frontiers | Frontiers in Environmental Science

TYPE Perspective
PUBLISHED 22 August 2022
DOI 10.3389/fenvs.2022.955121

OPEN ACCESS

EDITED BY
Zeeshan Khan,
Curtin University Sarawak, Malaysia

REVIEWED BY
Luigi Aldieri,
University of Salerno, Italy
Salman Wahab,
Qingdao University, China

*CORRESPONDENCE
Siying Yang,
yangsy@jlu.edu.cn

SPECIALTY SECTION
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

RECEIVED 28 May 2022
ACCEPTED 29 July 2022
PUBLISHED 22 August 2022

CITATION
Wang B, Liu F and Yang S (2022), Green economic development under the fiscal decentralization system: Evidence from china.
Front. Environ. Sci. 10:955121.
doi: 10.3389/fenvs.2022.955121

Green economic development under the fiscal decentralization system: Evidence from china

Bingbing Wang[1], Fengshuo Liu[2] and Siying Yang[3]*

[1]School of Economics and Management, Shanghai University of Political Science and Law, Shanghai, China, [2]School of Economics, Jilin University, Changchun, China, [3]Center for China Public Sector Economy Research and School of Economics, Jilin University, Changchun, China

The literature is still divided on the study of the ecological and economic effects of fiscal decentralization. To clarify the relationship between fiscal decentralization between central and local governments and green economic development in developing countries, we take China as an example to test the impact of fiscal decentralization on green total factor productivity and its mechanism. It is found that fiscal decentralization helps local governments play a greater role in the regional economic system and promotes green economic development. From the perspective of policy synergy, environmental regulation is an enhanced mechanism for fiscal decentralization to promote green economic development. We also find that technological innovation is an important mechanism for fiscal decentralization to promote green economic development. Our study develops the theory of fiscal federalism and affirms the necessity of decentralization system reform in the context of the green economy, which has important theoretical and practical implications.

KEYWORDS

fiscal decentralization, green economy, environmental regulation, technological innovation, China

Introduction

The vast majority of centralized countries are faced with the problem of the distribution and trade-off of powers and responsibilities between central and local governments. Therefore, some countries have been exploring the institutional reforms of the division of powers and responsibilities. However, these reforms may affect economic growth and the ecological environment by adjusting the relationship between the central and local governments. Our study focuses on the impact of fiscal decentralization on the local green economy, which is an interesting and important topic. On the one hand, fiscal decentralization may have an impact on the green economy by affecting the structure and efficiency of local fiscal expenditures. For example, some studies based on incentive theory and public choice theory have found that fiscal decentralization may affect local fiscal expenditures on science and technology and environmental protection as a way to influence the local green economy (Yang et al., 2020). On the other hand, the horizontal competition among local governments around

economic growth under the decentralization system may also affect the speed and quality of economic growth (Yan et al., 2022). Therefore, the reform of the fiscal decentralization system has the potential to influence the local green economy.

How to promote green economy development through institutional reform is a hot topic (Chen et al., 2022; Qi et al., 2022), and the literature has increasingly focused on the performance of the local green economy under the fiscal decentralization system (Safi et al., 2022). For example, Gao et al. (2022) examined the impact of fiscal decentralization on local carbon productivity based on provincial panel data in China and found that decentralization can leverage the local information advantages of local governments, which is an important institutional guarantee to improve local carbon productivity. Similarly, He (2015) found that fiscal decentralization also promotes an increase in local fiscal expenditures on environmental protection as a way to promote environmental governance. However, more studies have expressed concerns about urban environmental governance under a decentralized system (Cheng and Zhu, 2021; Yuan et al., 2022). For example, Li et al. (2022) examined the impact of fiscal decentralization on environmental pollution from the perspective of haze pollution and found that decentralization reinforces the economic growth preferences of local governments and is a key factor impeding environmental improvement. Qi and Yu (2022) found that decentralization makes it difficult for the central government to effectively constrain the self-interested investment preferences of local governments, which results in serious environmental pollution.

