Fiscal Decentralization, Environmental Protection Tax, and Air Pollution: An Empirical Analysis from the Perspective of SO_2 Emissions in 30 Provinces

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Abstract: Rapid economic development has brought many benefits to the people, but the contradiction between economic development and environmental degradation is also becoming increasingly prominent. In this context, through the panel data of 30 provinces (cities and autonomous regions) except Xizang from 2004 to 2020, a panel vector auto regression model (PVAR) was constructed, and the dynamic relationship between fiscal decentralization and variance decomposition was investigated using the impulse response function and variance decomposition methods. The results indicate that: (1) there is an important dynamic relationship between the emissions of sulfur dioxide, the tax rate of sulfur dioxide, and the decentralization of fiscal revenue. The increase in disposable income of local governments will correspondingly increase the cost of environmental governance, thereby achieving better air governance effects. (2) The dynamic relationship between sulfur dioxide emissions, sulfur dioxide tax rates, and fiscal expenditure decentralization is not significant. The reason may be that vicious competition between local governments will exacerbate the level of air pollution, and the behavior of local governments' prioritizing economy over environmental protection will lead to an increase in pollution levels instead of a decrease.

Keywords: Fiscal Decentralization; Air Pollution; Environmental Protection Tax; PVAR Model

1. Introduction

China has made significant achievements in economic development, but the contradiction between economic progress and environmental pollution is becoming increasingly prominent. With the rapid development of the economy, as society enters a certain level of industrialization, problems such as resource shortage, soil erosion, and air pollution are also on the rise [1]. In particular, air pollutants like nitrogen oxides and sulfur dioxide, and smoke and dust have caused serious harm to human health and living environment. In 2020, the Environmental Performance Index (EPI) evaluated 180 countries around the world, and China ranked 120th with an environmental performance index of 37.3 [2]. In the past decade, China has worked tirelessly to protect the environment, but it is still in a severe situation. Therefore, it is urgent to take measures to protect the environment and make efforts to actively respond to the call to build an environmentally friendly society and practice the concept that green waters and mountains are mountains of gold and silver.

The tax system for environmental protection, as a market participatory environmental system3, has attracted widespread attention from all walks of life. It intervenes in market behavior through tax policies to achieve emission reduction and pollution control. However, environmental governance is closely related to government policies. Taxation, as a part of fiscal revenue, is a means and method adopted by local governments under the "Chinese style decentralization". Whether it can be an important factor in air governance remains to be verified, is it possible for fiscal decentralization to enhance the beneficial impact of environmental protection taxes on the enhancement of the environment? Therefore, this article explores the relationship between fiscal decentralization, environmental protection tax, and air pollution, examining whether there is a dynamic relationship and

whether it can have an impact on air pollution.

2. Literature Review

The concept of environmental protection tax and air pollution was first proposed by Pigou in his 1920 book "Welfare Economics". Based on the theoretical framework, a large-scale discussion was conducted on the dual dividend of environmental protection tax. Domestic scholars mainly explored three aspects of the pollution fee system. Firstly, the collection of pollution discharge fees can significantly inhibit the discharge of pollutants. Secondly, the collection of pollution discharge fees can significantly inhibit economic development. Thirdly, by integrating the financial and environmental benefits of charging for pollution discharge, we can explore the dual impact of the pollution discharge fee system to achieve a win-win situation between environmental and economic construction [3]. Subsequently, China's first Environmental Protection Tax Law was proposed on January 1, 2018. In foreign countries, among the world's top air quality European countries, a relatively mature environmental protection tax system has already been established, and successful experience in air pollution control has been achieved. At the same time, it also indicates that there is a causal relationship between the establishment of environmental protection tax and air pollution control. In order to investigate the impact of environmental protection taxes on reducing emissions, a panel data model was established using data from 30 Chinese provinces (excluding Xizang) between 2005 and 2015, and the emission charge was used as a tool variable to analyze the emission reduction effect. After OLS method, it was concluded that the collection of emission charges had a significant inhibitory effect on emissions, industrial wastewater emissions, but had no significant effect on solid waste emissions [4]. It is evident that environmental taxes have a big influence on how air pollution is governed.

