Available online at www.HighTechJournal.org

HighTech and Innovation Journal

ISSN: 2723-9535

HighTech and Innovation Journal

Vol. 6, No. 2, June, 2025

Local Economic Autonomy and Enterprises' Green Total Factor Productivity: A Policy Substitution Perspective

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Received 17 December 2024; Revised 11 May 2025; Accepted 20 May 2025; Published 01 June 2025

Abstract

Global climate change and environmental degradation necessitate a transition toward sustainable economic development. The factors influencing green total factor productivity (GTFP), a crucial measure for sustainable economic growth, have garnered significant attention. This study investigates the impact of local economic autonomy on enterprises' GTFP in China, integrating both fiscal and environmental autonomy. Using panel data from 2008 to 2021, a generalized difference-in-differences (DID) model combined with the non-radial SBM-ML index measures GTFP. Findings indicate that while fiscal autonomy promotes GTFP, environmental autonomy hinders it, resulting in an overall negative effect of economic autonomy. A policy substitution effect emerges; wherein local governments prioritize environmental regulation over support for science and technology. Additionally, industrial structure upgrading plays a role in mitigating the negative impact of autonomy, offering empirical evidence relevant to sustainable development policies in transition economies.

Keywords: Local Economic Autonomy; Environmental Decentralization; Fiscal Decentralization; Generalized Difference-In-Differences Method; Green Total Factor Productivity.

1. Introduction

Global climate change and environmental degradation owing to economic activity threaten socioeconomic status and human health. Changes in environmental conditions increase the likelihood of severe weather incidents, such as floods and droughts, which cause substantial property losses. Exposure to climate warming, air pollution, and toxins increases individuals' risks of respiratory issues, cardiovascular problems, and cancer [1].

These concerns underscore the significance of fostering green economic growth, with GTFP being widely recognized as a key metric for assessing the progress of such development. GTFP incorporates the environmental impact of production into productivity calculations, thereby reflecting both the environmental impact of economic units and their economic output. Studies on GTFP have focused on its definition/measurement methods [2-6] and determinants as well as the impact of economic, social, and environmental effects [7-11]. However, among the multifaceted determinants of GTFP, the role of local governments' economic autonomy remains under-explored in extant literature. Related literature, such as studies on political, fiscal, and environmental decentralization, posits that local economic autonomy might exert its influence via multiple mediating mechanisms, specifically (1) governments' accountability incentives, (2) information acquisition costs for policy formulation, (3) corruption control effectiveness, and (4) intergovernmental policy coordination (see details in the literature review section). By integrating measures of fiscal autonomy and

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http://dx.doi.org/10.28991/HIJ-2025-06-02-012

environmental regulatory autonomy within the generalized DID model, this conceptual framework aligns seamlessly with the dual-dimensional nature of GTFP, which inherently encompasses both economic outputs and environmental performance. This theoretical congruence offers valuable insights into the complex interplay between governance structures and sustainable productivity growth.

Over the past few decades, China has experienced a significant economic shift from focusing on growth quantity to emphasizing development quality. The persistent trade-offs between economic expansion and environmental protection in this context reveal how government policies both influence and adapt to economic progress. Using data from the Chinese government and listed companies, this study analyzes how local economic autonomy affects GTFP. Results indicate that while fiscal autonomy promotes enterprises' GTFP, environmental autonomy tends to hinder it, leading to an overall negative effect from increased local governments' economic autonomy. Additionally, the cross-sectional impact of industrial structure upgrading and its mediating role between local economic autonomy and enterprises' GTFP is assessed. This influence appears stronger in cities where the tertiary sector surpasses the secondary sector in value contribution. Moreover, local governments balance various intervention measures, including introducing environmental regulations to substitute for their support of science and technology, a phenomenon referred to as the policy substitution effect.

The principal contributions of this research are summarized as follows. First, the study broadens existing research on the relationship between governments and green economic development. Although many studies have examined government influence on GTFP, most focus on how specific economic behaviors—such as local debt levels or environmental regulation impacts—affect GTFP. In contrast, this analysis combines two dimensions of government characteristics to measure local economic autonomy. Second, the distinct effects of government actions on GTFP have rarely been explored, and this study advances understanding by incorporating the role of industrial structure upgrading. Third, previous research has largely emphasized conceptual analyses of decentralization. Here, the impact of decentralization on green economic development is examined through both conceptual and empirical approaches, highlighting the mediating and policy substitution effects, wherein environmental regulations are implemented as alternatives to direct support for science and technology.

The remainder of this paper is structured as follows: Section 2 reviews the literature; Section 3 develops hypotheses; Section 4 describes the data and methodology; Section 5 presents the results and robustness tests; Section 6 concludes with policy implications.

2. Literature Review

2.1. Influencing Factors of GTFP

Following Zhang et al. [6], existing studies on the influencing factors of Green Total Factor Productivity (GTFP) can be categorized into three interconnected streams: technical, economic, and governmental streams.

Technical streams collectively highlight that technological advancements, including digital economy [12], fintech [13], green technology innovation (GTI) [7], and internet development [14], play a significant role in enhancing Green Total Factor Productivity (GTFP). While the specific mechanisms vary, these technologies generally improve GTFP through direct efficiency gains and indirect structural transformations. Economic streams also influence GTFP. Upgrading to cleaner industries (e.g., tertiary sectors) optimizes resource allocation and accelerates green technology adoption, fostering GTFP growth [15]. Other contributing factors include green finance [8] and high marketization, which promotes resource mobility and industrial upgrading [16]. Government streams involve factors such as environmental regulation intensity, fiscal decentralization, infrastructure levels, and intellectual property protection [9, 14, 17].

Among these factors, environmental regulation, which comprises pollution abatement costs and environmental emission standards, serves as an important factor influencing economic output and environmental pollution. While environmental regulation is often used as a mediating variable in prior research, consensus on its impact on sustainable development and GTFP is lacking. Environmental regulation has traditionally been considered to directly increase the production costs of enterprises, which may hinder economic growth [18]. However, recent studies mostly agree that environmental regulation may promote economic growth by pressuring enterprises to conduct green technological innovation as well as improve their utilization and production efficiency of resources [19]. Concurrently, some scholars believe a U-shaped correlation between environmental regulation and economic expansion exists [20], whereas others believe the impact of environmental regulation on economic growth is not significant [21].

