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Tax Incentives and Urban Green Innovation: Evidence from the "Replacing Business Tax with Value-Added Tax (VAT)" Reform

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Abstract

Tax reduction is an important measure to stimulate urban green innovation vitality. Taking the structural tax reduction policy of replacing business tax with VAT (the "VAT reform") as an example, this paper constructs a staggered difference-in-differences (DID) model based on panel data of 287 prefecture-level cities in China from 2009 to 2021 to evaluate the impact of the VAT reform on urban green innovation. The study finds that the implementation of the VAT reform significantly promotes the level of urban green innovation. Mechanism analysis shows that the tax reduction forces local governments to proactively adjust their expenditure structure, increasing spending on science and technology to broaden the tax base, thereby enhancing urban green innovation vitality. This paper provides empirical evidence for further leveraging the incentive role of tax incentives in green innovation.

Keywords

VAT Reform; Green Innovation; Tax Incentives

1. Introduction

Cities, as the core carriers of modern economy and civilization, have been accompanied by severe resource consumption and ecological pressure during rapid development, which have become key factors constraining high-quality urban development. Faced with continuously tightening resource and environmental constraints, the 20th National Congress of the Communist Party of China explicitly proposed the coordinated requirements of "accelerating the green transformation of development mode" and "implementing the innovation-driven development strategy," establishing green innovation as an important path to build a modern society with harmonious coexistence between humans and nature. Green innovation deeply integrates the core of green development and innovation-driven development, serving as the central engine to solve the ecological dilemma of urban

development and achieve a sustainable future. However, green innovation activities are highly dependent on technological research and application, characterized by high risks and long cycles, and thus cannot do without government financial support. Tax incentives, as an important tool affecting regional factor allocation and decision-making[1], provide a feasible path to enhance urban green innovation capacity.

The VAT reform, as a typical structural tax reduction policy, provides strong tax incentives for urban green innovation by eliminating double taxation and improving the industrial deduction chain. This policy reduces the turnover tax burden on enterprises, especially for cities with a high proportion of service industries and close industrial chain collaboration, freeing up more resources for green technology R&D and equipment upgrading. However, during the policy implementation process, different cities, constrained by differences in industrial structure, fiscal support capacity, and the perfection of supporting service systems, exhibit spatial heterogeneity in the transmission efficiency of policy dividends. In the critical period of economic transformation, facing the dilemma of fiscal imbalance, efficiently transforming the VAT reform from a tax instrument into a catalyst for green innovation requires differentiated implementation based on local industrial characteristics and fiscal capacity, thereby more effectively activating the endogenous driving force of urban green innovation.

2. Literature Review

2.1. Research on Urban Green Innovation

Current academic research on urban green innovation mainly focuses on the core issue of "how to promote economic growth while protecting the environment." Scholars generally believe that urban green innovation involves technological, managerial, and institutional innovations to achieve high-quality economic development at lower environmental costs[2]. Research hot spots focus on three aspects: Regarding driving factors, studies have found that the digital economy[3][4], government policies, and industrial upgrading[5] effectively stimulate green innovation vitality. Meanwhile, human capital, transportation conditions, and marketization levels[6] are also key supports. Regarding policy evaluation, scholars mostly verify the incentive effect of environmental regulation policies on green innovation[7][8][9][10] ; in addition, they have confirmed the incentive effects of green fiscal and financial policies such as green finance reform pilot zones[11] and energy-saving and emission-reduction fiscal policies[12]. A few studies have also found that innovative city pilots[13] and the "Broadband China" pilot policies[14] play important roles in driving green innovation. Regarding spatial effects, studies have found that green innovation exhibits regional imbalance[15] , but cities with high levels can drive surrounding areas through technological spillovers[16], forming a "multi-core" agglomeration pattern[17].

