

The Impact of Vertical Fiscal Asymmetries on the Strength of Environmental Regulations

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Abstract. Deepening the financial system reform is an important part of economic high-quality development, and environmental regulation is a necessary path. Based on this, in the context of China's economic development increasingly pursuing the green transformation of the new era, this paper stands on the perspective of vertical fiscal asymmetry to explore the changes in the strength of environmental regulation. Based on the panel data of 30 provinces between 2007 and 2021, I empirically analyze the impact of vertical fiscal asymmetry on the strength of environmental regulation and how it works. It is shown that vertical fiscal asymmetry has an inhibitory effect on the strength of environmental regulation, and the results of the mode of action show that the increase in the degree of marketization weakens the inhibitory effect of vertical fiscal asymmetry on the strength of environmental regulation to a certain extent. Therefore, it is necessary to take measures such as continuing to deepen the reform of the fiscal system, deepening the reform of the industrial structure, and moderately expanding the degree of local marketization, in order to reduce the negative impact of vertical fiscal asymmetry on the strength of environmental regulation, and to contribute to ecological civilization.

Keywords: Vertical Fiscal Asymmetry; Environmental Regulation; Marketization; Local Government Finance.

1. Introduction

China has made remarkable achievements in economic construction through the incentive model under Chinese decentralization [1]. However, although China, as a latecomer, has recognized the disadvantages of the development concept of "development first, governance later" in the process of industrialization in western countries, the fact that the government, enterprises, and residents of China generally attach more importance to economic benefits than environmental benefits at the early stage of economic development has led to environmental problems, such as haze, in the process of China's industrialization. In recent years, with economic development and people's growing desire for a better life, the topic of environmental governance has received increasing attention. The 20th National Congress of the Communist Party of China (CPC) emphasized the concept of "promoting green development and harmonious coexistence between human beings and nature". Environmental regulation, as the intervention behavior of local governments in the industry for the purpose of protecting the environment and saving resources, has become an important way to solve environmental problems [2]. Research shows that government environmental regulation in the "incentive mechanism" and "forcing mechanism" under the role of affecting the costs and benefits of enterprises, to guide the transformation and upgrading of enterprises, spatial transfer and market exit and other behaviors, which will help the local energy saving and emission reduction, and then positively affect the environmental governance [3]. In addition, environmental regulation also has the role of forcing the upgrading of regional industrial structure [4], promoting the use of digitalization in environmental governance [5], promoting economic development [6], stimulating consumers' green preferences [7], etc., which is of great significance in improving the industrial structure and the construction of "Beautiful China" .

The implementation of environmental regulatory policies by the government is inevitably affected by the current management system, which is most distinctively characterized by fiscal decentralization

[8]. The concept of Chinese decentralization was first proposed by Qian Yingyi, meaning the combination of economic decentralization and political centralization [9]. China's fiscal decentralization system has gone through an evolutionary process from the 1980s lump-sum system to the fiscal tax-sharing system in the 20th century. Among them, the tax-sharing reform implemented in 1994 increased the degree of fiscal decentralization while clarifying the criteria for the division of fiscal revenues between local and central governments [10]. However, the tax system does not provide a clear definition of intergovernmental rights and expenditures, which leads to the "upward collection of financial rights and downward dissolution of rights" [11], which leads to the local government facing a serious fiscal gap, thus giving rise to the vertical fiscal asymmetry.

Based on this, this paper uses a regression model and introduces control variables such as the proportion of the secondary industry to explore the relationship between vertical fiscal asymmetry and environmental regulation and the role of the degree of marketization in it. The contributions of this paper are mainly: first, in the research perspective, from the internal system rather than external policies to explore the impact, which enriches the research on vertical fiscal asymmetry and environmental regulation; second, in the content of the research, not only studied the relationship between vertical fiscal asymmetry and the strength of environmental regulation, but also investigated the effect of the degree of marketization.