Regarding the research on fiscal decentralization and air pollution, local governments, under the pressure of political performance, have accelerated their construction in the regional economy. The competition between regional governments has become increasingly fierce, presenting a situation of "emphasizing basic construction over public services", and even using the ecological environment as a substitute. The situation of environmental pollution has been deteriorating year by year, but it has not attracted the attention of regional governments [5]. Numerous academics have investigated the role of fiscal decentralization and examined how it affects environmental pollution from two angles: fiscal decentralization of revenue and fiscal decentralization of expenditure. They have concluded that expenditure decentralization is negatively correlated with pollutant emissions, and the relationship between income decentralization and pollutants is not clear [6]. Fiscal decentralization will lead to "competition" among local governments, reduce their control over environmental pollution, and exacerbate the severity of environmental pollution problems. From this, it can be concluded that under the development of an extensive economy, fiscal decentralization will increase pollutant emissions, while competition between local governments often overlooks environmental issues. In the long run, the problem of air pollution has become increasingly severe.

Research on taxes for environmental protection indicates that taxes play a major role in air governance. Domestic and foreign scholars have focused their research on the impact of taxation on environmental pollution in three aspects. First, they looked at the tax burden as a factor in determining how taxes affect environmental pollution. Many scholars have found that taxation burden is positively correlated with environmental pollution, and taxation burden has a positive promoting effect on the emission of industrial "three wastes" [7], therefore, reducing tax burden can effectively improve environmental quality; the second is investigating the effect of tax incentives on environmental pollution. The study found that the sense of responsibility of enterprises towards the environment weakens with the increase of incentives, which is more detrimental to environmental protection [8]. The third is investigating the effects of tax competition on environmental pollution. Tax competition can lead to a decrease in tax rates, and also lead to changes in environmental policies that tend to be adverse, ultimately leading to a decrease in environmental quality [9]. Fiscal decentralization not only has an

impact on environmental pollution itself, but may also amplify the impact of taxation on environmental pollution. The impact of fiscal decentralization on taxation; the more fiscal decentralization there is, the more power local governments have at their disposal. This will exacerbate the effect of taxes on environmental pollution [10]

Scholars from within the country have investigated the relationship between fiscal decentralization, environmental protection taxes, and air pollution. Specifically, they have looked at how taxes affect air pollution. As taxes and fees are composed of corporate income tax, urban maintenance and construction tax, pollution fees, and resource tax, the differences between their taxes and fees have been analyzed and compared. In the absence of fiscal decentralization, the impact of pollution fees on environmental pollution is not significant, under the influence of fiscal decentralization system, the coefficient of pollutant discharge fee coefficient is negative, indicating that increasing the intensity of pollutant discharge fee collection will improve environmental quality [11]. From this, in light of fiscal decentralization, it can be said that pollutant discharge fees have contributed positively to the management of air pollution.

In summary, the current research on environmental protection tax and air pollution, as well as fiscal decentralization and air pollution, is very mature both domestically and internationally. Nonetheless, there are disparities in study findings and not much attention has been focused on whether fiscal decentralization, environmental protection taxes, and air pollution are dynamically related. The selection of indicators is too cumbersome, neglecting the role of mutual influence between indicators, Therefore, this study takes the emissions of 30 provinces except Xizang from 2004 to 2020 as the indicator of air pollution, explores the relationship between fiscal decentralization, environmental protection tax and air pollution, makes contributions to environmental pollution control, and builds a beautiful China with positive behavior.

3. Model Establishment and Data Sources

3.1. Model Establishment

This paper uses panel data from 30 provinces except Xizang from 2004 to 2020. Compared with the VAR model, the PVAR (panel data vector autoregression) technology has lower requirements on the length of time series. Combining the traditional vector autoregression method and panel data model, we can better observe the individual heterogeneity factors that affect the model, treat the variables in the panel data system as endogenous, and explore sulfur dioxide emissions, The dynamic relationship between the three factors of sulfur dioxide tax rate, fiscal revenue decentralization and sulfur dioxide emissions, sulfur dioxide tax rate, and fiscal expenditure decentralization can be written as follows:

$$Y_{it} = \beta_0 + \sum_{n=1}^{p} \beta_n Y_{it-n} + \gamma_i + \sigma_i + \mu_{it} \quad (1)$$

Among them, $Y_{it} = [\, tSO_2 \;\; pSO_2 \;\; Decin]$ and $Y_{it} = [\, tSO_2 \;\; pSO_2 \;\; Decex]$, tSO_2 represent SO_2 tax rates, pSO_2 represent SO_2 emissions, $Decin$ represent fiscal revenue decentralization, and $Decex$ represent fiscal expenditure decentralization. Y_{it-n} represents the nth order delayed term of Y_{it}, i represents each province, t represents the year, p represents the lag order, β_n represents the coefficient matrix, γ_i and σ_i represents individual effects and time effects, respectively, and μ_{it} is a random disturbance term.