2.1. Research on the VAT Reform

The core goal of the VAT reform is to eliminate double taxation and optimize the tax system structure. By unblocking the upstream and downstream deduction chains, it significantly reduces the overall tax burden on enterprises[18] and thereby stimulates market vitality. Studies show that the VAT reform not only directly reduces enterprise tax burdens[19] but also promotes industrial specialization through the division of labor effect and enhances economic efficiency[20] . The reduction in tax burden, transmitted through industrial chains, exerts downward pressure on industry price levels and final consumer goods prices[21][22]. At the same time, the effects of policy implementation exhibit industry heterogeneity; for labor-intensive enterprises and those with slow fixed asset renewal, the tax burden may even increase[23]. Moreover, the policy mainly has a short-term pulling effect on economic growth rather than long-term growth enhancement[24]. For the manufacturing industry, the tax reform reduces the cost of outsourcing services, invigorating market vitality, but also exacerbates local government fiscal pressure[25]. The prominence of local fiscal pressure has drawn attention to the construction of local tax systems after the VAT reform[25][26]. Overall, academia affirms the positive role of the VAT reform in economic structure optimization and tax system modernization, but there is still controversy over its effect on income distribution optimization[27], and supporting mechanisms such as tax rate simplification and local fiscal compensation need improvement [28].

Existing literature mostly examines the impact of the VAT reform on green innovation from the perspectives of spatial spillovers, economic growth, and industrial structure at the firm level, providing a theoretical foundation for this study. Compared with existing literature, this paper takes 287 prefecture-level cities nationwide as the research target, comprehensively examines the quantity and quality of urban green innovation, explores the comprehensive impact of tax incentives on urban green technological innovation, and adds new empirical evidence for research on the impact of tax reform on urban green innovation capacity.

3. Theoretical Analysis

The implementation of the VAT reform directly reduces the institutional transaction costs of the service industry, especially for green innovation-intensive sectors such as information technology. The improvement of the VAT deduction chain deepens the division of labor among enterprises and accelerates the flow of technological factors, providing market impetus for urban green innovation. At the same time, the policy indirectly stimulates enterprises to increase green R&D investment by relieving their cash flow through structural tax reduction[29]. The modern service industries covered by the VAT reform are highly correlated with green technology, and their expansion directly increases the supply scale of urban green

technology[30]. This tax reform essentially builds a low-tax-cost institutional environment for green innovation activities, strengthening the urban green innovation foundation through market self-regulation mechanisms[31]. However, the transformation of business tax, a local main tax, into a central-local shared VAT leads to a sharp decline in local fiscal revenue[32]. This forces local governments to actively optimize their fiscal expenditure structure to cope with the fiscal gap [33]. To broaden the long-term tax base[34], local governments develop an innovation-driven economy by increasing the proportion of science and technology expenditure, improving technological R&D platforms, key laboratories, and other infrastructure[16], while promoting the integration of traditional industries with green technology. This achieves the agglomeration of innovation factors and industrial synergy, thereby improving the urban innovation ecosystem, reducing the institutional cost of green technology R&D, and enhancing urban green innovation capacity[35]. Based on this, this paper proposes the following two research hypotheses:

H1: The VAT reform helps improve the level of urban green innovation.

H2: The implementation of the VAT reform forces local governments to increase science and technology expenditure due to fiscal pressure, thereby indirectly stimulating urban green innovation.

4. Research Design

4.1. Model Specification

Value-added tax holds an important position in China's tax system structure. The VAT reform is one of the most significant tax reforms since the tax-sharing reform, having a clear effect on corporate behavior and economic activities, and its tax reduction effect is widely recognized by society. The reform was not a "one-size-fits-all" measure but was gradually implemented nationwide after piloting in different regions and industries. As a top-level design of national tax reduction policy, the VAT reform is not disturbed by local economic conditions and government behavior, alleviating endogeneity problems such as reverse causality to a certain extent. Therefore, using the exogenous variation from the VAT reform pilot to capture structural tax cuts, this paper employs a staggered difference-in-differences (DID) regression model:

$$Green_{i,t} = \alpha + \beta reform_{i,t} + \gamma X_{i,t} + city_i + year_t + \varepsilon_{i,t}$$