We aim to clarify the impact of fiscal decentralization on the green economy with China as an example. On the one hand, China is a typical centralized country and began the decentralization system reform in 1994. On the other hand, like other developing countries, China is facing severe environmental pressure. In 2021, China's energy output rate was 84% of that of the United States, 57% of that of Germany and 59% of that of Japan. The contribution rate of China's green total factor productivity (GTFP) growth to the overall economic growth is less than 30%, while the contribution rate of OECD countries has reached 60%. Research on China is a reference for other developing countries.

Compared with previous studies, our potential contributions are as follows. First, the ecological and economic effects of fiscal decentralization at the city level have been less explored. We construct urban green economic development indicators by GTFP and examine the impact of fiscal decentralization on the green economy, which makes up for the lack. Second, previous literature has neglected the examination of government policy synergy in the development of the green economy. We put fiscal decentralization and environmental regulation in the same analytical framework, explored the moderating mechanism of environmental regulation, and verified the theoretical viewpoint that multidimensional policies synergistically promote green economic development. Third, we also explore the mechanism of the effect of fiscal decentralization on the urban green economy from the perspective of technological innovation, which provides empirical evidence for understanding the economic and ecological effects of fiscal decentralization.

Literature review

Fiscal decentralization not only affects the supply of regional public goods but also profoundly affects the performance of the government's ecological functions (Weingast, 2009). Fiscal expenditure is the basic way for local governments to support green economic development (Lee, 2011). The rationalization of the economic power structure between central and local governments can effectively give play to the macrostrategic advantages of the central government and the information advantages of local governments, which improves the efficiency of fiscal expenditures (Xu, 2011; Yang et al., 2020). The second generation of fiscal federalism believes that devolving part of the fiscal revenue and expenditure authority to local governments can enhance the sense of responsibility of local governments and improve their fiscal efforts, thus improving fiscal expenditure efficiency (Oates, 1985; Qian and Roland, 1998). Additionally, fiscal federalism theory suggests that local governments can provide public goods more efficiently than the central government in accordance with the conditions of their jurisdictions and the heterogeneous preferences of their residents (Qiao et al., 2008). These arguments provide a theoretical basis for fiscal decentralization promoting urban green economic development.

However, decentralization is not always perfect. Fiscal decentralization may lead to vertical fiscal imbalance and distort local government behavior, which results in negative outputs (You et al., 2019). For example, it has been argued that China's fiscal decentralization system lacks integrity and normativity and negatively affects ecological improvement (Yang et al., 2021). This is due to the irrational design of the fiscal decentralization system that may cause an imbalance in economic structure and the prevalence of local government corruption (Xie et al., 1999; He, 2015; Jia and Nie, 2017). In addition, fiscal decentralization weakens the macrocontrol ability of the central government. When there is no effective supervision mechanism for local governments, fiscal decentralization makes it more difficult for the central government to restrain the behavior of local governments, resulting in self-interested investment preferences of local governments that "emphasize scale over ecology" (Zhang and Zou, 1998).

In addition, a growing body of literature pays attention to the impact of fiscal decentralization on technological innovation (Feng et al., 2021). For example, Lin and Zhou

(2021a) argue that the vertical fiscal imbalance caused by decentralization is an important cause of inefficient technological innovation. Yang et al. (2020) found that fiscal decentralization predisposes local governments to a preference for "scale over innovation" in fiscal investment, which inhibits local governments' innovation functions. However, technological innovation is an important support for ecological improvement (Koseoglu et al., 2022). Therefore, some studies have explored the role of fiscal decentralization in affecting ecological performance from the perspective of technological innovation and found that fiscal decentralization leads to the distortion of local government incentives, inhibits the government innovation function, and further inhibits energy performance (Lin and Zhou, 2021b). Drawing on these ideas, we also build a mediating effect model to test whether fiscal decentralization can affect the green economy by influencing technological innovation.

