiscd	*stax*	*fiscd*
rinlev	21.80***	5.621***	13.81***
	(3.297)	(1.475)	(1.930)
stax			1.422***
			(0.152)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.500	0.896	0.596

Note: * * *, * *, and * indicate significance levels of 1 %, 5 %, and 10 %, respectively. The robust standard error of dual clustering is shown in parentheses.

Table 7
Estimation results of non-tax effects.

Panel A			
Variable name	pathA	pathB	pathC
	fiscd	*ntax*	*fiscd*
inlev	10.70***	1.349***	8.339***
	(1.256)	(0.309)	(1.180)
ntax			1.748***
			(0.284)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.515	0.708	0.583
Panel B			
Variable name	pathA	pathB	pathC
	rfiscd	*ntax*	*rfiscd*
inlev	10.02***	1.349***	8.297***
	(1.520)	(0.309)	(1.489)
ntax			1.276***
			(0.262)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.575	0.708	0.597
Panel C			
Variable name	pathA	pathB	pathC
	fiscd	*ntax*	*fiscd*
rinlev	21.80***	2.906***	16.58***
	(3.297)	(0.756)	(3.053)
ntax			1.798***
			(0.287)
Individual effect	YES	YES	YES
Annual effect	YES	YES	YES
Control variable	YES	YES	YES
Observed value	496	496	496
Number of provinces	31	31	31
R^2	0.500	0.707	0.572

Note: * * *, * *, and * indicate significance levels of 1 %, 5 %, and 10 %, respectively. The robust standard error of dual clustering is shown in parentheses.

5. Discussion

China is a developing country and the way it collects taxes needs to be improved. Technological innovations help enterprises to improve efficiency and change the way taxes are collected; innovations in information technology can help governments process data, thus improving the efficiency of tax collection and can increase tax revenues [46]. China is a developing country with a large number of low- and middle-income earners. The deep integration of technologies such as artificial intelligence and finance has produced fintech, the latter of which can promote digital financial inclusion. Digital inclusive finance can increase the income of low- and middle-income people [47]. As the economic status of these low- and middle-income earners improves and their incomes grow, their tax contributions to the government will also increase [48]. In other words, technological innovations increase tax revenues for the government. In turn, tax revenue facilitates the realization of basic infrastructural development, which stimulates investment, which in turn leads to economic growth [49]. Economic growth in turn brings more tax revenue to the government. The increase in tax revenue for local governments will enhance their level of fiscal decentralization. Our study argues that technological innovation enhances the level of fiscal decentralization of local governments through increased tax revenues. Therefore, our study is consistent with the findings of these studies.

Technological innovation is not only related to road management systems, building management systems and utility management, but also solid waste management [50]. Technological innovations can improve road management, building management and public facility management and provide new technological solutions for solid waste disposal. Therefore, technological innovations can improve the quality of the environment [51,52], thereby improving people's quality of life. In addition, smart city construction is being promoted across China, and technologies such as artificial intelligence are core technologies for smart city construction. Smart cities allow people to travel more conveniently and live more comfortably, which can improve people's quality of life [53]. Revenue from real estate-related land sales is the most important non-tax revenue for local governments in China. By improving people's quality of life, technological innovation can help increase local housing prices, which in turn can increase land prices, which in turn can increase the non-tax revenues of local governments in China, and thus increase the level of fiscal decentralization of local governments. Our study concludes that technological innovation enhances the fiscal decentralization of local governments by increasing non-tax revenues. Our study is consistent with these findings.

Overall, our study shows that technological innovations can increase the level of fiscal decentralization of local governments. Financial support for technological innovation is a common approach for local governments. Our study implies that rather than reducing their fiscal decentralization, local governments will eventually increase their level of fiscal decentralization and enhance their control over financial resources. Therefore, local governments can boldly support technological innovation in their regions. For the central government, the low level of technological innovation in some relatively backward regions will inevitably reduce the level of fiscal decentralization of these local governments, which is not conducive to the economic development of these regions. At present, the central government mainly increases the financial income of these localities through transfer payments. Our research shows that, in addition to transfer payments, the central government can also support technological innovation in these places to promote their economic development on the one hand and increase their fiscal revenues on the other.