In equation (1), Greeni,t represents the green innovation level of cityi in yeart; reformi,t is a 0-1 dummy variable indicating whether the VAT reform has been implemented; Xi,t denotes a set of control variables; lambdai is the unobservable city fixed effect; mut is the year fixed effect; and varepsiloni,t is the random error term. The coefficient beta measures the average differential impact of the VAT reform on green innovation before and after the policy. If the estimated value β> 0 and statistically significant, it indicates that compared with the pre-policy period,

the implementation of the pilot policy significantly increases the green innovation level of pilot cities.

4.2. Variable Selection

4.2.1. Dependent Variable

Currently, scholars often measure green innovation by the number of green patent applications or the number of green patent grants. Considering the rigor of examination, this paper adopts the principle of quality first and selects the number of green patent grants as the dependent variable. In the robustness test, the number of green patent applications is introduced for analysis.

4.2.2. Independent Variable

This paper treats the VAT reform pilot policy as a quasi-natural experiment and uses reform to characterize the reform. Specifically, if cityi implements the VAT reform pilot in yeart, then reform takes the value 1; otherwise, 0. Although the policy was eventually implemented nationwide, different batches of cities implemented it in different years. Since the reform start time is specific to the month and the empirical process uses years, considering the time lag of policy effects, this paper defines the reform time for Shanghai as 2012; for provinces and cities that started the reform in the second half of 2012 (including Beijing, Jiangsu, Anhui, and six other provinces/municipalities), the reform time is defined as 2013; and for the remaining provinces and cities, the reform time is defined as 2014.

4.2.3. Control Variables

Based on existing studies[36] , this paper also controls for other variables that may potentially affect the growth of private economy entrepreneurship. These include: (i) Urban economic development level – measured by the logarithm of GDP per capital to mitigate extreme values and heteroskedasticity; (ii) Education expenditure – measured as the ratio of education expenditure to general government fiscal expenditure; (iii) Population size – measured by the logarithm of total year-end population; (iv) Industrial structure – measured by the ratio of tertiary industry value to regional GDP; (v) Foreign investment level – measured by the ratio of actual utilized foreign capital to regional GDP; (vi) Urbanization level – measured by the ratio of urban permanent population to total permanent population; (vii) Government intervention – measured by the ratio of general government fiscal expenditure to regional GDP.

4.3. Data Description

This paper uses panel data from 287 prefecture-level cities in China from 2009 to 2021 to analyze the impact of tax incentives on green innovation levels. Missing values are supplemented by interpolation. The data are sourced from the China City

Statistical Yearbook, the EPS data platform, and various city statistical yearbooks.

Table 1. Descriptive Statistics

Variables	Obs	Mean	Std.Dev.	Min	Max
Green Innovation	3724	0.352	1.059	0	18.238
reform	3724	0.206	0.404	0	1
Economic Development	3724	10.655	0.628	4.595	13.056
Education Expenditure	3724	0.177	0.04	0	0.356
Population Size	3724	5.885	0.704	2.97	8.136
Industrial Structure	3724	0.416	0.102	0.098	0.839
Foreign Investment	3724	0.017	0.019	0	0.229
Urbanization	3724	0.548	0.155	0.151	1.001
Government Intervention	3724	0.202	0.13	0.044	2.349

5. Empirical Analysis

5.1. Baseline Regression Results

The staggered DID model is used to identify the impact of the VAT reform pilot policy on green innovation. Table 2 reports the baseline regression results. Column (1) shows the estimates without control variables or city/year fixed effects. Column (2) includes city and year fixed effects. Columns (3) and (4) add city-level control variables to columns (1) and (2), respectively. The baseline regression results indicate that the estimated coefficient of the VAT reform variable is significantly positive in all specifications, suggesting that compared to cities that have not yet implemented the pilot, the VAT reform significantly promotes green innovation in pilot cities.