3.2. Data Description

To investigate the dynamic connection between fiscal decentralization, environmental taxes, and air pollution, the selection of variables also needs to be scientific and reasonable. The following is an explanation of the selection of variables and data sources.

The level of fiscal decentralization is the first important factor to consider. The degree of fiscal decentralization is one important indicator of the degree of fiscal autonomy of local governments [12]. In China, fiscal revenue and expenditure are mostly used as indicators to measure the degree of fiscal decentralization. Therefore, this article draws inspiration from Ding Pengcheng's research [13] and sets the indicators for measuring fiscal decentralization as fiscal revenue decentralization ($Decin$) and fiscal expenditure decentralization ($Decex$), To calculate the degree to which each province has decentralized its fiscal revenue and expenditure, use the ratio of provincial general

public budget revenue and expenditure to national general public budget expenditure and revenue.

Another variable is the environmental tax variable. The variable used to measure environmental protection tax in this article is the tax rate. In 2018, the Environmental Protection Tax Law was officially implemented. Prior to this, the country used the collection of pollution fees for control. The collection standard for pollution fees was established on July 1, 2003. In the "Regulations on the Collection and Use of Pollution Fees", the collection standard, collection scope, collection object, tax calculation method, and tax calculation standard for pollution fees were detailed. On the basis of "tax burden translation", the collection standards for environmental protection tax and pollution discharge fee are consistent, which can achieve a smooth connection between the two.

The last important variable is the air pollution variable. The measurement indicator for air pollution is the amount of sulfur dioxide emissions. China's environmental issues are getting worse as a result of the country's economy growing so quickly. Air pollution has had a huge negative impact on human physical and mental health [14]. Among them, sulfur dioxide is the main source of air pollution, and its impact on human living environment reflects that sulfur dioxide is emitted into the air, forming acid rain, which not only damages soil structure, Moreover, it can also damage the nutritional components in the soil and corrode the surface of plants, indicating that sulfur dioxide can cause irreversible damage to the environment [15]. In order to gauge the level of air pollution, sulfur dioxide emissions from 2004 to 2020 are utilized as an indicator.

3.3. Data Sources

The data on fiscal decentralization in this article comes from the "China Statistical Yearbook" and "China Environmental Statistical Yearbook", as well as official data published by provincial statistical bureaus. Due to the serious lack of data in Xizang, this paper selects 30 provinces except Xizang as panel data to conduct empirical research on sulfur dioxide emissions, sulfur dioxide tax rates, the decentralization of fiscal revenue and fiscal spending.

4. Empirical Analysis

4.1. Stability Inspection

In order to test the stationarity of panel data, this article uses Levin Lin Chu (LLC test) and Im Esaran Shin (IPS test), two of the most widely used unit root tests. Table 1 shows the results of LLC and IPS tests on sulfur dioxide emissions, sulfur dioxide tax rates, the decentralization of fiscal revenue and fiscal spending. It can be seen that the P-value of fiscal decentralization expenditure on the LLC test is close to 0, indicating that it passed the significance test at the 1% level of the LLC test, but did not pass the stationarity test in the IPS test. The P values of sulfur dioxide tax rate and sulfur dioxide emissions are both close to 1, and both have not passed the LLC and IPS tests. Therefore, in order to proceed with the next analysis, the first-order differences of sulfur dioxide tax rate, sulfur dioxide emissions, fiscal decentralization expenditure, and fiscal decentralization income were tested. Table 2 shows the test results of the first order difference, which shows that the P-values of the first order difference for sulfur dioxide emissions, the levels of fiscal revenue and expenditure decentralization are almost equal. The significance test at the 10% level for sulfur dioxide tax rate indicates that the data is first-order flat. After obtaining a stable state of panel data, the next step is to conduct panel cointegration to explore whether there is a long-term equilibrium relationship among the three.