2.2. Impact of Decentralization on GTFP

The nexus between decentralization and GTFP/sustainable economic growth has long been controversial among scholars. Some believe that decentralization can improve GTFP. For example, Song et al. [9] showed that fiscal decentralization directly increases GTFP. As the autonomy of local governments increases, they must take more

responsibility for local economic development [22]. Furthermore, local governments' information advantage concerning local economic development (i.e., they can more easily obtain information about local needs and the cost of providing services) promotes the rational allocation of resources [23, 24]. Shah [25] found that a government with more local power can reduce corruption in the long run because decentralization narrows the gap between governments and residents. This influence, effected by the government's higher autonomy, is generally considered conducive to economic development and GTFP.

Conversely, some scholars believe that decentralization is negatively related to GTFP. For example, fiscal decentralization leads to increased competition among local governments for greater fiscal advantages, exacerbating environmental deterioration [4]. A potential 'race to the bottom' scenario may arise: when environmental regulation in the surrounding area is less stringent than that within its own jurisdiction, the local government will reduce its environmental regulation or capital tax to attract industry transfer [26]. Hwang [27] found that regional competition can lead to lower capital tax and worse environmental pollution. Some research also indicates that decentralization exacerbates corruption in local governments because there are more opportunities for corruption at the local level [28]. More importantly, local government policies (e.g., pollution abatement measures) rarely affect only local regions and tend to have spillover effects at the national or international level since they are public goods. Local governments may ignore the benefits of basic research investments, pollution information exchanges, and pollution control technologies in other regions [29, 30]. The resulting underestimation of the broader national or global benefits of investment and responsibility in this area reduces enthusiasm for providing these public goods. Improvements in economic autonomy aggravate the degree and possibility of such neglect by local governments, resulting in a decline in both economic and environmental benefits. Prud'Homme [28] pointed out that the problem lies in whether to provide these services with positive externalities and the difficulty of the joint provision of such public services at different levels.

3. Research Gaps and Hypotheses Development

3.1. Research Gaps

Although some studies have examined the impact of government autonomy on GTFP, most have focused on a single dimension of autonomy, yielding inconsistent findings. Moreover, the varying relationships between government autonomy and GTFP have not been sufficiently explored. Pollution levels are known to differ by industry, and the presence of tertiary industries may enhance technological innovation, leading to regional differences in industrial structure. Additionally, the influence of decentralization on GTFP remains largely theoretical and lacks robust empirical validation.

3.2. Research Hypotheses

While some studies suggest that decentralization promotes GTFP, a significant body of research has identified a negative correlation between them. Therefore, the overall impact of economic autonomy on GTFP is considered negative for four primary reasons: reduced policy coordination, excessive government intervention, increased corruption, and diminished support for science and technology.

According to externality theory and the core/periphery model of the regional economy, economic activities in one region impact economic performance in other regions. For example, Lejour & Verbon [31] argued that higher taxes have a negative impact on investment activities in one region, which is then passed onto other regions. When different regions can coordinate with each other and formulate joint policies (e.g., joint tax policies), such collaboration can help improve redistribution and raise economic growth. However, decentralization leads to a lack of coordination among regions as well as between local and central governments, producing inefficient tax rates and impacting economic development negatively [32].

If local economic autonomy increases, the reduced dependence on the central government may increase regional competition and reduce the level of regional policy coordination. Consequently, the allocation of human resources, information, technology, and other resources between regions becomes inefficient, hindering environmental governance and scientific and technological innovation in local areas. Concurrently, the improvement in economic autonomy may also lead to local government intervention in economic affairs and the intensification of corruption by officials, such as rent-seeking behaviors, which increase the operating costs of enterprises and negatively impact innovation [33, 34], ultimately hindering the increase in enterprises' GTFP.

Hypothesis 1: Local economic autonomy hinders the improvement of GTFP.

In addition, government support and regulation can affect GTFP by influencing scientific and technological innovation and pollution control capacity. Reduced support for scientific and technological research and fewer environmental regulations may discourage enterprises from establishing innovative production processes and attempting product innovation as well as from implementing effective environmental pollution control measures, which can lead to a decline in GTFP. However, differences in the characteristics of environmental regulation and support for science and

technology in terms of the risk/return, performance measurement, and level of positive externalities can affect governments' policy choices after decentralization because they have more say on how their jurisdiction develops according to their policy preferences.

First, scientific and technological innovation usually incurs greater costs and risks than pollution control, especially basic scientific research with far-reaching impacts, which is highly uncertain and delivers benefits only in the long term [35]. Most environmental regulations implemented by coercive means have obvious and faster effects [36]. Second, the difficulty of measuring the economic and social value of basic research can reduce the enthusiasm of local governments to invest. Conversely, direct environmental regulations are easier to supervise and evaluate. Third, the positive externalities of science and technology, especially basic scientific research achievements, affect the whole industry and society at large, making the cost of imitation and learning much lower than that of innovation; this leads to free-riding behavior. By contrast, the environmental impact is mainly limited to the local administrative region. Hence, with decentralization in economic regulation, local governments have gained more selectivity in choosing the mode of economic development for their regions and tend to ignore direct support for scientific and technological innovation and are more inclined to take responsibility for environmental pollution. While the former leads to a decrease in enterprises' GTFP in that region, the latter serves as a catalyst.

Hypothesis 2: The increased economic autonomy of local governments negatively impacts governments' support for science and technology and thus enterprises' GTFP.

Hypothesis 3: The increased economic autonomy of local governments positively affects the level of environmental regulation and thus enterprises' GTFP.

Further, owing to the decline in support for science and technology, the government may increase environmental regulation to promote local economic performance to compensate for the adverse effects that may arise from this decline in regional development. Therefore, there are substitution effects between different policy directions, especially when local governments have some discretion over choosing their mode of economic regulation. This results in the unidirectional policy substitution effect of environmental regulations from support for science and technology (Figure 1).

Hypothesis 4: There is a one-way policy substitution effect to focusing on environmental regulation from supporting science and technology following an increase in local economic autonomy.