2. Literature Review and Theoretical Analysis

Domestic and international literature has a more comprehensive study on the influencing factors of environmental regulation. Starting from internal policies, Ren (2018) classified environmental regulation into three categories: command-and-control regulation, market-based regulation, and voluntary regulation, and based on data from 30 Chinese provinces during 2000-2013, combined with the STIRPAT model, concluded that different types of regulation have different impacts on eco-efficiency in different regions. The effect of environmental regulatory intensity on environmental regulation is controversial, with Porter and van der Linde (1995) arguing that strict regulation can be effective in promoting firms to innovate to reduce emissions, while Palmer, Oates, and Portney (1995) argued that incentive-based instruments may be more effective relative to environmental regulation, and Ayres and Braithwaite (1992) suggest that "responsive regulation" between deterrence and compliance is the optimal strategy. From the perspective of the subject of environmental regulation, the amount of influence that polluters have on environmental regulation is directly proportional to the size of the company itself, its closeness to the government, and the strength of rent-seeking from the government; the public is at a disadvantage in the environmental regulation game because the "free-rider" effect weakens the willingness to act together; and the environmental regulatory agency has a greater degree of discretionary power (Liu, 2008). In addition, Gao (2021) proposes to pay attention to the positive interaction between foreign direct investment and environmental regulation, especially the need to give full play to the role of market-based regulation, while Blohmke (2017) proposes that green advocacy and governance capacity are the main structural determinants of the quality of environmental regulation through structural equation modeling on a dataset of 47 countries. In China, the central government's linkage of official promotions to local performance has led to a regional "competition for growth" promotion tournament (He and Ma, 2020), and competition for environmental regulation has arisen as environmental regulation affects the location of mobile capital (Lu and Chen, 2019). In this regard, Cui et al. (2023) point out that the state of environmental regulation competition among local governments is affected by the three states of competition for attracting capital, environmental protection assessment and public environmental protection demands, and that environmental regulation competition may lead to the "boundary effect" of pollution (Chen and Wang, 2023).

Regarding the impact of fiscal decentralization on environmental governance, scholars at home and abroad generally have the following three views: fiscal decentralization is unfavorable to environmental governance, fiscal decentralization is favorable to environmental governance, and there is a nonlinear relationship between fiscal decentralization and environmental governance (Liu

et al., 2022). As for the unfavorable theory of fiscal decentralization, Han and Meng (2018) argued that under fiscal decentralization, local governments focus more on stimulating economic growth and neglect environmental governance, forming "bottom-up competition" under "GDP worship" (Dijkstra, 2010), while Li et al. (2021) argue that fiscal decentralization can affect public service provision by influencing local governments' revenue and expenditure preferences, thus squeezing environmental protection inputs. In terms of results, Dong et al. (2022) found that fiscal decentralization has a significant negative spillover effect on green innovation through a spatial Durbin model, while Sigman (2014) verified the idea of "race to the bottom" based on an analysis of the degree of deterioration of water pollution and the degree of fiscal decentralization around the world. As for the favorable theory of fiscal decentralization, some studies show that fiscal decentralization can give full play to the information advantage of local governments (Zou et al., 2019), which is conducive to the formation of local environmental regulatory networks (Jiang and You, 2016), and some studies believe that there is a positive spillover effect of the level of environmental governance in geographically and economically neighboring regions (Tang et al., 2022). From the results, Li (2019) concludes that fiscal decentralization has a significant positive effect on carbon emissions by expressing the degree of fiscal decentralization through different indicators, and Li (2021) finds that fiscal decentralization can significantly and positively affect environmental equality. For the nonlinear impact view, Xu et al. (2017) empirically prove that fiscal decentralization has an inverted "U"-shaped impact on industrial wastewater emissions and a "U"-shaped impact on industrial sulfur dioxide emissions, and Shao et al. (2022) also found that fiscal decentralization can also be used as a threshold variable for the impact of environmental regulation on regional eco-efficiency to indirectly influence environmental governance.

Vertical fiscal asymmetry is derived from the fiscal decentralization system. The existing studies on vertical fiscal asymmetry mainly focus on the formation causes and social effects (Zhang et al., 2022). Among the studies on the social effects of vertical fiscal asymmetry, the relationship between vertical fiscal asymmetry and public service provision has received extensive attention. Chu and Chi (2018) argue that vertical fiscal imbalance distorts the transfer payment system and leads to a significant decline in the capacity of public service provision; Gong and Lu (2009) find that, based on the index measurement, local governments invest a large amount of financial resources in infrastructure construction expenditure projects, while the expenditure on livelihood projects is obviously insufficient; and Shen and Guo (2021) argue that vertical fiscal imbalance exacerbates local governments' land finance behavior and promote local environmental pollution. Some scholars also believe that the vertical fiscal imbalance and the governance capacity of local governments are in an inverted U-shape (Li and Su, 2023). However, although some scholars have empirically found that vertical fiscal asymmetry has a significant inhibitory effect on environmental governance and the efficiency of green development (Guo et al., 2020), little literature has directly explored the direct effect of vertical fiscal asymmetry on the strength of environmental regulation. In view of this, this paper proposes the following research hypotheses:

Hypothesis 1: Vertical fiscal asymmetry negatively affects the strength of environmental regulation

In addition, the degree of marketization may affect the relationship between vertical fiscal asymmetry and the strength of environmental regulation. Yuan et al. (2023) argued that giving full play to the market mechanism and reducing government intervention in the production activities of enterprises are more conducive to the cleaner transformation of the manufacturing industry as well as easing the financial and fiscal pressure on government finances. As the most important market-oriented environmental regulation policy, Wu et al. (2021) point out that the carbon emission right policy can control the total pollution emission of the society by restricting the amount of carbon used by the enterprises, while Feng et al. (2020) revalidated the strong baud hypothesis of sulfur emission right by studying the sulfur dioxide emission trading pilot of China's large-scale market-oriented environmental regulation in 2007. Some scholars have also incorporated environmental taxes into market-based environmental regulation, concluding that environmental taxes may lead to changes in

industrial structure (Fan and Liu, 2017). In view of this, this paper proposes the following two research hypotheses:

Hypothesis 2: There is a threshold effect of the marketization level on the impact of vertical fiscal asymmetry on the strength of environmental regulation, and the negative inhibitory effect of vertical fiscal asymmetry on the strength of environmental regulation will be significantly weakened after crossing the threshold.

Hypothesis 3: the marketization level can regulate the impact of vertical fiscal asymmetry on environmental regulation, and the performance of the marketization level to enhance the negative impact of vertical fiscal asymmetry on the strength of environmental regulation has an inhibitory effect.

Based on this, this paper will explore the impact of vertical fiscal asymmetry on environmental regulation from the perspective of empirical research, and analyze the threshold effect and moderating effect of the level of marketization in the relationship between the two.

3. Modeling, Variable Selection and Data Sources

3.1. Modeling

In this paper, an econometric model is constructed to test the correctness of hypothesis 1, as shown in equation (1):

$$Eigdp_{it} = \alpha_0 + \alpha_1 Vfi_{it} + \sum \phi_j X_{jit} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

where i and t denote province and year respectively, $Eigdp$ denotes environmental regulation intensity, Vfi denotes vertical fiscal asymmetry, X denotes a series of control variables that may affect public environmental expenditures. α_0 denotes the constant term, α_1 and ϕ denote the unknown regression coefficients. λ and μ denote area (province) fixed effects and time fixed effects. ε denotes the random perturbation term.

In order to verify the correctness of hypothesis 2, this paper introduces the degree of marketization as a threshold variable to construct an econometric model on the basis of equation (1), as shown in equation (2):

$$Eigdp_{it} = \begin{cases} \beta_0 + \beta_1 Vfi_{it} + \sum \phi_j X_{jit} + \lambda_i + \mu_t + \varepsilon_{it} (Mkt < q) \\ \beta'_0 + \beta_2 Vfi_{it} + \sum \phi_j X_{jit} + \lambda_i + \mu_t + \varepsilon_{it} (Mkt > q) \end{cases} \quad (2)$$

Where β_0 and β'_0 denote constant terms, β_1 and β_2 denote the regression coefficients when the degree of marketization is less than or greater than the threshold respectively.

In order to verify the correctness of hypothesis 3, this paper introduces the degree of marketization on the basis of equation (1), and at the same time introduces the interaction term between this variable and vertical fiscal asymmetry, as shown in equation (3):

$$Eigdp_{it} = \gamma_0 + \gamma_1 Vfi_{it} + \gamma_2 Vfi_{it} \times Mkt_{it} + \gamma_3 Mkt_{it} + \sum \psi_j X_{jit} + \lambda_i + \mu_t + \varepsilon_{it} \quad (3)$$

Where, γ_0 denotes the constant term, γ_1, γ_2 and γ_3 all denote unknown regression coefficients. Where the degree of marketization is adopted from Fan's research data, which will be explained in detail in the variable selection section.