Table 1. Panel Unit Root Inspection Results

		tSO_2	pSO_2	Decin	Decex
LLC	t-values	7.1679	5.1068	-1.4165	-6.0908
	p-values	1.0000	1.0000	0.0783	0.0000
IPS	t-values	7.4233	12.7017	2.9569	-0.8803
	p-values	1.0000	1.0000	0.9984	0.1893

Table 2. First Order Difference Unit Root Test Results

		D.. tSO_2	D. pSO_2	D.Decin	D.Decex
LLC	t-values	-1.8157	-6.9776	-4.6868	-5.2888
	p-values	0.0347	0.0000	0.0000	0.0000
IPS	t-values	-9.8122	-9.1573	-6.0600	-7.5955
	p-values	0.0000	0.0000	0.0000	0.0000

4.2. Panel Cointegration Inspection

In order to explore the cointegration relationship among the three, KAO test was

used, which is applicable to the testing of multiple economic variables and provides scientific support for the cointegration test of panel data in this article. Panel cointegration tests were conducted on two sets of panel data: (1) sulfur dioxide tax rate, sulfur dioxide emissions, fiscal expenditure decentralization, and (2) sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal decentralization of revenue. Table 3 demonstrates that both panel data sets' P-values for the DF and ADF tests are nearly equal to zero, passing the significance test at the 1% level, indicating a long-term equilibrium relationship between sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal expenditure decentralization. There is also a long-term equilibrium relationship between sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal revenue decentralization.

Table 3. Panel Cointegration Inspection Results

	tSO_2, pSO_2, Decin		tSO_2, pSO_2, Decex	
	DF	ADF	DF	ADF
Statistic	-18.2399	-7.2628	-18.3207	-7.2094
P	0.0000	0.0000	0.0000	0.0000

4.3. Selection of Optimal Lag Order

Before conducting GMM estimation, it is necessary to select the lagged order of the sample. Excessive selection of lagged order can lead to severe loss of sample capacity, while too small selection of lagged order can reduce the credibility of panel data results. Therefore, the optimal lagged order is selected based on the minimum criteria of AIC, BIC, and HQIC. As shown in Table 4, the optimal lag order for the data set of sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal expenditure decentralization can be determined as three orders, while the optimal lag order for the data set of sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal revenue decentralization is also three orders. Once the optimal lag order is determined, it is easy to analyze the panel data in the next step.

Table 4. Analysis Results of the Best Lag Order

	tSO_2, pSO_2, Decin			tSO_2, pSO_2, Decex		
Lag	AIC	BIC	HQIC	AIC	BIC	HQIC
1	-0.281987	0.622047	0.074326	1.30924	2.21327	1.66555
2	-1.13315	-0.094224*	-0.722517	-0.08168	0.957243	0.328949
3	-1.20372*	-0.01388	-0.732063*	-0.460243*	0.729601*	0.011418*
4	-1.13224	0.2279	-0.59142	-0.190698	1.16944	0.350118
5	-0.882371	0.671803	-0.262433	-0.031945	1.52223	0.587992

4.4. GMM Estimation Results

After conducting unit root tests, panel cointegration analysis, and selecting the optimal lag order, Table 5 presents the GMM estimation results of sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal revenue decentralization for the model. The following conclusions are drawn.

The increase in sulfur dioxide tax rate can effectively reduce sulfur dioxide emissions in a short period of time. Sulfur dioxide emissions decrease as fiscal revenue decentralization increases. In the equation of sulfur dioxide emissions as the dependent variable, the sulfur dioxide tax rate has a negative impact on sulfur dioxide emissions when lagging behind stage 1, demonstrateing that with the increase of sulfur dioxide tax rate, sulfur dioxide emissions will decrease. However, in lag stage 2 and lag stage 3, the increase of sulfur dioxide tax rate will increase sulfur dioxide emissions and become more significant over time. The degree of fiscal revenue decentralization has a positive impact on sulfur dioxide emissions when it lags behind the first period, indicating that as the degree of fiscal revenue decentralization increases, sulfur dioxide emissions will increase. When it lags behind the second period, the impact changes from positive to significantly negative, suggesting that the more fiscal revenue is decentralized, the more successful the reduction of sulfur dioxide emissions is.