Table 2. Baseline Regression Results

VARIABLES	(1)	(2)	(3)	(4)
reform	0.836***	0.6051***	0.3237***	0.4058***
	(0.189)	(4.1119)	(3.5309)	(3.5675)
Economic Development			0.3496***	-0.3540***
			(5.6663)	(-2.9011)
Education Expenditure			-0.6519	1.9037*
			(-1.0110)	(1.9321)
Population Size			0.5277***	3.0499**
			(6.8254)	(2.2375)
Industrial Structure			1.7462***	-0.9457*
			(2.6987)	(-1.6533)
Foreign Investment			-0.2210	-3.6871**
			(-0.2039)	(-2.2789)
Urbanization			1.7068***	-0.8062
			(4.9985)	(-1.3144)
Government Intervention			1.0770***	-0.4314
			(2.9716)	(-0.8978)
Constant	0.179***	0.0540	-8.3049***	-13.7755*

	(0.0222)	(1.3918)	(-6.9504)	(-1.7759)
City FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES
Observations	3,724	3,724	3,675	3,675
R-squared	0.102	0.201	0.395	0.297

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses are t-statistics based on clustered robust standard errors. Same below.

5.2. Parallel Trend Test

The sample period of this paper is 2009–2021. Since Shanghai, the first pilot city to implement the VAT reform, began in 2012, there are no sample values more than three periods before the reform. Therefore, we only set time dummies for three periods before the reform, merging values for periods more than three years before the reform into period -3. The reference period is the 1-3 periods before the reform. To focus on the policy effect during the pilot phase, years after 2016 are folded. The results are shown in Figure 1. Before the policy implementation, the estimated coefficients of the relative time dummies have confidence intervals that significantly contain zero, indicating that compared to the period one year before the reform, there is no significant difference in green innovation between the treatment and control groups before the policy, i.e., the baseline model satisfies the parallel trend assumption. After the policy implementation, the estimated coefficients increase significantly, indicating that the pilot policy leads to a rise in green innovation.

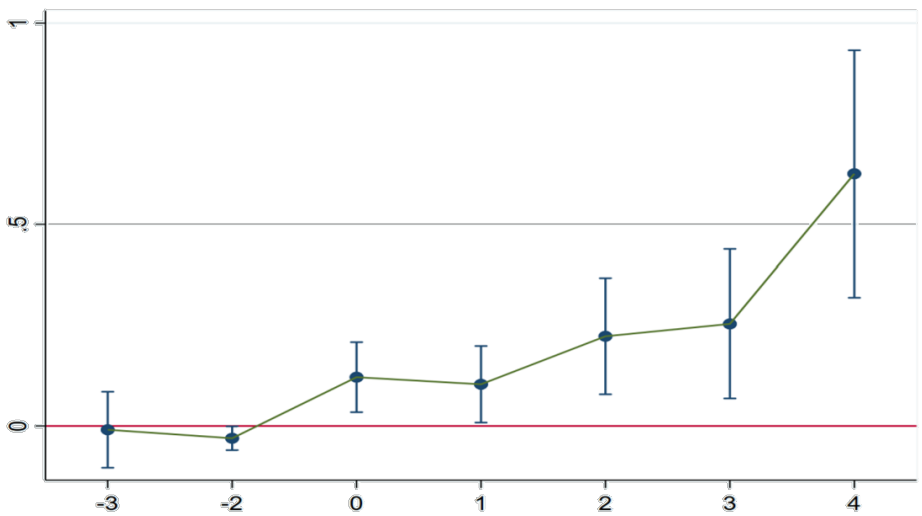


Figure 1. Parallel Trend Test

Note: The solid points and vertical lines represent the 95% confidence intervals.