Limited by data collection, our study is based on provincial data. This means that it is difficult to apply our findings directly to the 300 cities in China. This is the shortcoming of this paper.

6. Conclusion

This study, based on theoretical analysis and provincial panel data spanning 2005 to 2020, investigates the impact of technological innovation on the fiscal decentralization of local governments and elucidates its underlying mechanism. The results reveal that technological innovation positively influences the fiscal decentralization of local governments, with a standardized increase of 0.1508 for each standard deviation in technological innovation. The mechanism stems from technological innovation enhancing enterprise profitability, subsequently augmenting both tax and non-tax revenues for local governments. Notably, when non-tax revenue at the central government level surpasses tax revenue, the resultant increase in local government revenue further elevates the level of fiscal decentralization.

Drawing from these findings, several key insights emerge. Firstly, technological innovation proves beneficial for fostering fiscal decentralization at the local government level, a factor known to contribute to high-quality economic development [4]. Therefore, concurrently promoting technological innovation and enhancing the fiscal decentralization of local governments is a strategic approach that regions can adopt. Secondly, recognizing that technological innovation's impact on fiscal decentralization is rooted in improved enterprise profitability, additional supportive measures at the central level can be implemented to enhance overall business profitability and leverage fiscal decentralization for improved economic development quality. Lastly, the study suggests that in regions with a high level of industrial structure, technological innovation plays a more pronounced role in enhancing fiscal decentralization. In areas with lower industrial structure, a multifaceted approach should be considered to elevate fiscal decentralization and mitigate development imbalances.