In the explained variable sulfur dioxide tax rate equation, sulfur dioxide emissions have a

negative impact on the sulfur dioxide tax rate when there is a lag of 1 period, indicating that an increase in sulfur dioxide emissions will lead to a decrease in the sulfur dioxide tax rate. However, when there is a lag of 2 periods, the impact of sulfur dioxide emissions on the sulfur dioxide tax rate changes from negative to positive, indicating that over time, an increase in sulfur dioxide emissions will lead to an increase in the sulfur dioxide tax rate, When there is a lag of three periods, the impact of sulfur dioxide emissions on sulfur dioxide tax rates becomes negatively correlated. When there is a lag of 1 period, the more decentralized the fiscal revenue system is, the higher the sulfur dioxide tax rate. However, when there is a lag of 2 periods, the sulfur dioxide tax rate will decrease with the increase of fiscal revenue decentralization. When there is a lag of 3 periods, it is still positively correlated.

In the explained variable fiscal revenue decentralization equation, when there is a lag of 1 and 3 period, sulfur dioxide emissions have a significant positive impact on the degree of fiscal revenue decentralization. When there is a lag of 2 periods, the impact changes from positive to significantly negative correlation indicating that an increase in sulfur dioxide emissions will importantly exacerbate the degree of fiscal revenue decentralization. When there is a lag of 1 period, the rate of sulfur dioxide taxation and the decentralization of fiscal revenue have a strong positive correlation, indicating that an increase in sulfur dioxide tax rate will lead to an increase in fiscal revenue decentralization. However, when there is a lag of 2 periods, the significant positive relationship turns to a significant negative correlation, showing a different situation from the lag of 1 period. Over time, sulfur dioxide tax rate still has a positive impact on fiscal revenue decentralization.

Table 5. GMM Estimation Results of tSO_2, pSO_2, Decin

	h_so2		h_tso2		h_decin	
	P	t	p	t	p	t
L.h_so2	1.056***	0.0534	-0.00417	0.00528	1.21e-05*	6.58e-06
L2.h_so2	0.0526	0.0572	0.00179	0.00503	-2.55e-05***	6.76e-06
L3.h_so2	-0.170***	0.0452	-0.000381	0.00397	1.42e-05***	3.50e-06
L.h_tso2	-1.365	0.881	0.686***	0.118	0.000343**	0.000133
L2.h_tso2	0.421	0.707	0.00786	0.0711	-0.000253***	8.14e-05
L3.h_tso2	1.170**	0.476	0.0277	0.0717	1.24e-05	7.77e-05
L.h_decin	1.470	990.8	256.3*	146.0	1.197***	0.209
L2.h_decin	-1.510*	814.7	-168.8*	86.44	-0.290**	0.146
L3.h_decin	257.9	257.9	64.23	50.33	-0.0486	0.0700

Table 6 shows the GMM estimation results of sulfur dioxide tax rate, sulfur dioxide emissions, and fiscal expenditure decentralization.

The sulfur dioxide tax rate and fiscal expenditure decentralization are important influencing factors for sulfur dioxide emissions. Raising the tax rate on sulfur dioxide can reduce emissions of sulfur dioxide. Sulfur dioxide emissions will decrease as fiscal expenditure becomes more decentralized. The dependent variable in the equation is the amount of sulfur dioxide emissions, when there is a lag of 1 period, the sulfur dioxide tax rate will have a negative impact on sulfur dioxide emissions. However, as the number of periods increases, the impact of the sulfur dioxide tax rate on sulfur dioxide emissions gradually shifts from negative to significantly positive, indicating that the sulfur dioxide tax rate is the influencing factor of sulfur dioxide emissions and will rise in tandem with the rate of sulfur dioxide taxation. When falling behind periods 1 and 2, the amount of sulfur dioxide emissions will also rise, and the degree of decentralization of fiscal expenditure will positively affect sulfur dioxide emissions. However, in the end, when lagging behind 3 periods, the degree of fiscal expenditure decentralization will have a significant negative impact on sulfur dioxide emissions, indicating that the greater the degree of fiscal expenditure decentralization, the less sulfur dioxide emissions will be.

In the explained variable sulfur dioxide tax rate equation, sulfur dioxide emissions have a negative impact on the sulfur dioxide tax rate when lagging behind 1 and 3 periods, but in

lagging behind 2 periods, the sulfur dioxide tax rate will increase with the increase of sulfur dioxide emissions and have a positive impact. When there is a lag of 1 period, the greater the degree of fiscal expenditure decentralization, the higher the sulfur dioxide tax rate will increase. However, when there is a lag of 2.3 periods, the decentralization of fiscal expenditure has a positive but temporary effect on the rate of sulfur dioxide taxation.