5.3. Placebo Test

To further test whether the regression results are driven by the VAT reform itself, we conduct a placebo test by randomly assigning a reform year to each city within the sample period to check if the results are disturbed by unobservable factors. Specifically, we randomly draw a reform year for each city and perform 500 random

samplings of the reform dummy. The placebo test results are shown in Figure 2. As shown, most of the coefficient estimates are significant at the 1% level, but the true estimate of our study (about 0.4058) is significantly different from the placebo test results. This indicates that our estimates are not significantly affected by unobserved city characteristics or other potential factors, verifying the robustness of the baseline results from a counterfactual perspective.

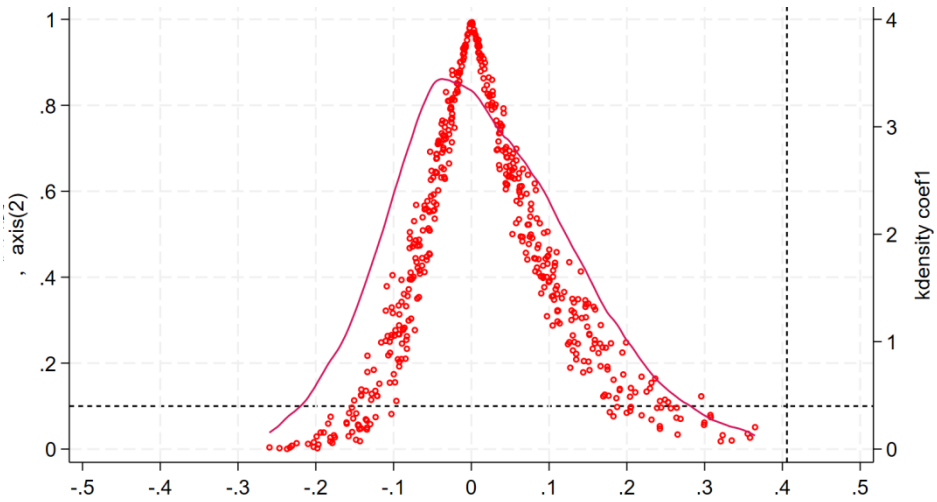


Figure 2. Placebo Test

5.4. Robustness Tests

5.4.1. Replacing the Dependent Variable

In the baseline regression, we used the number of green patent grants (green) as the dependent variable to measure urban green innovation. In related studies, some literature also uses the number of green patent applications as a proxy variable for green innovation. To test the robustness of the baseline results, we replace the dependent variable with the number of green patent applications and re-run the regression. The results are shown in Table 3, column (1). The results indicate that the VAT reform pilot policy significantly increases the level of urban green innovation, and the baseline results are robust.

5.4.2. Clustering at the Province Level

Although the baseline regression already controls for city-level clustered standard errors, considering that the VAT reform pilot policy is implemented at the provincial level, cities in the same province are affected in the same year, implying possible correlation in the error terms. To better reflect the true changes in the reform effect, we further cluster standard errors at the higher provincial level. As shown in Table 3, column (2), the estimated coefficient remains significantly positive, supporting our main conclusion.

5.4.3. Winsorization

According to the descriptive statistics, the dependent variable green innovation has obvious outliers, which may bias the estimates. Therefore, we winsorize the variables at the 1% and 99% percentiles. After removing the extreme values, the regression results are presented in Table 3, column (3). The regression results show that the pilot policy still has a significant positive effect on green innovation, confirming the robustness of our conclusion.

Table 3. Robustness Tests

	(1)	(2)	(3)
VARIABLES	green_apply	province cluster	winsorized
reform	0.711***	0.4058**	0.3262***
	(0.201)	(2.4181)	(4.1795)
Controls	YES	YES	YES
Constant	-21.23*	-13.7755	-8.4684**
	(12.79)	(-1.3120)	(-2.1773)
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	3,675	3,675	3,675
R-squared	0.273	0.297	0.379

5.4.4. Excluding Other Policy Interference

To accurately identify that the VAT reform is the main policy factor affecting the growth of green innovation, we further control for the influence of other related policies during the sample period. During the sample period, the National Smart City pilot policy was gradually promoted, and such innovation-driven policies can directly promote green innovation. Meanwhile, the "Broadband China" strategy, gradually implemented from 2014, also reflects the technological effects of information infrastructure construction. To exclude the potential influence of these policies on green innovation, we include them as exogenous shocks in the robustness test. Specifically, we add year dummies for the National Smart City pilot and the "Broadband China" pilot to the baseline model. The results are shown in Table 4. The coefficient of the VAT reform dummy remains significantly positive, indicating that the VAT reform significantly enhances green innovation even after controlling for these policies.