3.2. Variable Selection

3.2.1. Explained Variable

The key to measuring the strength of environmental regulation lies in environmental protection investment. This paper chooses to use the amount of investment in environmental pollution control in each province in each year as a proportion of GDP as an indicator of the strength of environmental

regulation, denoted by $Eigdp$. In the actual regression analysis, the substitution is actually the logarithm of the base 10, i.e. $LgEigdp$.

3.2.2. Explanatory Variable

Vertical fiscal asymmetry is measured by fiscal expenditure decentralization minus fiscal revenue decentralization. Following the measurement of Liu (2018), the fiscal expenditure decentralization and the fiscal revenue decentralization can be expressed as in Table 1, respectively.

Table 1. Representation of Fiscal Expenditure Decentralization and Fiscal Revenue Decentralization Variables

Variable	Calculation
Fiscal revenue decentralization	Ratio of per capita local fiscal revenue budget to (per capita local fiscal revenue budget + per capita central fiscal revenue budget)
Fiscal expenditure decentralization	Ratio of per capita local fiscal expenditure budget to (per capita local fiscal expenditure budget + per capita central fiscal expenditure budget)

The greater the fiscal expenditure decentralization and the smaller the revenue decentralization, the greater the vertical fiscal asymmetry. In the actual regression analysis, the substitution is actually the logarithm of the base 10, i.e. $LgVfi$.

3.2.3. Threshold Variable and Moderating Variable

In measuring the degree of marketization, this paper refers to the comprehensive marketization index of each province from 1997 to 2022 calculated by Fan (2022), and in the actual regression analysis, the substitution is actually the logarithm of the base 10, i.e. $LgMkt$.

3.2.4. Control Variables

Since there are more factors affecting public environmental expenditures, a certain number of control variables must be introduced to obtain more robust results. Specifically as follows: (1) Industrial structure. Changes in industrial structure will affect the degree of environmental pollution, which in turn affects the government's pollution control inputs as well as the strength of environmental regulation. In this paper, the industrial structure is measured by the proportion of the secondary industry, which is denoted by Sip ; (2) government intervention. Government intervention reflects the government's willingness of public expenditure to a certain extent, which is measured by the proportion of local general budget expenditure to local GDP, which is denoted by Gi in this paper; (3) Openness to the outside world. The degree of openness to the outside world reflects the international trade situation of each local government and the degree of utilization of foreign factor resources, which affects the local government expenditure structure by influencing the regional economic growth pattern, and ultimately affects the environmental expenditure. In this paper, the foreign trade ratio Tp is used to measure the degree of openness to the outside world, specifically measured as the total import and export of each local government accounted for the proportion of each local GDP; (4) the degree of environmental pollution. Generally speaking, the greater the degree of environmental pollution in the place, there will be more demands for the management of the environment of the people's aspirations, the local government will invest more in the environment. In this paper, the annual emission of sulfur dioxide (tons) is used as an indicator of the degree of local environmental pollution, and the variable is denoted by $SO2$.

It is worth noting that the above control variables substituted in the actual regression analysis are actually logarithms with a base of 10, i.e. $LgSip, LgGi, LgTp, LgSO2$.

3.3. Data Sources

The empirical analysis in this paper utilizes panel data for 30 provinces in China (Tibet, Hong Kong, Macau, and Taiwan are excluded due to lack of data) for 15 years from 2007 to 2021. The empirical

data are obtained from the EPS database, the Annual Report of China's Ecological and Environmental Statistics, and the marketization index calculated by Fan Gang in the Report on China's Sub-Provincial Marketization Index. Table 2 presents the descriptive statistics of each variable.

Table 2. Descriptive statistical analysis

Variable	Symbol	Sample value	Mean value	Standard deviation	Minimum value	Maximum value
Investment in environmental pollution control as a share of GDP	<i>Eigdp</i>	450	0.014	0.008	0.0003	0.046
Vertical fiscal asymmetry	<i>Vfi</i>	450	0.347	0.102	0.097	0.535
Secondary industry proportion	<i>Sip</i>	450	0.442	0.089	0.158	0.615
Government intervention	<i>Gi</i>	450	0.235	0.100	0.087	0.643
Trade Proportion	<i>Tp</i>	450	0.285	0.331	0.008	1.721
Sulfur dioxide emissions	<i>SO2</i>	450	498410.7	429042.1	1422	1827397
Level of marketization	<i>Mkt</i>	450	7.837	1.921	3.359	12.390

4. Analysis of Empirical Results

4.1. Baseline Estimates

Table 3 shows the results of the baseline estimates. Only the results for the impact of vertical fiscal asymmetry are included in column (1) of table 3. Control variables are added progressively in columns (2) through (5) to control for impacts. The regression coefficients in columns (1) through (5) are all significant at least at 5 percent according to the t-test.