Methodology

Models

We investigate the impact of fiscal decentralization on the green economy by a two-way fixed effect model as in Eq. 1.

$$GTFP_{it} = \alpha_0 + \alpha_1 fisdec_{it} + \alpha_j \sum X_{jit} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

where $GTFP_{it}$ denotes the GTFP of city i in year t, which is used to measure the level of urban green economy. This is appropriate because GTFP is a composite indicator that captures both economic growth and negative outputs of energy consumption and the environment (Yang et al., 2022). $fisdec$ indicates the degree of fiscal decentralization. X_{jit} refers to a series of control variables that affect urban green economy, including industrial structure and population density and so on. μ_i denotes the city dummy variable and ν_t is the year dummy variable. ε_{it} is the error term.

Based on Eq. 1, we continue to construct the models shown in Eqs. 2, 3 to test the mechanism of fiscal decentralization influencing the green economy.

$$innovation_{it} = \beta_0 + \beta_1 fisdec_{it} + \beta_j \sum X_{jit} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

$$GTFP_{it} = \gamma_0 + \gamma_1 fisdec_{it} + \gamma_2 innovation + \gamma_j \sum X_{jit} + \mu_i + \nu_t + \varepsilon_{it} \quad (3)$$

If fiscal decentralization has a significant effect on local green economy, that is, if α_1 is significant, then Eqs. 2, 3 are further estimated. If β_1 and γ_2 are simultaneously significant, then fiscal decentralization affects urban green economy by influencing technological innovation; thus, its indirect effect is $\beta_1 \times \gamma_2$. If they are not simultaneously significant, then the indirect effect of technological innovation is not significant.

Variables and data

As mentioned earlier, we use GTFP to characterize the development level of green economy. Wang et al. (2020) proposed a two-period Biennial Malmquist–Luenberger Productivity Index (Biennial MLPI or BML) to measure GTFP. The index can not only solve the problem of infeasible solutions but also take into account technological retrogression. In addition, the previously calculated index also remains robust when the sample years are increased. Therefore, the index is somewhat better than the Global Malmquist–Luenberger Productivity Index (GML). We measure labor input in terms of the number of employed persons, capital input in terms of the real capital stock, and energy input in terms of the city's annual electricity consumption. It is important to note that we use the perpetual inventory method to calculate capital stock. In particular, we set the depreciation rate at 10.96%. Output indicators include both expected output and unexpected output. The expected output is measured by real gross domestic product (GDP), which is converted to GDP in constant prices in 2003 through the GDP deflator. We measure the unexpected output by the emissions of three pollutants produced in industrial production: wastewater, sulfur dioxide and soot.

Fiscal decentralization (*fisdec*) is the core explanatory variable. Similar to Yang et al. (2020), we approximate the level of fiscal decentralization using the proportion of urban per capita fiscally budgeted expenditure to the sum of central, provincial and urban per capita budgeted expenditure.

The level of technological innovation (*innovation*) is our mediating variable. Considering that invention patents have the most innovative value and economic value among all patent types, we use the ratio of invention patent applications to the total population within a city to measure technological innovation.

We also control the following variables. (1) Financial development level (*finance*), measured by the ratio of bank deposits and loan balances to regional GDP. (2) Industrial structure (*indstru*), measured by the proportion of added value of the service industry in GDP. (3) Marketization level (*marketization*), measured by the marketization index of each province as disclosed by Wang et al. (2019). (4) Population density (*population*), measured by the logarithm of population per square kilometer. (5) Local government growth incentive (*goal*), measured by the economic growth targets set by local governments at the beginning of the year. (6) Environmental regulation (*ER*), measured by the frequency of environment-related words in the government's annual work report.

Due to the availability of data, we conduct empirical analysis based on the panel data of 285 cities from 2003 to 2018. The data of invention patent applications are obtained from China's Research Data Platform. The marketization level is obtained from the China Provincial Marketization Index Report. Local

TABLE 1 Statistical characteristics of variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
GTFP	4,560	0.6492	0.2535	0.1337	1.7132
fisdec	4,560	0.2764	0.1254	0.0430	0.8464
innovation	4,560	−0.6548	1.8719	−6.4433	5.1056
ER	4,560	0.0047	0.0024	0.0000	0.0229
finance	4,560	2.1238	1.0419	0.5081	11.1728
indstru	4,560	37.4211	9.0422	8.5800	85.3400
marketization	4,560	6.6387	1.6853	2.3300	11.7100
population	4,560	5.7125	0.9126	1.5476	7.8816
Goal	4,560	9.4874	1.6330	5.0000	15.0000

government economic growth targets and environmental regulation intensity are obtained by the authors according to the annual governments' work reports of each city. Other data are obtained from the China Urban Statistical Yearbook. The statistical characteristics of each variable are shown in Table 1.