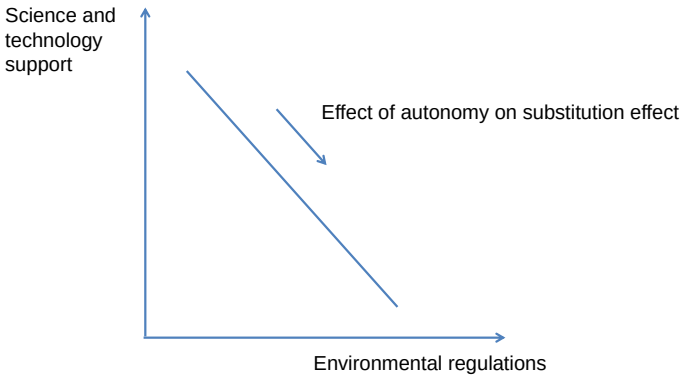

Figure 1. Policy substitution effect of local economic autonomy

The different impacts of decentralization on the economy and environment can also be related to other factors. Khan et al. [37] found that enhancing institutional quality and human capital could amplify the negative influence of fiscal decentralization on carbon emissions. Therefore, differences in regional industrial structures may impact the relationship between regional autonomy and enterprises' GTFP differently. Measuring the returns and risks of research investment is thus crucial for enterprises and governments to make investment decisions. Improving the tertiary industry's development locally can accelerate the agglomeration effect of research investment, gradually reducing the risks and costs of research investment failures for companies and regions while promoting technological innovation. Simultaneously, industries based on technology and science are more responsive to research outcomes and more likely to enjoy their benefits. For example, Wang et al. [38] found that agglomeration in the information and communication technology industry reduces carbon emissions through increased technological innovation and economies of scale.

The agglomeration of tertiary industries may generate diffusion effects that promote coordination among regional governments and facilitate resource allocation [38]. Therefore, it has a restraining effect on the negative impact of increased local government autonomy. Moreover, upgrading the local industrial structure prompts a shift in economic development patterns from resource- or labor-intensive to technology- and knowledge-intensive [39], which directly

increases the share of non-polluting enterprises within the economy. This reduces the difficulty for governments to regulate the environment and enhances their proactive attitudes towards environmental regulation. Furthermore, upgrading industrial structures improves the efficiency of coordinating resources, promoting increased GTFP. Hence, this study proposes the following:

Hypothesis 5: Industrial structural upgrades weaken the negative relationship between local governments' economic autonomy and enterprises' GTFP.

Figure 2 illustrates the influence pathway from economic autonomy to GTFP, considering both the direct and indirect effects.

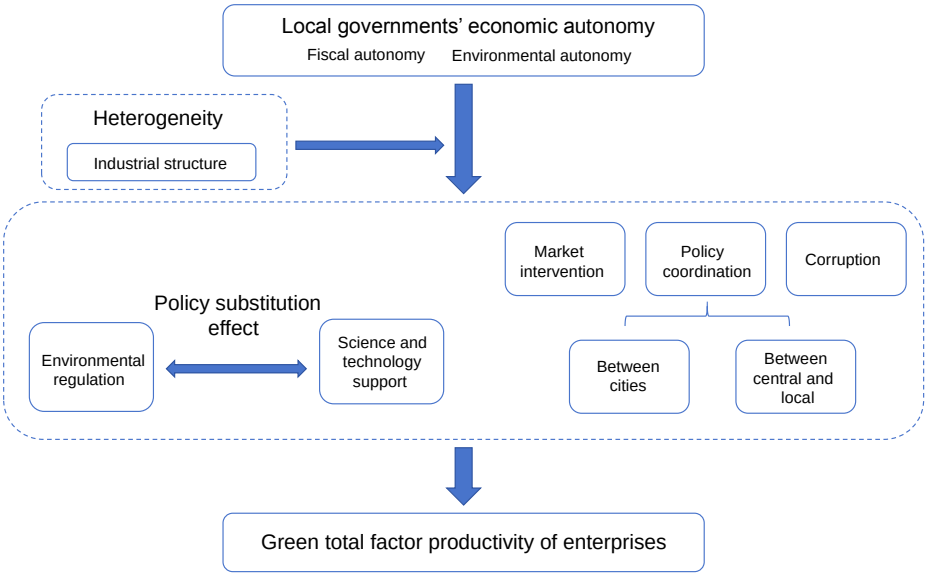

Figure 2. Impact mechanism of local economic autonomy on enterprises' GTFP

4. Data and Method

4.1. Core Explanatory Variables

Fiscal Autonomy (FA)

Many countries have decentralized their fiscal power to promote economic development and reduce poverty [40]. Contrary to the decentralization of environmental regulations, fiscal decentralization improves the government's overall capacity to utilize fiscal resources. As it is not targeted at a particular field, it allows for a broad enhancement of local governments' freedom in fiscal expenditure, policy formulation, and execution. In this context, the fiscal decentralization index is introduced as the first criterion for measuring government autonomy. Drawing on [9], the degree of self-financing by local governments—represented by the ratio between fiscal revenue and expenditure—is used to reflect this dimension of autonomy.

Environmental Autonomy (EA)

Fiscal autonomy reflects only the basic level of autonomy. As environmental issues receive increasing emphasis in economic development, relying solely on fiscal autonomy fails to capture the full scope of governmental decision-making considerations. Consequently, environmental autonomy serves as a more comprehensive measure of government autonomy in economic regulation. Environmental autonomy is primarily determined by environmental decentralization. Traditionally, two methods represent environmental decentralization: one measures the number of staff within the government's environmental sector, and the other assesses whether local governments possess legislative authority over environmental matters. The delegation of legislative authority to local governments in environmental affairs constitutes a clearer manifestation of environmental decentralization, granting greater discretion in regulating environmental issues and enhancing autonomy in environmental governance. In contrast, the size of environmental management departments is a relatively indirect indicator, influenced by government financing and environmental awareness, and does not directly signify environmental decentralization. Thus, changes in local governments' legislative authority over environmental matters are used as a proxy for variations in environmental autonomy to measure levels of autonomous control over environmental regulation.

In 2015, a new revision of the Legislation Law of the People's Republic of China (hereafter "Legislation Law") granted over 270 prefecture-level cities the authority to legislate on environmental issues, strengthening local

governments' capacity to regulate local economic and environmental development. As the implementation of this legal revision took effect after October 2015, and given the typical lag in the impact of legal measures, 2016 is regarded as the year when policy effectiveness became evident. The other 53 cities not affected by this revision in 2015 serve as the control group, while the remaining cities constitute the experimental group.