Table 4. Excluding Other Policy Interference

	(1)	(2)
VARIABLES	green	green
reform	0.3766***	0.4030***
	(3.6134)	(3.5985)
Broadband China	0.3634***	
	(4.0245)	
Smart City		0.0677
		(0.8175)
Controls	YES	YES

City FE	YES	YES
Year FE	YES	YES
Constant	-13.7011*	-13.7698*
	(-1.7825)	(-1.7682)
Observations	3,675	3,675
R-squared	0.315	0.298

6. Mechanism Analysis

The baseline regression results confirm that the VAT reform significantly promotes urban green innovation. To explore the channels through which it works, we conduct a mechanism test using fiscal support paths. As shown in Table 5, columns (1) and (2) indicate that the implementation of the VAT reform positively affects science and technology expenditure, and science and technology expenditure positively affects green innovation, both significant at least at the 5% level. This suggests that the VAT reform increases science and technology expenditure, and higher science and technology spending leads to stronger urban green innovation capacity. By eliminating double taxation, the reform reduces government tax revenue. To achieve expected goals, the government reallocates resources, increases science and technology spending, provides resource support for enterprises, and reduces the risk of innovation. Therefore, the indirect effect coefficient of science and technology expenditure and the direct effect coefficient have the same sign, indicating that science and technology expenditure plays a mediating role in the impact of the VAT reform on urban green innovation.

Table 5. Mechanism Test Results

	(1)	(2)	(3)
VARIABLES	green	sci	green
sci			9.5798**
			(2.5717)
did	0.836***	0.00551***	0.3530***
	(0.189)	(0.00121)	(3.0820)
Controls	YES	YES	YES
City FE	YES	YES	YES
Year FE	YES	YES	YES
Constant	0.179***	-0.194***	-11.9217
	(0.0222)	(0.0486)	(-1.5906)
Observations	3,724	3,675	3,675
R-squared	0.102	0.160	0.311

7. Heterogeneity Analysis

7.1. City Type Differences

This study uses the national smart city pilot as a city classification criterion to examine the heterogeneous impact of the VAT reform on green technological innovation. As shown in Table 6, columns (1) and (2), the green innovation promotion effect of the VAT reform is not significant in smart city pilot cities but is

significantly positive in non-smart cities. The reason may be that the smart city pilot policy itself releases policy dividends through mechanisms such as digital transformation and green innovation, and its early construction has already significantly improved the green innovation level of the region, leaving relatively saturated policy space for tax incentives. In contrast, non-smart cities, lacking such systematic policy support, are more sensitive to the tax incentives of the VAT reform.

7.2. Industrial Structure Differences

The VAT reform, as a structural tax reduction, mainly stimulates economic activity by eliminating double taxation and reducing enterprise tax burdens. After the reform, enterprises can deduct intermediate inputs, reducing the overall tax burden of the tertiary industry. This paper divides cities into groups of high and low service industry share based on the median proportion of the service industry to examine the heterogeneous impact of tax incentives on green technological innovation under different industrial structures. The regression results in Table 6, columns (3) and (4), show that in cities with a low share of the service industry, the effect of the VAT reform on green technological innovation is only significant at the 10% level, indicating a weak or unstable effect; whereas in cities with a high share of the service industry, the effect is significant at the 1% level, showing a direct and significant driving effect of tax reduction on green technological innovation. This may be because cities with a high service industry share often rely heavily on traditional service industries, have a single industrial structure and lack upgrading impetus, leading to insufficient green innovation vitality; while cities with a low service industry share have greater room for industrial transformation, and policy stimulus can more effectively promote resource optimization and green technological innovation, thus the coefficient is significant.