Results and discussion

First, we estimate Eq. 1 based on city panel data to examine the effect of fiscal decentralization on the green economy and the results are shown in regressions (1–5) in Table 2. Among them, regression (1) is the result of estimation with only fiscal decentralization as the independent variable. We can see that fiscal decentralization plays a significant role in the development of urban green economy. Regression (2) further incorporates a series of control variables, and the results show that the coefficient of fiscal decentralization remains positive and still passes the significance test of 1%. The above results show that fiscal decentralization promotes urban green economy. This confirms the applicability of fiscal federalism theory in

TABLE 2 Estimation results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	GTFP	GTFP	GTFP	GTFP	GTFP	Innovation	GTFP
	Benchmark regression	Adding control variables	Adding interactive items of province and year	Estimation after sample deletion	Moderating effect of environmental regulation	Mediating effect of technological innovation	
fisdec	0.3571***	0.4250***	0.3818***	0.4915***	0.3543***	2.1282***	0.4250***
	(0.0527)	(0.0543)	(0.0546)	(0.0582)	(0.0628)	(0.2988)	(0.0543)
innovation							0.0106***
fisdec×ER					13.1615**		(0.0028)
					(5.8906)		
finance		−0.0229***	−0.0037	−0.0245***	−0.0225***	0.0516**	−0.0229***
		(0.0037)	(0.0041)	(0.0042)	(0.0037)	(0.0206)	(0.0037)
indstru		0.0029***	0.0016***	0.0025***	0.0028***	−0.0047**	0.0029***
		(0.0004)	(0.0005)	(0.0004)	(0.0004)	(0.0023)	(0.0004)
marketization		0.0006	−0.0834**	−0.0025	0.0013	0.0860***	0.0006
		(0.0039)	(0.0378)	(0.0042)	(0.0039)	(0.0213)	(0.0039)
population		−0.0149	−0.0047	−0.0213*	−0.0153	0.0450	−0.0149
		(0.0115)	(0.0109)	(0.0125)	(0.0115)	(0.0638)	(0.0115)
Goal		−0.0087***	−0.0261	−0.0103***	−0.0086***	0.0738***	−0.0087***
		(0.0017)	(0.0227)	(0.0018)	(0.0017)	(0.0093)	(0.0017)
ER		4.1966***	3.1089***	3.8274***	0.3200	10.1761**	4.1966***
		(0.8443)	(0.8364)	(0.9001)	(1.9294)	(4.6677)	(0.8443)
Constant	0.9563***	1.0664***	1.6229***	1.1619***	1.0819***	−4.8927***	1.1157***
	(0.0086)	(0.0728)	(0.3184)	(0.0781)	(0.0731)	(0.3740)	(0.0690)
Sobel test						0.0008*** (0.0001)	
Observations	4,560	4,560	4,560	4000	4,560	4,560	4,560
R-squared	0.6530	0.6639	0.7638	0.6824	0.6643	0.9250	0.8665

Note: ***, ** and * indicate the significance levels of 1%, 5% and 10% respectively.

promoting decentralization reform and green economy in a large developing country such as China (Tiebout, 1956; Oates, 1985). The development of green economy is inherently dependent on local governments. On the one hand, local governments have a more specialized understanding of the development of green economy in their regions. Fiscal decentralization is conducive to the local information advantages of local governments, which overcomes the information asymmetry between the central government and local governments and guarantees the accuracy and flexibility of fiscal expenditures. On the other hand, fiscal decentralization has a certain incentive effect to stimulate the degree of fiscal effort and responsibility of local governments while expanding their fiscal expenditure authority, which is conducive to improving local fiscal expenditure efficiency on green economy.