Table 3. Baseline regression of the effect of vertical fiscal asymmetry on the strength of environmental regulation

	(1)	(2)	(3)	(4)	(5)
<i>Vfi</i>	-1.300***(-3.34)	-0.879**(-2.16)	-0.902**(-2.23)	-0.954**(-2.34)	-0.957**(-2.35)
<i>Sip</i>		1.167*** (3.24)	0.979*** (2.58)	0.871** (2.24)	0.816** (2.07)
<i>Gi</i>			-0.425(-1.54)	-0.445(-1.61)	-0.473*(-1.69)
<i>Tp</i>				0.119(1.28)	0.127(1.37)
<i>SO2</i>					0.054(0.77)
Time fixed effects	controlled	controlled	controlled	controlled	controlled
Area Fixed Effects	controlled	controlled	controlled	controlled	controlled
Constant term	-2.595***(-13.3)	-2.012***(-7.63)	-2.421***(-6.47)	-2.419***(-6.47)	-2.770***(-4.7)
R^2	0.1625	0.1837	0.1885	0.1918	0.1930
<i>Obs</i>	450	450	450	450	450

(Note: t-values are in parentheses; ***, **, and * indicate significant at 1%, 5%, and 10%)

In columns (1) through (5) of Table 3, the coefficients on vertical fiscal asymmetry are all significantly negative, which indicates that vertical fiscal asymmetry does inhibit environmental regulatory effort and Hypothesis 1 holds. Taking column (1) as an example, for every unit increase in vertical fiscal asymmetry, the strength of environmental regulation decreases by 1.3 units. The

reason for this may be that in the context of vertical fiscal asymmetry, local governments pay more attention to GDP growth and land finance behavior, and environmental regulation is neglected due to the "bottom-up competition" among local governments.

The addition of control variables is also statistically significant. For example, the coefficients of the proportion of the secondary industry are 1.167, 0.979, 0.871, 0.816, which are significantly positive at least at 5%, indicating that the proportion of the secondary industry promotes environmental regulation. The reason for this may be that the government has to increase environmental regulation in order to maintain the basic environmental quality in the case of a high proportion of the more polluting secondary industry, indicating the necessity of reducing the proportion of the secondary industry; the coefficient of government intervention of -0.473 is significant at 10%, indicating that the government's budgetary expenditures may be tilted towards the expenditures of the non-environmental section when increased.

4.2. Heterogeneity Test

This paper conducted heterogeneous regressions based on time and region respectively. The time is divided into 2012 and before and after 2012, based on the fact that since the 18th Party Congress held on November 8, 2012, the government of China has obviously focused more on the ecological civilization and protection; the 30 provinces involved are divided into the east, the central and western region. The results are shown in Table 4.

Table 4. Heterogeneity test for the effect of vertical fiscal asymmetry on the strength of environmental regulation

	Eastern Region	Central and Western Region	2012 and before	after 2012
<i>Vfi</i>	-0.151(-0.34)	-2.004***(-2.66)	-0.866*(-1.70)	-0.237(-0.34)
<i>Sip</i>	-0.314(-0.45)	0.058(0.11)	0.314(0.61)	-0.094(-0.13)
<i>Gi</i>	1.354*** (3.07)	-1.453***(-3.83)	0.095(0.21)	-0.913**(-2.17)
<i>Tp</i>	-0.505(-1.56)	-0.059(-0.52)	0.038(0.26)	0.189(1.17)
<i>SO2</i>	0.362*** (3.85)	-0.416***(-2.84)	0.432*(1.95)	-0.025(-0.22)
Time fixed effects	controlled	controlled	controlled	controlled
Area fixed effects	controlled	controlled	controlled	controlled
Constant term	-3.091***(-3.42)	-1.402(-1.45)	-4.686***(-3.54)	-2.26**(-2.38)
R^2	0.3110	0.2992	0.2616	0.1773
<i>Obs</i>	165	285	180	270

(Note: t-values are in parentheses; ***, **, and * indicate significant at 1%, 5%, and 10%)

The results in Table 4 show that the coefficient of vertical fiscal asymmetry is still negative after dividing by time and region, and that the data from the Midwest, 2012 and earlier have stronger correlations. Overall, the total sample can be considered suitable for regression analysis.