While this paper delves into the mechanism through which technological innovation impacts fiscal decentralization, it acknowledges certain limitations. For instance, in measuring the regional level of technological innovation, while the prevalent approach involves assessing application volume with patent data, greater precision could be achieved by utilizing indicators such as the volume of patented data authorizations or other more refined metrics. Enhancing the accuracy of measuring technological innovation levels constitutes a prospective avenue for future research in this paper. In addition, studying the impact of technological innovations in cities on the level of fiscal decentralization in cities based on Chinese city data is also a future research direction.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Wenhong Li: Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Conceptualization. **Dan Li:** Writing – review & editing, Resources, Funding acquisition, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] B. Guo, Y. Wang, H. Zhang, C. Liang, Y. Feng, F. Hu, Impact of the digital economy on high-quality urban economic development: evidence from Chinese cities, Econ. Modell. 120 (2023) 106194.
[2] Z. Li, S.Y. Yang, Fiscal decentralization, government innovation preference and regional innovation efficiency, Manag. World 34 (110) (2018) 29–42, 193–194.
[3] B.R. Weingast, Second generation fiscal federalism: implications for decentralized democratic governance and economic development, SSRN Electron. J. 65 (2006) 279–293.
[4] T. Zhang, H.X. Jiang, L.T. Wei, Fiscal decentralization, promotion incentives and high-quality economic development, J. Shanxi Univ. Finan. Econ. 43 (2021) 16–28.
[5] X. Chen, H. Mi, P. Zhou, Whether to decentralize and how to decentralize? The optimal fiscal federalism in an endogenous growth model, Appl. Econ. (2023) 1–18.
[6] C. Xu, The fundamental institutions of China's reforms and development, J. Econ. Lit. 49 (4) (2011) 1076–1151.
[7] N. Ahmad, L. Youjin, S. Žiković, Z. Belyaeva, The effects of technological innovation on sustainable development and environmental degradation: evidence from China, Technol. Soc. 72 (2023) 102184.
[8] S.C. Park, S.K. Lee, The innovation system and regional growth strategy in Denmark, AI Soc. 19 (2005) 292–308.
[9] E.C. Wang, R&D efficiency and economic performance: a cross-country analysis using the stochastic frontier approach, J. Pol. Model. 29 (2007) 345–360.
[10] C.Q. Wu, M.L. Deng, Scientific and technological innovation, opening to the outside world and high-quality development of the Changjiang economic belt, Sci. Technol. Prog. Policy 36 (2019) 33–41.
[11] Q.J. Zhang, W.J. Bai, Science and Technology Innovation, utilization of foreign capital and efficiency of capital allocation—an analysis based on epidemic crisis and financial crisis, Res. Econ. Manag. 41 (2020) 92–107.
[12] X.W. Chen, Contribution rate of scientific and technological progress and Total factor productivity: analysis of measurement methods and statistical status quo, J. Southwest Minzu Univ. (Humanit. Soc. Sci.) 40 (2019) 107–115.
[13] Z. Li, S.Y. Yang, Fiscal decentralization, government innovation preference and regional innovation efficiency, Manag. World 34 (110) (2018) 29–42, 193–194.
[14] M. Porter, The completive advantage of nations, Harv. Bus. Rev. 68 (1990) 73–91.
[15] D.X. He, W.L. shen, Does fiscal decentralization affect financial decentralization—comparative Analysis of spatial effect based on inter-provincial decentralization data, Econ. Res. J. 51 (2016) 42–55.
[16] S. Melat, L. Peng, Q. Zhou, The impact of fiscal decentralization on economic growth: a comparative analysis of selected African and OECD countries, Heliyon 9 (9) (2023) e19520.
[17] X.Y. Zhan, W.B. Liu, China-style fiscal decentralization and local economic growth–Evidence from provincial and municipal government management by objectives, Manag. World 36 (2020) 23–39, 77.
[18] H. Davoodi, H.F. Zou, Fiscal decentralization and economic growth: a cross-country study, J. Urban Econ. 43 (1998) 244–257.
[19] T. Zhang, H.F. Zou, Fiscal decentralization, public spending, and economic growth in China, J. Publ. Econ. 67 (1998) 221–240.
[20] Y. Zhu, X. Zhou, J. Li, F. Wang, Technological innovation, fiscal decentralization, green development efficiency: based on spatial effect and moderating effect, Sustainability 14 (7) (2022) 4316.
[21] L. Liu, W. Zhang, Fiscal decentralisation and technological innovation efficiency in China: an efficiency decomposition perspective, Technol. Anal. Strat. Manag. (2023) 1–14.
[22] D.R. Agrawal, D.E. Wildasin, Technology and tax systems, J. Publ. Econ. 185 (2020) 104082.