The factors affecting green economy are complex and some of them are difficult to quantify precisely. In addition, it is difficult to accurately include all control variables affecting green economy in our regressions. Therefore, the aforementioned estimation results face the problem of missing variables to some extent. We construct the interaction term between year and province where the city is located and add it to Eq. 1 for estimation to alleviate the problem of omitted variables. The results are shown in regression (3). The coefficient of fiscal decentralization is positive at the significance level of 1%, which is consistent with the previous results. In addition, China's provincial capitals, municipalities directly under the central government, and municipalities with independent planning status have special status in regional and even national economic development, and most of them also enjoy special fiscal policies and political resources. Therefore, in regression (4) we exclude the sample of these cities. As seen, the results also affirm the role of fiscal decentralization in the development of green economy.

Existing studies have neglected the environmental institutional context in which fiscal decentralization affects green economy. Fiscal decentralization may have a differential impact on the green economy under different environmental regulation intensities. For this reason, we construct the interaction term between environmental regulation and fiscal decentralization and bring it into Eq. 1 for estimation. The results are shown in regression (5) in Table 2. The coefficient of fiscal decentralization remains significantly positive, while the interaction term is also significantly positive at the 1% level. This is similar to the findings of Song et al. (2018), which provides evidence that fiscal decentralization may better promote green economy under strict environmental regulation policies. Thus, environmental regulation is a reinforcing mechanism for fiscal decentralization to promote green economy and increasing the intensity of environmental regulation can strengthen the role of fiscal decentralization in promoting green economy.

Finally, we estimate Eqs. 2, 3 to examine the mechanism of fiscal decentralization influencing green economy. The results are shown in regressions (6) and (7) in Table 2. Fiscal decentralization can effectively promote technological innovation. This is also consistent with the view of fiscal federalism theory that fiscal decentralization enables local governments to better provide necessary public goods for technological innovation. In addition, technological innovation also plays a significant role in promoting urban green economy, which is also consistent with the mainstream view that technological innovation provides technical support and guarantees for green economy (Yan and Zhang, 2021). Combining the results of the two regressions, it can be judged that fiscal decentralization can promote the development of green economy by promoting technological innovation. In addition, we also conducted a Sobel test, and the results also support the existence of the mediating effect of technological innovation. After controlling for the mediating effect of technological innovation, the coefficient of fiscal decentralization on green economy remains significantly positive. This shows that technological innovation is a partial mediating variable and that fiscal decentralization may also promote urban green economy through other mechanisms.

Conclusion

We investigate the impact of fiscal decentralization on green economy and its mechanism based on panel data from China's cities. As emphasized by the theory of fiscal federalism, fiscal decentralization enables local governments to better perform the functions in the regional economic system and promote urban green economy. From the perspective of policy synergy, environmental regulation is an enhanced mechanism for fiscal decentralization to promote urban green economy. China's city-level environmental and fiscal policies have achieved effective synergy in promoting green economy. We also find that technological innovation is an important mechanism for fiscal decentralization to promote urban green economy. This finding complements studies on the ecological and economic effects of fiscal decentralization. Our study emphasizes the necessity of decentralization system reform in the development of green economy and affirms the applicability of fiscal federalism theory in guiding the practice of decentralization system reform in developing countries, which has important theoretical and practical implications.

Based on the above conclusion, more attention should be given to the role of decentralization system reform in green economic development. On the one hand, fiscal decentralization system reform should be deepened and give local governments greater autonomy in fiscal expenditure. On the other hand, green development requires the coordination of policies in different areas, especially the environmental system. In addition, innovation is an important support for green economic development. The reform of decentralization system should strengthen the incentive effect on technological innovation.