4.3. Robustness Tests

Based on column (5) of Table 3, this paper also conducts a series of robustness tests to confirm the good robustness of the baseline regression results, as presented in Table 5.

4.3.1. Lagging the Vertical Fiscal Asymmetry Variable *Vfi* by One Period

Since there may be a lag in the impact of policies on the economy and government spending behavior, the vertical fiscal asymmetry variable *Vfi* is lagged by one period in column (1) of Table 5. According to the results in column (1) of Table 5, the coefficient of the vertical fiscal asymmetry

variable *Vfi* is -0.856, which is significant at the 5% level, indicating that vertical fiscal asymmetry still has a dampening effect on the strength of environmental regulation.

Table 5. Robustness test for the effect of vertical fiscal asymmetry on the strength of environmental regulation

	(1)	(2)	(3)
<i>Vfi</i>	-0.856**(-1.99)	-1.164**(-2.11)	-2.215***(-4.77)
<i>Sip</i>	0.890**(2.06)	0.751*(1.75)	-0.160(-0.38)
<i>Gi</i>	-0.485(-1.64)	-0.527*(-1.9)	-0.831***(-2.74)
<i>Tp</i>	0.131(1.30)	0.136(1.44)	0.110(1.07)
<i>SO2</i>	0.029(0.39)	0.037(0.52)	-0.357***(-3.01)
Time fixed effects	controlled	controlled	controlled
Area fixed effects	controlled	controlled	controlled
Constant term	-2.532***(-4.21)	-2.951***(-3.49)	-1.491**(-2.02)
<i>Cragg</i>		475.781	
R^2	0.1914	0.5385	0.2354
<i>Obs</i>	420	420	390

(Note: t-values are in parentheses; ***, **, and * indicate significant at 1%, 5%, and 10%)

4.3.2. Instrumental Variable Estimation

Vertical fiscal asymmetry in different years in each region may have temporal correlation, and the lagged vertical fiscal asymmetry does not directly affect the strength of environmental regulation but indirectly, so this paper chooses to lag the vertical fiscal asymmetry by one period as an instrumental variable. The data in column (2) of Table 5 shows that, the lagged coefficient is -1.164 and meets the 5% significant, and the value of *Cragg* 475.781 is obviously greater than 10 indicating that there is no weak instrumental variable, which indicates that vertical fiscal asymmetry still has an inhibitory effect on the strength of environmental regulation.

4.3.3. Excluding Part of the Sample

Due to the special economic and political status of China's four municipalities in the development process, the municipalities are excluded from the sample here. Column (3) of Table 5 shows that the coefficient of vertical fiscal asymmetry variable *Vfi* is -2.215 on 1% after the municipality is excluded, which indicates that vertical fiscal asymmetry still has an inhibiting effect on the strength of environmental regulation, and the inhibiting effect is more obvious after the municipality is excluded.

4.4. Analysis of the Impact of the Degree of Marketization

On the basis of column (5) in Table 3, this paper introduces the marketization index as a threshold variable and a moderating variable to explore its threshold effect and moderating effect in the process of vertical fiscal asymmetry to inhibit the strength of environmental regulation, respectively, and the specific results are shown in Table 6.

4.4.1. Threshold Effect

According to the first column of Table 6, the coefficient of vertical fiscal asymmetry variable *Vfi* is -0.922 and 5% significant when the marketization index *Mkt* (logarithmic base of 10) is less than 1.0561; when the marketization index is greater than 1.0561, the coefficient of vertical fiscal asymmetry variable *Vfi* is -0.371, which indicates that the marketization index acts as a single-

threshold variable in the process of the vertical fiscal asymmetry (the assumption 2 is valid), and that the inhibitory effect of vertical fiscal asymmetry on the strength of environmental regulation is significantly weaker as the degree of marketization increases. This may be due to the fact that when the degree of marketization is higher than the threshold, activities such as carbon emission rights and environmental taxes are effectively developed, which contribute to the government's commitment to the environment at the same level of vertical fiscal asymmetry.