Economic Autonomy (AUTO)

Constructing a comprehensive indicator of local government autonomy poses significant challenges, as it requires accounting for multiple factors such as political and economic considerations, as well as the weighting assigned to these factors. Legislative and administrative oversight and organizational elements also play a role [41]. To determine whether government autonomy affects enterprises' GTFP—which encompasses both economic output and environmental output—economic autonomy is defined by combining fiscal autonomy and environmental autonomy. This autonomy can thus be characterized as the regulatory autonomy of local governments concerning sustainable economic development. However, because fiscal autonomy is a continuous variable and environmental autonomy is a dummy variable, integrating the two while highlighting their combined impact as the core explanatory variable necessitates a specific approach. Accordingly, the general DID model from [42] is employed, multiplying fiscal autonomy and environmental autonomy to achieve this integration. (Details are provided in the description of Equation 1 in the ***Benchmark regression model*** section).

4.2. Explained Variable: GTFP

To measure enterprises' production and environmental efficiency comprehensively, this study adopts a non-radial SBM-ML index to calculate enterprises' GTFP [43]. This calculation method incorporates energy inputs and environmental pollution into the evaluation system, addressing the limitations of traditional total factor productivity, which fails to fully account for enterprise factor productivity. The measurement of input and output indicators for enterprise GTFP is detailed as Table 1.

Table 1. The input and output indicators of enterprises' GTFP

Input factors	Labour input	The number of employees
	Capital input	Net fixed assets
	Energy input	Calculated on industrial electricity consumption in the city where the enterprise is located, considering the proportion of employees in relation to urban employment
Expected output	Enterprise operating income	
Non-expected output	Emissions of industrial sulphur dioxide, industrial wastewater, and industrial smoke and dust are converted based on the proportion of employees to urban employment to represent non-expected output.	

4.3. Control Variable

As enterprises' GTFP could be affected by a multitude of macro and micro factors, based on the existing literature, this study selects control variables from two dimensions: the city and enterprise levels.

At the city level, the per capita GDP (*Affl*) indicates the wealth level of urban residents [12]. The total number of green patents authorized in a region (*Autho*) reflects the advancement of green technology in that area, which is crucial for mitigating environmental pollution [19]. The proportion of the sum of imports and exports volume to regional GDP is used to reflect the openness level (*Open*), which also affects the overall economy [12]. In line with the pollution halo hypothesis, which posits that foreign direct investment (*FDI*) can enhance environmental conservation, this study quantifies FDI by the ratio of actual foreign capital inflow to the regional GDP. The level of urbanization (*City*), which is typically associated with economic growth, is gauged by the percentage of the urban population relative to the total population within the locality. Infrastructure construction is represented by the per capita road area coverage (*Road*) and gas penetration rate (*Gas*). More details of the measurements are presented in Table 2.

At the enterprise level, firm size (*Size*) is taken into account, as it is generally believed to influence production efficiency and technological innovation [44]. Additionally, the company's return on equity (*ROE*) and asset-liability ratio (*lev*) are included to control for their potential effects.

As a company may have been influenced by its productivity in the previous year, a lagged one-period GTFP (*L1.GTFP*) is controlled.

4.4. Mediating Variable

Science and Technology Support of Governments (Scitechsup)

Although enterprises are direct participants in technological R&D, owing to the strong externalities of such activities, it is difficult for companies to achieve effective research investment without external incentives. Therefore, the government's scientific expenditures are particularly important. From a fiscal expenditure standpoint, this study employs the ratio of local fiscal scientific expenditure to total expenditure as an indicator of the support provided by local governments for technological research and development. This reflects the balancing result of government fiscal spending: a larger proportion indicates stronger government support for science and technology.

Environmental Regulation (Enviregu)

To prevent the incomplete construction of indicators that might result in biased estimations of the intensity of government environmental regulations, this study measured government environmental regulations based on their direct outcomes. These outcomes include the overall utilization rate of general industrial solid waste, the centralized treatment rate of wastewater by treatment plants, and the harmless treatment rate of domestic waste.

Table 2. Descriptive statistics

Variables	Definition/measurement	Mean	Std. Dev.	Min	Max
GTFP	Green total factor productivity of the enterprise	0.943	0.111	0.747	1.148
FA	Fiscal autonomy: Local government's general public budget revenue/general public budget expenditure	0.733	0.206	0.081	1.107
EA	Environmental autonomy: Determined according to the implementation of the Legislation Law	0.116	0.321	0	1
AUTO	Autonomy of local governments in economic regulation	0.06	0.178	0	0.945
L1.GTFP	One-period-lagged corporate GTFP	0.916	0.111	0.72	1.12
Affl	Natural logarithm of regional GDP per capita	11.254	.577	8.549	13.056
Autho	Natural logarithm of the total number of green patents granted in the region	6.552	1.867	0	9.811
FDI	Ratio of actual utilisation of foreign capital to regional GDP	0.03	0.02	0	0.229
Open	Total imports and exports/gross regional product	0.588	0.586	0	3.279
City	Town population/total population	0.729	0.167	0.151	1.001
Road	Road area per capita	2.524	0.56	0.351	4.096
Gas	Gas penetration rate	0.977	0.061	0.11	1.063
Size	Natural logarithm of a business' total assets	22.703	1.323	19.317	26.452
ROE	Return on equity	0.068	0.544	-45.737	1.117
Lev	Ratio of total liabilities to total assets of a business	0.493	0.191	0.007	0.979
Scitechsup	Government technology support: General public budget science expenditure/Total general public budget expenditure	0.037	0.023	0.004	0.12
Enviregu	Environmental regulation: General industrial solid waste comprehensive utilisation rate, sewage treatment plant centralised treatment rate, and household garbage harmless treatment rate	0.348	0.029	0.167	0.484
Struc	Industrial structural upgrading: Added value of tertiary industry to that of secondary industry	1.479	0.974	0.139	5.349

4.5. Sample Selection and Data Sources

Data on China's listed companies from 2008 to 2021 serve as the basis for analysis. The following samples were excluded prior to further processing: (1) ST and *ST enterprises, (2) research samples lacking major data, and (3) financial companies and those engaged in financial operations. To mitigate potential impacts on the interaction term of environmental autonomy and preserve data quality, samples involving companies that relocated between general prefecture-level cities and larger cities after 2016 were removed. City panel data were matched to the remaining sample companies, with further exclusions applied to samples with substantial missing data; linear interpolation was employed to complete variables with minor gaps. Additionally, listed company samples lacking continuous main data across years were excluded to convert the non-balanced panel data into balanced panel data, ensuring more robust empirical analysis of same-dimensional sample data. Data sources include the China Urban Statistical Yearbook, China Environmental Statistical Yearbook, annual reports of listed companies, social responsibility reports of listed companies, and the websites of listed companies.