[23] M. Dai, Y.F. Zhang, W. Huang, How does trade liberalization affect China's regional labor market? Manag. World 35 (2019) 56–69.
[24] X.H. Gong, Y.X. Cao, Capital deepening and improvement of labor productivity in manufacturing sector—from the perspective of wage increase and government investment, Econ. Rev. (2014) 51–63.
[25] W.L. Fu, Y.H. Zhao, Tax Incentive, cash flow and the structural deviation of enterprise investment, Econ. Res. J. 49 (2014) 19–33.
[26] C. Gu, X.Y. Pan, Tax Reduction and revenue structure—study on the trend of non-tax revenue, Publ. Finan. Res. (2020) 19–34.
[27] P.H. Xi, A pro-cyclical study of non-tax revenue in China — a case study of state-owned enterprises, Publ. Finan. Res. (2020) 35–47.
[28] K. Wang, et al., How does incubator promote enterprise innovation?–Microscopic evidence from the Haidian District Science Park in Zhongguancun, Manag. World 35 (2019) 102–118.
[29] K.R. Shen, W.L. Fu, Fiscal decentralization and regional economic growth in China, Manag. World 31–39 (2005) 171–172.
[30] B. Xu, The impact of fiscal decentralization on the development of Informatization: growth Incentives and institutional barriers, Res. Finan. Econ. Issues (2017) 57–64.
[31] Z.X. Tan, Y.Y. Zhang, An empirical study on the relationship between fiscal decentralization and environmental pollution, China Popul. Resour. Environ. 25 (2015) 110–117.
[32] Y. Zhang, L.T. Gong, Tax-sharing reform, fiscal decentralization and China's economic growth, China Econ. Q. 5 (2005) 75–108.
[33] C. Zhang, Foreign human capital, cultural diversity and urban innovation in China, World Econ. 42 (2019) 172–192.
[34] X.Q. Ping, Q. Huang, R. An, Research on land transfer fee and real estate tax in local fiscal revenue, Acad. J. Zhongzhou (2016) 29–37.
[35] K.Q. Wang, G.X. Li, H. Liu, Reduction of industrial land, high-quality economic development and local revenue, Publ. Finan. Res. 33–46 (2019) 61.
[36] X. Wang, L. Li, Fiscal decentralization and regional financial development: theory and demonstration from the perspective of central government, Publ. Finan. Res. (2012) 31–35.
[37] Y.B. Lv, Z.D. Jin, Y. Fu, Spatial relationship between fiscal decentralization, financial decentralization and local economic growth, Publ. Finan. Res. (2020) 25–44.
[38] J.L. Zhu, An empirical study on the relationship between urbanization and finance, Urban Dev. Stud. 21 (2014) 5–11.
[39] D.L. Yang, Z.C. Ren, P.W. Li, A study on the effect of List of current and former capitals of subdivisions of China population density on talent concentration, Popul. J. 42 (2020) 82–92.
[40] K. Guo, Land Fiscal Dependence, fiscal gap and housing price—research based on provincial panel data, Econ. Rev. (2013) 69–75.
[41] Y.Q. Wang, W. Li, Y. Dai, How Zombie Enterprises Affect corporate innovation? Evidence from Chinese industrial enterprises, Econ. Res. J. 53 (2018) 99–114.
[42] M.A. Petersen, Estimating standard errors in finance panel data sets: comparing approaches, Rev. Financ. Stud. 22 (2009) 435–480.
[43] L. Liu, W. Zhang, Fiscal decentralisation and technological innovation efficiency in China: an efficiency decomposition perspective, Technol. Anal. Strat. Manag. (2023) 1–14.
[44] Y. Kim, H. Li, S. Li, Corporate social responsibility and stock price crash risk, J. Bank. Finance 43 (2014) 1–13.
[45] C.T. Li, et al., Financial science and technology and enterprise innovation—evidence from the listed companies on the new third board, China's Indust. Econ. (2020) 81–98.
[46] M. Hilton, Using information technology to improve tax and revenue collection, The Inst. Braz. Bus. Public Manag. Issues (2008) 1–35.
[47] X. Chen, H. Zhang, X. Cheng, Taoism and digital inclusive finance, Heliyon 9 (4) (2023) e14965.
[48] G. Oz-Yalaman, Financial inclusion and tax revenue, Central Bank Review 19 (3) (2019) 107–113.
[49] C.N. Worlu, E. Nkoro, Tax revenue and economic development in Nigeria: a macroeconometric approach, Acad. J. Interdiscipl. Stud. 1 (2) (2012) 211–223.
[50] C.L. Goi, The impact of technological innovation on building a sustainable city, Int. J. Qual. Innovat. 3 (2017) 1–13.

[51] Y. Cheng, U. Awan, S. Ahmad, Z. Tan, How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth, Technol. Forecast. Soc. Change 162 (2021) 120398.
[52] C. Cheng, X. Ren, K. Dong, X. Dong, Z. Wang, How does technological innovation mitigate CO2 emissions in OECD countries? Heterogeneous analysis using panel quantile regression, J. Environ. Manag. 280 (2021) 111818.
[53] J.C.F. De Guimarães, E.A. Severo, L.A.F. Júnior, W.P.L.B. Da Costa, F.T. Salmoria, Governance and quality of life in smart cities: towards sustainable development goals, J. Clean. Prod. 253 (2020) 119926.