It should be noted that our study also has shortcomings and room for further expansion. For example, we did not include the environmental decentralization system in the analytical framework. Environmental decentralization and fiscal decentralization are two important issues that cannot be ignored in the reform of the decentralization system between the central government and local governments. Considering the synergy of the two types of decentralization systems in the process of promoting green economy is an important issue that needs to be studied in the future. In addition, although we examined the impact mechanism of fiscal decentralization on green economy from the perspective of technological innovation, we failed to exclude the existence of other mechanisms. The diverse mechanisms of the impact of fiscal decentralization on green economy also need to be further clarified in future studies.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization, YS; Methodology, FL; Data, FL and BW; Writing—original draft preparation, SY; Writing—review and editing, SY and BW; Investigation, SY; Funding acquisition, SY.

Funding

This work is supported by Special Research Project on Clean Government Construction of Jilin University, [Grant No. 2021LZY010] and Social Science Research Project of Jilin Provincial Department of Education [Grant No. JJKH20211237SK].

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Reference

Chen, B., Liu, M., Ye, W., and Zhang, B. (2022). Assessing the impact of green nudges on ozone concentration: Evidence from China's night refueling policy. *J. Environ. Manag.* 312, 114899. doi:10.1016/j.jenvman.2022.114899

Cheng, Z., and Zhu, Y. (2021). The spatial effect of fiscal decentralization on haze pollution in China. *Environ. Sci. Pollut. Res.* 28, 49774–49787. doi:10.1007/s11356-021-14176-y

Feng, C., Shi, B., Yan, H., Yang, S., and Bai, C. (2021). Sustainable export innovation behavior of firms under fiscal incentive. *Front. Psychol.* 12, 769795. doi:10.3389/fpsyg.2021.769795

Gao, F., Xue, S., and Sun, R. (2022). Does fiscal decentralization promote or inhibit the improvement of carbon productivity? Empirical analysis based on China's data. *Front. Environ. Sci.* 10, 903434. doi:10.3389/fenvs.2022.903434

He, Q. C. (2015). Fiscal decentralization and environmental pollution: Evidence from Chinese panel data. *China Econ. Rev.* 36, 86–100. doi:10.1016/j.chieco.2015.08.010

Jia, R. X., and Nie, H. H. (2017). Decentralization, collusion, and coal mine deaths, collusion, and coal mine deaths. *Rev. Econ. Statistics* 99 (1), 105–118. doi:10.1162/REST_a_00563

Koseoglu, A., Yucel, A. G., and Ulucak, R. (2022). Green innovation and ecological footprint relationship for a sustainable development: Evidence from top 20 green innovator countries. *Sustain. Dev.* doi:10.1002/sd.2294

Lee, C. Y. (2011). The differential effects of public R&D support on firm R&D: Theory and evidence from multi-country data. *Technovation* 31 (5-6), 256–269. doi:10.1016/j.technovation.2011.01.006

Li, X., Lu, Y., Rafique, M. Z., and Asl, M. G. (2022). The effect of fiscal decentralization, environmental regulation, and economic development on haze pollution: Empirical evidence for 270 Chinese cities during 2007–2016. *Environ. Sci. Pollut. Res.* 29, 20318–20332. doi:10.1007/s11356-021-17175-1

Lin, B., and Zhou, Y. (2021b). Does fiscal decentralization improve energy and environmental performance? New perspective on vertical fiscal imbalance. *Appl. Energy* 302, 117495. doi:10.1016/j.apenergy.2021.117495

Lin, B., and Zhou, Y. (2021a). How does vertical fiscal imbalance affect the upgrading of industrial structure? Empirical evidence from China. *Technol. Forecast. Soc. Change* 170, 120886. doi:10.1016/j.techfore.2021.120886

Oates, W. E. (1985). Searching for leviathan: An empirical study. *Am. Econ. Rev.* 75 (4), 748–757.

Qi, Y., and Yu, J. (2022). Decentralization and local pollution activities: New quasi evidence from China. *Econ. Transition Institutional Change*. doi:10.1111/ecot.12328

Qi, Z., Zhang, E., Wang, C., and Liu, W. (2022). The power of civilization: The role of civilized cities in corporate ESG performance. *Front. Environ. Sci.* 10, 872592. doi:10.3389/fenvs.2022.872592

Qian, Y. Y., and Roland, G. (1998). Federalism and the soft budget constrain. *Am. Econ. Rev.* 88 (5), 1143–1162.