4.6. Benchmark Regression Model

The revised Legislation Law of the People's Republic of China in 2015 granted certain local governments the authority to legislate on environmental issues, thereby enhancing autonomy in environmental management. This legislative change enables the application of a DID method to measure the autonomy of local governments'

environmental regulations. Given the necessity to integrate fiscal autonomy and environmental autonomy as the core explanatory variable, a general DID method is adopted as the baseline regression model. Moreover, to provide further policy insights, the impact of environmental and fiscal autonomy on firms' GTFP was examined separately. In particular, to mitigate sample selection bias and improve comparability between the control and experimental groups, this study used the synthetic DID method [45] to test the effect of environmental autonomy on firms' GTFP. This method integrates the strengths of the traditional DID approach with synthetic control methods, effectively reducing the reliance on parallel trend assumption testing. Furthermore, time and firm fixed effects were introduced into all models to address endogeneity concerns and prevent the omission of important variables. The model specifications are as follows:

$$GTFP_{it} = \alpha_0 + \alpha_1 AUTO_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (1)$$

$$\left(\hat{\tau}^{sdid}, \hat{\mu}, \hat{\alpha}, \hat{\beta}\right) = \underset{\tau,\mu,\alpha,\beta}{argmin}\left\{\sum_{i=1}^{N}\sum_{t=1}^{T}(GTFP_{it} - \mu - \alpha_i - \beta_t - EA_{it}\tau)^2 \hat{\omega}_i^{sdid}\hat{\lambda}_t^{sdid}\right\} \quad (2)$$

$$GTFP_{it} = \beta_0 + \beta_1 FA_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (3)$$

Equation 1 represents the generalized DID model used in this study. In this equation, *GTFP* refers to the GTFP of an enterprise. *AUTO*=*Treat*×*Post*×*FA* is the key explanatory variable, reflecting local economic autonomy. Here, *FA* represents local fiscal autonomy, *Treat*×*Post* indicates environmental autonomy (*EA*), and *Treat* is a dummy variable distinguishing between treatment and control group cities; *Treat*=1 denotes the cities that have acquired environmental legislative power after the revision of legislation law, whereas *Treat*=0 represents the other cities. The variable *Post* is a binary indicator for the policy implementation period, with 1 indicating the years after 2016 and 0 representing the years before. M_i and λ_t denote the firm-specific and time-specific fixed effects, respectively, and ε_{it} is the stochastic error term.

Equation 2 represents a synthetic difference model, in which individuals in the control group with characteristics similar to those of the experimental group's *GTFP* are assigned higher weights, ensuring approximate parallel trends between the two groups in pre-policy samples; this weight is denoted as ω_i. Assigning weights to the pre-policy period serves to align the trends of *GTFP* for control group individuals before and after the policy intervention, represented by λ_t. Minimizing Equation 2 enables estimation of the average effect of *EA* on *GTFP*, where α_i denotes firm-fixed effects and β_t represents year-fixed effects.

Equation 3 corresponds to a normal two-way fixed effects model used to assess the impact of *FA* on *GTFP*; the other variables have similar meanings as those in Equation 1.

5. Results

5.1. Benchmark Regression

Table 3 displays the impact of different factors on firms' GTFP across the three models. The first and second columns present the outcomes of Equation 1, revealing the study's primary focus: the influence of local government economic autonomy on GTFP, with and without control variables. After controlling for other variables, the coefficient of *AUTO* on *GTFP* is significant at a 5% level, with an estimated effect of -0.0026. This indicates that an increase in local governments' economic autonomy is detrimental to firm performance and significantly reduces enterprises' GTFP, confirming Hypothesis 1.

The remaining columns present the experimental results for Models 2 and 3, with the additional control variables of fiscal and environmental autonomy introduced in Equations 2 and 3, respectively. After controlling for other variables, environmental autonomy significantly inhibits the improvement of firms' GTFP at a 5% significance level, whereas fiscal autonomy has a promoting effect on GTFP at a 5% significance level, with impact effects of -0.0017 and 0.0071, respectively. Thus, although fiscal autonomy promotes GTFP, environmental autonomy leads to a GTFP decline in firms.

The findings indicate that local economic autonomy negatively affects enterprises' GTFP ($\beta = -0.0026$, $p < 0.05$), aligning with theoretical predictions concerning policy coordination challenges and substitution effects. This result contrasts with Song et al. [9], who found that fiscal decentralization positively impacts GTFP in China. The discrepancy arises because this study incorporates environmental autonomy (a binary policy shock) alongside fiscal autonomy, whereas Song et al. [9] focused solely on fiscal decentralization. These results align with the arguments of [46], suggesting that environmental decentralization may trigger a "race to the bottom" in regulatory stringency, ultimately undermining productivity.

Notably, fiscal autonomy positively correlates with GTFP ($\beta = 0.0071$, $p < 0.05$), consistent with [22], who highlight fiscal autonomy's role in improving resource allocation. Environmental autonomy, however, hinders GTFP ($\beta = -0.0017$, $p < 0.05$), corroborating [26]'s observation that decentralized environmental regulation may reduce innovation incentives.

Table 3. Effects of different variables on the firm's GTFP under the three models

Models Variables	(1)	(2)	(3)	(4)	(5)	(6)
	General DID		Synthetic DID		Fixed effects model	
	GTFP		*GTFP*		*GTFP*	
Auto	-0.0023* (0.0012)	-0.0026** (0.0013)				
EA			-0.0015* (0.0008)	-0.0017** (0.0008)		
FA					0.0029 (0.0029)	0.0071** (0.0031)
Control variables	No	Yes	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	7588	7588	7588	7588	7588	7588

Note. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.2. Robustness Tests

5.2.1. Parallel Trend Test

A parallel trend test in the control and experimental groups was a prerequisite for using the DID approach. To assess the impact of the local government's overall economic regulation autonomy using the DID method, it was necessary to ensure that the GTFP of enterprises in the control and experimental groups were aligned prior to the enactment of the new legislation. By constructing time dummy variables for pre- and post-implementation years and experimental group dummy variables, the model was estimated, yielding the results presented in Table 4. None of the interaction term coefficients prior to legislation implementation passed significance tests—an approximately similar trend was observed in changes in the *GTFP* between the control and experimental groups, which satisfied the assumption of parallel trends, validating the results (see Figure 3).