Table 6. Marketization index effect in the process of vertical fiscal asymmetry inhibiting environmental regulation efforts

	<i>Mkt</i>	<i>EIGDP</i>
<i>Mkt</i> <1.0561	-0.922**(-2.11)	
<i>Mkt</i> >1.0561	-0.371(-0.82)	
<i>Vfi</i>		-1.135***(-2.78)
<i>Vfi</i> × <i>Mkt</i>		4.639*** (2.91)
<i>Mkt</i>		-0.547(-1.55)
<i>Sip</i>	1.393*** (3.36)	0.796** (2.03)
<i>Gi</i>	0.393(1.32)	-0.471* (-1.67)
<i>Tp</i>	0.014(0.07)	0.118(1.28)
<i>SO2</i>	-0.005(-0.06)	-0.050(-0.63)
Constant term	-1.549***(-3.23)	-1.742**(-2.49)
<i>R</i> ²	0.1892	0.2100
<i>Obs</i>	450	450

(Note: t-values are in parentheses; ***, **, and * indicate significant at 1%, 5%, and 10%)

4.4.2. Moderating Effect

According to the second column of Table 6, after adding the marketization index *Mkt* and its interaction term with *Vfi*, the coefficient of *Vfi* is -1.135 at 1% significance and the coefficient of the interaction term is 4.639, which satisfies 1% significance as positive. This suggests that there is a moderating effect of the degree of marketization in the process of vertical fiscal asymmetry inhibiting the strength of environmental regulation, and hypothesis 3 holds. Specifically, the degree of marketization can weaken the inhibitory effect of vertical fiscal asymmetry on environmental regulation to a certain extent, and the specific reasons may be that enterprises pay more attention to green investment and public opinion pays more attention to environmental protection, and so on.

5. Conclusion and Insights

5.1. Main Conclusion

Deepening the reform of the fiscal system is of great significance in increasing the strength of environmental regulation and thus building a "green China". This paper reveals the possible mechanisms of fiscal decentralization and vertical fiscal asymmetry on environmental protection inputs, and the possible paths of marketization. After confirming the control variables, the paper examines the correlation between vertical fiscal asymmetry and environmental regulation by regressing the panel data of 30 provinces from 2007 to 2021, and draws the following conclusions: First, vertical fiscal asymmetry has an inhibitory effect on the strength of environmental regulation, which suggests that the prevailing fiscal imbalance among local governments in China is not conducive to ecological civilization at present; Secondly, the increase in marketization weakens the

inhibitory effect of vertical fiscal asymmetry on the strength of environmental regulation to a certain extent, and the path of action may be a threshold effect or a moderating effect.

5.2. Insights

First, continuously deepening the reform of the financial system and moderately reducing vertical financial asymmetry can effectively raise the degree of importance that local governments attach to ecological construction. Since the tax-sharing reform in 1994, the trend of "collecting financial power upward and dismantling administrative power downward" has become more and more obvious, resulting in the emergence of obvious vertical financial asymmetry in China's financial system. Since vertical fiscal asymmetry has an inhibitory effect on the environmental regulation of local governments, the government should moderately reduce the vertical fiscal asymmetry. First, it needs to define more clearly the financial and administrative rights and deepen the reform of the financial system, and second, it should improve the tax system of local governments and reduce the financial gap of local governments.

Besides, deepening the reform of the industrial structure and gradually reducing the proportion of the secondary industry can achieve ecological civilization while reducing the amount of expenditure. The secondary industry, as a processing and production industry, includes light industry, heavy industry, mining industry and so on, with low added value. Wang(2023) showed that an increase in secondary industry is obviously accompanied by a rise in carbon emissions. As for the relationship between the secondary industry proportion and environmental regulation, Fan et al. (2024) argued that environmental regulation and industrial structure optimization have an inverted U-shaped influence, while this paper suggests that the optimization of industrial structure will force the optimization of the environment. The methods to reduce the proportion of secondary industry mainly include formulating policies to restrict the monopoly industry such as oil, formulating policies to encourage the development and transformation of service industry and high-end manufacturing industry, and regulating and guiding the digital economy.

Finally, expanding the degree of marketization by local governments and increasing the degree of market openness can effectively promote the green transformation of enterprises. Xie et al. (2021) suggest that market-oriented reforms can effectively improve green total factor productivity, and with the improvement of marketization, the factor market will be improved, which will stimulate the desire of enterprises to innovate the green technological innovation. In this regard, the central government should improve the relevant laws and regulations, incentivize green technological innovation and achievement transformation, improve the green patent system, and ensure the standardization of carbon trading and other market behaviors.

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