Table 6. Heterogeneity Analysis

	(1)	(2)	(3)	(4)
VARIABLES	Smart city pilot	Non-smart city	Low service share	High service share
reform	0.0405	0.5961**	0.0400***	0.5221*
	(0.6265)	(2.2291)	(2.6958)	(1.7515)
Controls	YES	YES	YES	YES
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Constant	0.9242	18.3359**	-0.0995	9.1411
	(0.9610)	(2.0619)	(-0.9281)	(1.4579)
Observations	2,321	1,308	1,830	1,812
R-squared	0.603	0.355	0.497	0.508

8. Conclusion and Policy Recommendations

8.1. Conclusion

Based on panel data from 287 prefecture-level cities in China from 2009 to 2021, this

paper empirically tests the impact of the VAT reform on urban green innovation using a staggered difference-in-differences model. The main findings are as follows: (1) The VAT reform significantly enhances urban green innovation by reducing the cost of green R&D for enterprises. (2) The policy indirectly empowers green innovation by forcing a transformation in the fiscal expenditure structure. The tax revenue changes induced by the VAT reform lead local governments to actively optimize resource allocation, significantly increasing the share of science and technology expenditure, thereby supporting the construction of green technology infrastructure and R&D systems. (3) The policy effects exhibit significant heterogeneity: in non-smart cities, the promotion effect of the VAT reform on green innovation is more prominent, reflecting the higher sensitivity of regions lacking existing policy support to tax incentives; in cities with a high share of the service industry, the policy, through tax burden reduction and industrial synergy, generates a stronger driving effect on green innovation, highlighting the importance of aligning industrial structure with tax reform.

8.2. Policy Recommendations

8.2.1. Deepen tax neutrality reform and strengthen cost compensation mechanisms for green innovation

The full-chain deduction mechanism of VAT should be further improved, expanding the scope of input tax deduction for green technology R&D expenses, thereby reducing the marginal cost of green innovation for enterprises. It is essential to address the problem of insufficient input tax deduction for service enterprises due to high labor costs and to explore additional deductions for green technology R&D[37]. At the same time, promote the coordinated reform of environmental protection tax and VAT, incorporating carbon footprint into the assessment system for green innovation tax preferences. Through a "tax preference-environmental regulation" policy mix, stimulate the Porter effect so that the benefits of green innovation gradually exceed compliance costs[38].

8.2.2. Establish a long-term mechanism for fiscal expenditure transformation to address market failures in green innovation

Establish a fiscal expenditure assessment system oriented toward green innovation, incorporating indicators such as the share of science and technology expenditure and the conversion rate of green technology into local government performance evaluations. Set up special transfer payments for green innovation to support green technology infrastructure in non-smart cities, alleviating local fiscal pressure through central fiscal subsidies[39] . Promote the shift of fiscal science and technology funds from "scattered subsidies" to "results purchase" mode, giving priority to the procurement of green patented technologies, thereby creating demand-pull for the market.

8.2.3. Implement regionally differentiated policies to activate the potential of policy-sensitive areas

Implement a combined "tax preference-capacity building" policy for non-smart cities: on the one hand, increase the accelerated depreciation ratio for green equipment; on the other hand, strengthen digital governance capacity support, breaking down information barriers through cross-city technology collaboration platforms[40]. In fiscal transfer payments, add a "green innovation response coefficient" to provide preferential support for less developed regions with high policy elasticity, mitigating the differences in fiscal sustainability between eastern and western regions. For cities with a high share of the service industry, pilot "green service industry tax preference packages," including VAT rebates for technology outsourcing services and tax exemptions for green intellectual property transactions, to promote the integration of service industry and manufacturing green technology. Establish a service industry green innovation index, linking its growth with corporate income tax rates to guide service industry capital to flow toward green technology sectors.

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