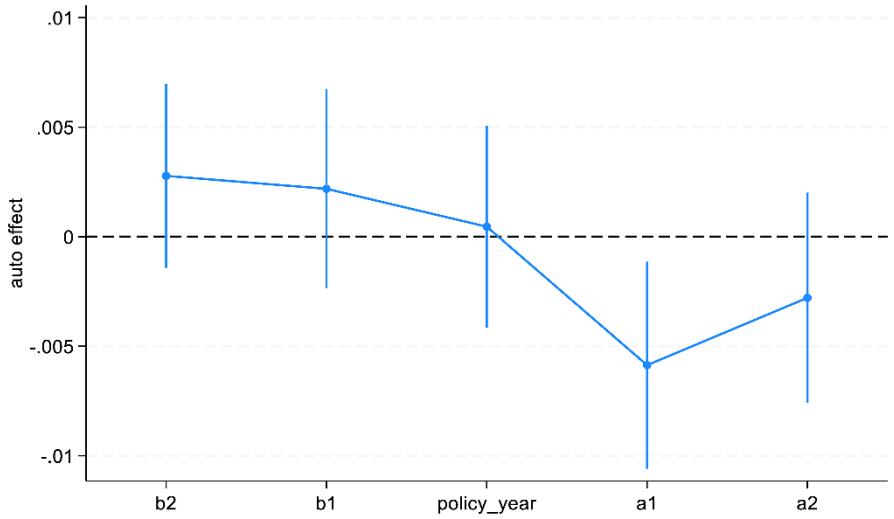

Figure 3. Parallel trend test results

5.2.2. Placebo Test

To eliminate the influence of omitted variables and random factors on the results, fictitious and randomized treatment groups were established, and the baseline model was subsequently re-run 1,000 times to ensure robustness. The scatterplot in Figure 4 displays the p-values of the AUTO coefficient across the randomized treatment groups, with the vertical dashed line representing the true AUTO coefficient of the actual treatment group and the horizontal dashed line indicating a p-value threshold of 0.1. Most estimated coefficients from the fictitious treatment groups cluster near zero and lie above the 10% significance level line, far from the true estimated coefficient, with only a few values approaching the true values. Consequently, the estimated coefficients from the fabricated treatment groups are not statistically significant, indicating that the results are not driven by random factors and are robust.

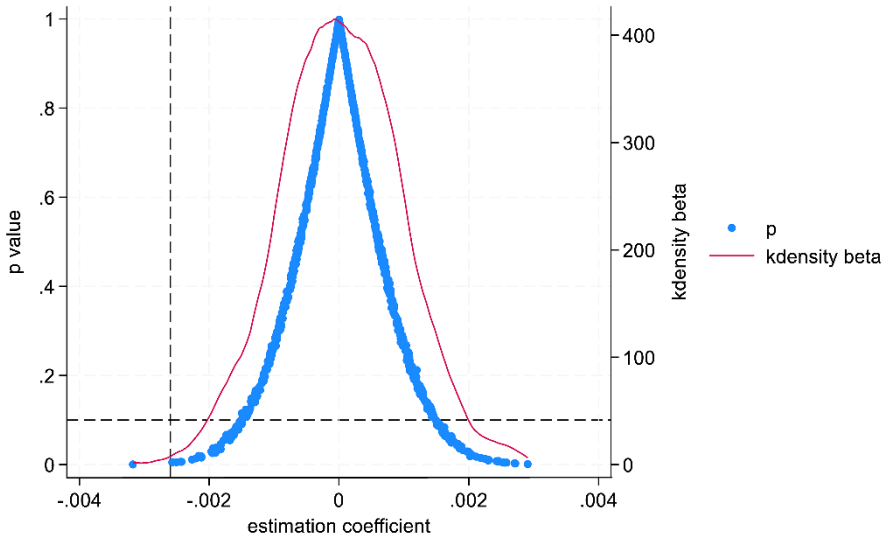

Figure 4. Placebo test results

5.2.3. Propensity Score Matching–Difference-in-Differences (PSM- DID)

As the majority of the control group in this study comprised provincial capitals, municipalities directly governed by the central government, heterogeneity exists compared with ordinary prefecture-level cities. Therefore, to address endogeneity issues and improve the robustness of the experimental results, this study employs the propensity score matching (PSM) method to match the treated sample with cities that have similar characteristics in all aspects except for *AUTO*. Subsequently, the matched group was subjected to regression analysis. Table 4 displays the re-estimated results—even after controlling for the control group, AUTO's estimated coefficient on *GTFP* remains significantly negative. Thereby reinforcing the robustness of the findings.

Changing the sample

As major events may directly or indirectly affect enterprise productivity, as research indicates that the 2008 economic crisis reduced firms' innovation drive [47, 48], governments may relax their consideration of environmental issues and adopt more lenient intervention measures to stimulate economic recovery. During the COVID-19 pandemic, local governments imposed varying degrees of restrictions on businesses to protect the health of residents, which also impacted productivity. Therefore, this study excludes the years affected by major events and re-estimates the regression coefficients of local governments' economic regulatory autonomy. Table 4 encapsulates the summarized findings. Column (3) in Table 4 presents the re-estimated results after excluding the data from 2008 to 2009, the years impacted by the global financial crisis. Column (4) presents the re-estimated results, with data from 2020 and 2021 excluded to eliminate the impact of the COVID-19 pandemic. Even after removing the years affected by major events, the estimated coefficient for local governments' economic regulatory autonomy remains significantly negative—this study's findings are not altered by the occurrence of major economic events.

Table 4. PSM- DID, results, and changing samples results

Models Variables	(1)	(2)	(3)	(4)
	PSM- DID		Excluding years affected by the economic crisis (2008, 2009)	Excluding years affected by COVID-19 (2020, 2021)
	GTFP	*GTFP*	*GTFP*	*GTFP*
AUTO	-0.0028* (0.0014)	-0.0030** (0.0014)	-0.0031** (0.0014)	-0.0034** (0.0014)
Constant	0.7657*** (0.0008)	0.9023*** (0.0237)	0.9215*** (0.0224)	0.8544*** (0.0202)
Control variables	No	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
R^2	0.9831	0.9834	0.9809	0.9827
Observations	5366	5356	6504	6504

Note. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.3. Mechanism Test

5.3.1. Mediating Effect and Masking Effect

To examine whether autonomy affects firms' GTFP through science and technology support and environmental regulations, this study employs the following three-step mediation model:

$$Med_{it} = \beta_0 + \beta_1 AUTO_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (4)$$

$$GTFP_{it} = \gamma_0 + \gamma_1 AUTO_{it} + \gamma_2 Med_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (5)$$

In this model, *Med* represents the mediating variable. In this study, science and technology support (*Scitechsup*) and environmental regulation (*Enviregu*) are used as mediating variables. Table 5 details the mediation effect outcomes. Column (2) reports the results of Equation 4—after controlling for other variables, local economic autonomy has a significant negative estimate coefficient at the 1% level for *Scitechsup* (-0.0050). Column (3) displays the test results for Equation 5, showing that the two-period lagged *Scitechsup* has a significantly positive estimate coefficient at the 10% level for *GTFP* (0.0333). This suggests that government autonomy reduces the intensity of science and technology support and negatively affects enterprises' GTFP, validating Hypothesis 2.