Qiao, B., Martinez-Vazquez, J., and Xu, Y. (2008). The tradeoff between growth and equity in decentralization policy: China's experience. *J. Dev. Econ.* 86, 112–128. doi:10.1016/j.jdeveco.2007.05.002

Safi, A., Wang, Q. S., and Wahab, S. (2022). Revisiting the nexus between fiscal decentralization and environment: Evidence from fiscally decentralized economies. *Environ. Sci. Pollut. Res. Int.* doi:10.1007/s11356-022-19860-1

Song, M., Du, J., and Tan, K. (2018). Impact of fiscal decentralization on green total factor productivity. *Int. J. Prod. Econ.* 205, 359–367. doi:10.1016/j.ijpe.2018.09.019

Tiebout, C. M. (1956). A pure theory of local expenditures. *J. Polit. Econ.* 64 (5), 416–424. doi:10.1086/257839

Wang, K., Pang, S., Ding, L., and Miao, Z. (2020). Combining the biennial Malmquist–Luenberger index and panel quantile regression to analyze the green total factor productivity of the industrial sector in China. *Sci. Total Environ.* 739, 721140280. doi:10.1016/j.scitotenv.2020.140280

Wang, X., Fan, G., and Hu, L. (2019). *China Provincial marketization index report 2018*. Beijing: Social Science Literature Press. in Chinese.

Weingast, B. R. (2009). Second generation fiscal federalism: The implications of fiscal incentives: The Implications of Fiscal Incentives. *J. Urban Econ.* 65 (3), 279–293. doi:10.1016/j.jue.2008.12.005

Xie, D., Zou, H. F., and Davoodi, D. (1999). Fiscal decentralization and economic growth in the United States. *J. Urban Econ.* 45 (2), 228–239. doi:10.1006/juec.1998.2095

Xu, C. (2011). The fundamental institutions of China's reforms and development. *J. Econ. Literature* 49 (4), 1076–1151. doi:10.1257/jel.49.4.1076

Yan, C., Di, D., Li, G., and Wang, J. (2022). Environmental regulation and the supply efficiency of environmental public services: Evidence from environmental decentralization of 289 cities in China. *Growth Change* 53 (2), 515–535. doi:10.1111/grow.12596

Yan, X., and Zhang, Y. (2021). The effects of green innovation and environmental management on the environmental performance and value of a firm: An empirical study of energy-intensive listed companies in China. *Environ. Sci. Pollut. Res.* 28, 35870–35879. doi:10.1007/s11356-021-12761-9

Yang, S., Li, Z., and Li, J. (2020). Fiscal decentralization, preference for government innovation and city innovation Evidence from China. *Chin. Manag. Stud.* 14 (2), 391–409. doi:10.1108/CMS-12-2018-0778

Yang, S., Lu, J., Feng, D., and Liu, F. (2022). Can government-led civilized city construction promote green innovation? Evidence from China. *Environ. Sci. Pollut. Res. Int.* doi:10.1007/s11356-022-20487-5

Yang, X., Wang, J., Caona, J., Renna, S., Ren, Q., and Wu, H. (2021). The spatial spillover effect of urban sprawl and fiscal decentralization on air pollution: Evidence from 269 cities in China. *Empir. Econ.* 63, 847–875. doi:10.1007/s00181-021-02151-y

You, D., Zhang, Y., and Yuan, B. (2019). Environmental regulation and firm eco-innovation: Evidence of moderating effects of fiscal decentralization and political competition from listed Chinese industrial companies. *J. Clean. Prod.* 207, 1072–1083. doi:10.1016/j.jclepro.2018.10.106

Yuan, R., Li, C., Memon, J., Ali, M., and Nawaz, M. (2022). The nexus between fiscal decentralization and environmental sustainability in Japan. *Front. Environ. Sci.* 10, 905461. doi:10.3389/fenvs.2022.905461

Zhang, T., and Zou, H. F. (1998). Fiscal decentralization, public spending and economic growth in China. *J. Public Econ.* 67 (2), 221–240. doi:10.1016/S0047-2727(97)00057-1