Columns (4) and (5) show the results of Equations 4 and 5, using *Enviregu* as the mediating variable. The estimated coefficient of *AUTO* on *Enviregu* is 0.0110, significant at the 1% level. In Column (5), the estimated coefficient of *Enviregu*'s impact on *GTFP* is 0.0224 at the 5% significance level, but the estimated coefficient of *AUTO* is significantly negative at the 1% level—local government autonomy reduces its negative impact on GTFP by promoting the improvement of the *Enviregu* level. Therefore, the final total effect of *AUTO* on *GTFP* (− 0.0026) is weaker than its direct effect (− 0.0029); expressly, there is a masking effect, which verifies Hypothesis 3.

The negative effect of autonomy on science and technology support (Scitechsup, $\beta = -0.0050$, $p < 0.01$) and positive effect on environmental regulation (Enviregu, $\beta = 0.0110$, $p < 0.01$) reveal a policy substitution effect. This aligns with [6] framework, where government streams (e.g., environmental regulation) interact with technical streams (e.g., innovation). Specifically, the substitution effect reflects a trade-off between short-term regulatory outcomes (government stream) and long-term innovation investments (technical stream), as identified by Addy & Jiří [36].

The masking effect (β = −0.0029 vs. −0.0026) suggests environmental regulation partially offsets autonomy's negative impact, consistent with [20]'s finding that moderate environmental regulation can enhance efficiency. However, the net negative effect underscores the dominance of innovation suppression over regulatory gains, echoing [21] critique of compliance costs.

Table 5. Results of mediating and masking effects

Models Variables	(1)	(2)	(3)	(4)	(5)
	GTFP	Mediating effect of research support		Inhibitory effect of environmental regulation	
		Scitechsup	*GTFP*	*Enviregu*	*GTFP*
AUTO	-0.0026** (0.0013)	-0.0050*** (0.0010)	-0.0031** (0.0014)	0.0110*** (0.0016)	-0.0029*** (0.0013)
Scitechsup			0.0333* (0.0189)		
Enviregu					0.0224** (0.0094)
Constant	0.8564*** (0.0183)	0.0304*** (0.0005)	0.9194*** (0.0224)	0.2296*** (0.0232)	0.8513*** (0.0184)
Control variables	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
R^2	0.9864	0.1966	0.9809	0.3011	0.9864
Sample size	7588				

Note. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. In conducting the mechanism test, the objective is to demonstrate that autonomy influences GTFP through its effect on support for science and technology. Given that the impact of science and technology on GTFP may exhibit a lagged effect rather than manifesting in the same year, the two-period lagged *Scitechsup* variable was employed to verify its mediating effect.

5.3.2. Substitution Effect of Policies

To verify whether an increase in local economic regulation autonomy results in unidirectional policy substitution effects, *Scitechsup* serves as the mediating variable, and the influence of autonomy on environmental regulation is examined in three steps, following an approach similar to a mediation effect model.

$$Enviregu_{it} = \alpha_0 + \alpha_1 AUTO_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (6)$$

$$Scitec\_sup_{it} = \beta_0 + \beta_1 AUTO_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (7)$$

$$Enviregu_{it} = \gamma_0 + \gamma_1 AUTO_{it} + \gamma_2 Scitec\_sup_{it} + \sum \eta_j Control_{jit} + \mu_{it} + \lambda_{it} + \varepsilon_{it} \quad (8)$$

Among them, α_1 represents the overall effect of *AUTO* on environmental regulation; β_1 in Equation 7 denotes the impact of *AUTO* on science and technology support (policy to be substituted); γ_1 in Equation 8 represents the direct impact of *AUTO* on environmental regulation after controlling for the influence of science and technology support and other control variables, whereas γ_2 reflects the extent to which environmental regulation responds to science and technology support after controlling for the influence of *AUTO* and other control variables, indicating a potential substitution effect.

Table 6 presents the experimental results. As examined within the context of mediating and masking effects, the findings indicate that greater local economic autonomy leads governments to reduce support for science and technology while increasing environmental regulation. Additionally, Table 6 shows that the estimated coefficient of *Scitechsup* on *Enviregu* is significantly negative, approximately -0.2535. Given that both estimated coefficients β_1 and γ_2 are significantly negative at the 1% level, it can be inferred that local governments employ environmental regulation as a substitute for science and technology support, thereby validating Hypothesis 4.

Table 6. Results of substitution effect

Variables	(1)	(2)	(3)
	Enviregu	***Scitechsup***	***Enviregu***
AUTO	0.0110*** (0.0017)	-0.0050*** (0.0010)	0.0097*** (0.0016)
Scitechsup			-0.2535*** (0.0202)
Constant	0.2296*** (0.0232)	0.0304*** (0.0005)	0.2018*** (0.0230)
Control variables	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes
R^2	0.3011	0.1966	0.3164
Sample size		7588	

Note. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.3.3. Cross-Section Effect Test

To explore how regional heterogeneity affects the correlation between government behavior and corporate performance, this study measures industrial structural upgrading (*Stru*) by employing the tertiary-to-secondary industry value-added ratio. The sample is stratified into two groups at the median value: cities with industrial structures below the median and those above it. After conducting a group regression analysis on the baseline model, as shown in Table 7, a significant negative correlation between *AUTO* and *GTFP* was found in cities with lower levels of industrial structure, with an estimated regression coefficient of -0.0030 at a significance level of 10%. However, no similar significant negative impact was observed for economic regulation autonomy on corporate GTFP in cities with more industrial structures. This difference verifies Hypothesis 5, suggesting that industrial structural upgrading helps mitigate the negative effects of local government regulatory autonomy on corporate GTFP.

The mitigating role of industrial structure upgrading (Struc ≥ 1.17) aligns with [15], who emphasize that tertiary industries reduce pollution intensity and foster innovation. This result extends [16] work on marketization, demonstrating that structural upgrading enhances policy coordination and reduces regulatory burdens. In contrast, regions with lower industrial structure (Struc < 1.17) exhibit amplified negative effects, corroborating [38] analysis of innovation agglomeration in technology-intensive sectors.

Table 7. Results of heterogeneity test

Groups Variables	(1)	(2)
	Struc < 1.17	**Struc ≥ 1.17**
	GTFP	***GTFP***
AUTO	-0.0030* (0.0017)	0.0005 (0.0106)
Constant	0.9285*** (0.0276)	0.8814*** (0.0323)
Control variables	Yes	Yes
Year fixed effect	Yes	Yes
Firm fixed effect	Yes	Yes
R^2	0.9834	0.9806
Sample size	3795	3793

Note. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

6. Conclusions

6.1. Main Findings

Exploring the relationship between government behavior and corporate economic performance holds significant importance for advancing sustainable economic development. Using sample data from Chinese listed companies from 2007 to 2021, this study calculates enterprise GTFP with a non-radial SBM-ML index and thoroughly examines the impact of local governments' economic regulation autonomy on enterprises' GTFP across two dimensions: environmental and fiscal decentralization. Furthermore, the analysis investigates the roles of different types of government policies and regional differences in industrial structure in shaping government-enterprise relations. Based on the findings of this study, three principal conclusions are identified.

First, based on a difference-in-differences model, fiscal and environmental decentralization were used to measure the autonomy of local governments' economic regulation. The results show that an increase in local government autonomy has a hindering effect on enterprises GTFP. This is because increased autonomy reduces policy coordination between regions and reduces dependence on the central government; intensified competition between regions leads to increased corruption and excessive intervention in economic activities. Separately, fiscal autonomy promotes enterprises' green total factor, whereas environmental autonomy hinders its improvement.

Second, owing to the existence of policy substitution effects, local governments weighed their options between environmental regulations and support for science and technology. Higher levels of science and technology support imply lower levels of environmental regulation. The increased autonomy of local governments effects greater policy discretion, making them more willing to enhance environmental regulations than science and technology support. Improvements in environmental regulations are also partly aimed at compensating for the reduction in science and technology support. Therefore, autonomy leads to an increase in the level of environmental regulation and reduces the negative impact on GTFP. However, autonomy decreases science and technology support and suppresses corporate GTFP.

Finally, considering the differentiated impact of regional industrial structure levels, evidence shows that in regions with lower levels of industrial structure, government autonomy continues to significantly inhibit enterprises' GTFP. However, this negative effect is absent in regions with higher levels of industrial structure, suggesting that upgrading the regional industrial structure influences local governments' economic regulatory behavior.

6.2. Policy Implications

This article provides several policy recommendations. First, in contrast to the central government, local governments have a clear information advantage in terms of local economic development and are closer to local businesses and residents. It is crucial for them to fully leverage this information and proximity advantage by adopting reasonable policies and guaranteeing the efficacious execution of central policies. As local government autonomy increases, they should enhance cooperation among regions and improve coordination between local policies as well as between local and central policies. They should also consider positive externalities when formulating policies, actively implement those with higher positive externalities, and promote the efficient allocation of resources. For example, increasing fiscal support for scientific and technological research can reduce the cost of innovation for businesses, enhancing their GTFP.

Second, considering the differentiated impacts of fiscal and environmental decentralization, as well as their combined hindrance to the GTFP of enterprises, it is not appropriate to simply consider the positive influence of fiscal decentralization on corporate economic performance. When designing decentralization reform plans, the central government should comprehensively consider the differentiated effects of administrative system reform and economic development integration under different decentralization conditions on microeconomic entities' input-output efficiency and resource allocation optimization at the local level. For example, by combining carbon emissions accounting with carbon footprint measurements, efforts should be made to strengthen the coordination between government governance and enterprise green development.

Third, as the supervisory bodies of the regional economy, local governments do not participate directly in the production and operational activities of enterprises. They lack sufficient understanding of enterprise production and operations. Therefore, local governments should fully coordinate the relationship between government and enterprises, reduce excessive intervention in enterprises, strengthen integrity construction, and lower rent-seeking costs for businesses to provide a favorable political environment. Concurrently, the government must balance at least two objectives: environmental protection and economic growth. Local governments should focus on economic growth and take responsibility for environmental pollution issues, as its deterioration will hinder economic development. It is unacceptable to sacrifice the environment by allowing unrestricted pollution emissions from companies or by excessively restricting business activities owing to environmental protection concerns.

Fourth, enhancing the industrial structure not only amplifies the technological innovation agglomeration effect but also eases the difficulty of environmental regulations. This further reduces the risk associated with government science and technology support. Local governments should take appropriate measures to encourage the transformation of the industrial structure from resource- and labor-intensive to knowledge- and talent-intensive. Short-term policies include providing better financial subsidies and preferential tax policies for tertiary industries, whereas long-term policies can consider improving mechanisms for attracting talent and promoting higher levels of human capital, providing a talent foundation for upgrading the industrial structure.

6.3. Limitations and Prospects

The impact of local government autonomy on the economy has several aspects. The findings of this study are derived solely from Chinese corporate sample data, without considering differences in political systems and economic structures among countries, thus limiting their generalizability. Baskaran et al. [33] analyzed 31 studies on the impact of fiscal decentralization on the economy and find that such an impact is influenced by regional heterogeneity and the methodologies adopted by researchers. Therefore, subsequent research ought to concentrate on exploring how the factors related to political systems and economic structures contribute to governments' influence on firms' GTFP. Furthermore, this study measured the autonomy of local governments in economic regulation using two indicators closely related to sustainable development: fiscal autonomy and environmental autonomy. More indicators could be incorporated to enhance the measurement of local governments' economic autonomy. Finally, due to the diversity in government policy directions, local governments not only make trade-offs between support for scientific and technological innovation and environmental regulations but may also have substitution relationships in other areas. Further investigation into policy substitution effects would contribute to a better understanding of governmental behavior and provide guidance for innovative governance models.

7. Declarations

7.1. Data Availability Statement

The data presented in this study are available in the article.

7.2. Funding

The author received no financial support for the research, authorship, and/or publication of this article.

7.3. Institutional Review Board Statement

Not applicable.

7.4. Informed Consent Statement

Not applicable.

7.5. Declaration of Competing Interest

The author declares 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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