In the fiscal expenditure decentralization equation of the dependent variable, sulfur dioxide emissions have a positive impact on fiscal expenditure decentralization when lagging behind period 1, indicating that an increase in sulfur dioxide emissions will lead to an increase in fiscal expenditure decentralization. However, when lagging behind periods 2 and 3, there is an increase in sulfur dioxide emissions and a decrease in fiscal expenditure decentralization. When lagging behind period 1, an increase in sulfur dioxide tax rate will lead to an intensification of fiscal expenditure decentralization. However, when lagging behind periods 2 and 3, sulfur dioxide tax rate has a significant negative correlation with fiscal expenditure decentralization, indicating that an increase in sulfur dioxide tax rate will weaken fiscal expenditure decentralization.

Table 6. GMM Estimation Results of tSO_2, pSO_2, Decex

	h_so2		h_tso2		h_decex	
	P	t	p	t	p	t
L.h_so2	1.034***	0.0517	-0.00771	0.00483	2.21e-06	6.74e-06
L2.h_so2	0.0653	0.0523	0.00669	0.00445	-4.33e-07	7.74e-06
L3.h_so2	-0.169***	0.0457	-0.00143	0.00383	-2.95e-07	4.36e-06
L.h_tso2	-1.211	0.969	0.768***	0.109)	0.000351**	0.000172
L2.h_tso2	0.730	0.738	0.0421	0.0709	-4.11e-05	8.68e-05
L3.h_tso2	0.968**	0.453	-0.00169	0.0767	-0.000192**	8.90e-05
L.h_decex	345.9	831.2	176.2	144.9	0.840***	0.250
L2.h_decex	292.8	566.6	-32.83	40.68	0.0369	0.0898
L3.h_decex	-697.0***	255.2	-22.04	22.57	-0.127***	0.0480

4.5. Pulse Response Function Analysis

Pulse response function analysis explains the bidirectional dynamic relationship between variables, which can effectively grasp the future trend of variables. Figure 1 shows the pulse response graph of sulfur dioxide emissions, sulfur dioxide tax rates, and fiscal revenue decentralization. Several conclusions can be drawn from the graph. Firstly, after being impacted by sulfur dioxide emissions, the tax rate showed a negative response in the early stage, but after the fourth stage, it changed from a negative response to a positive response, indicating that an increase in sulfur dioxide emissions will lead to a decrease in sulfur dioxide tax rates in the short term, but the duration will not be long, In the long run, the sulfur dioxide tax rate will still increase with the increase of sulfur dioxide emissions. Secondly, after being impacted by sulfur dioxide emissions, fiscal revenue decentralization initially responds positively and shows no fluctuations over time, indicating that an increase in sulfur dioxide emissions will exacerbate the degree of fiscal revenue decentralization. Thirdly, after being impacted by the sulfur dioxide tax rate, the sulfur dioxide emissions initially showed a weak positive response, but turned negative after the third period, indicating that in the long run, an increase in sulfur dioxide tax rate will reduce sulfur dioxide emissions. Fourthly, after being impacted by the sulfur dioxide tax rate, fiscal revenue decentralization has made a positive response in the initial stage, reaching its peak in the fifth period, with no significant fluctuations after the fifth period. This indicates a positive relationship between sulfur dioxide tax rate and fiscal revenue decentralization, and an increase in sulfur dioxide tax rate will lead to a greater degree of fiscal revenue decentralization. Fifth, after being impacted by fiscal revenue decentralization, sulfur dioxide emissions showed a positive response in the early stage, turning into a negative response in the fourth period, and reaching a peak in the sixth period. This indicates that in the short term, an increase in fiscal revenue decentralization will lead to an increase in sulfur dioxide emissions,

but the duration is extremely short. In the long run, sulfur dioxide emissions will decrease with the increase in fiscal revenue decentralization. Sixth, the sulfur dioxide tax rate has responded positively to the impact of fiscal revenue decentralization, reaching its peak in the fourth period, indicating that in the long run, an increase in fiscal revenue decentralization will lead to an increase in sulfur dioxide tax rate.

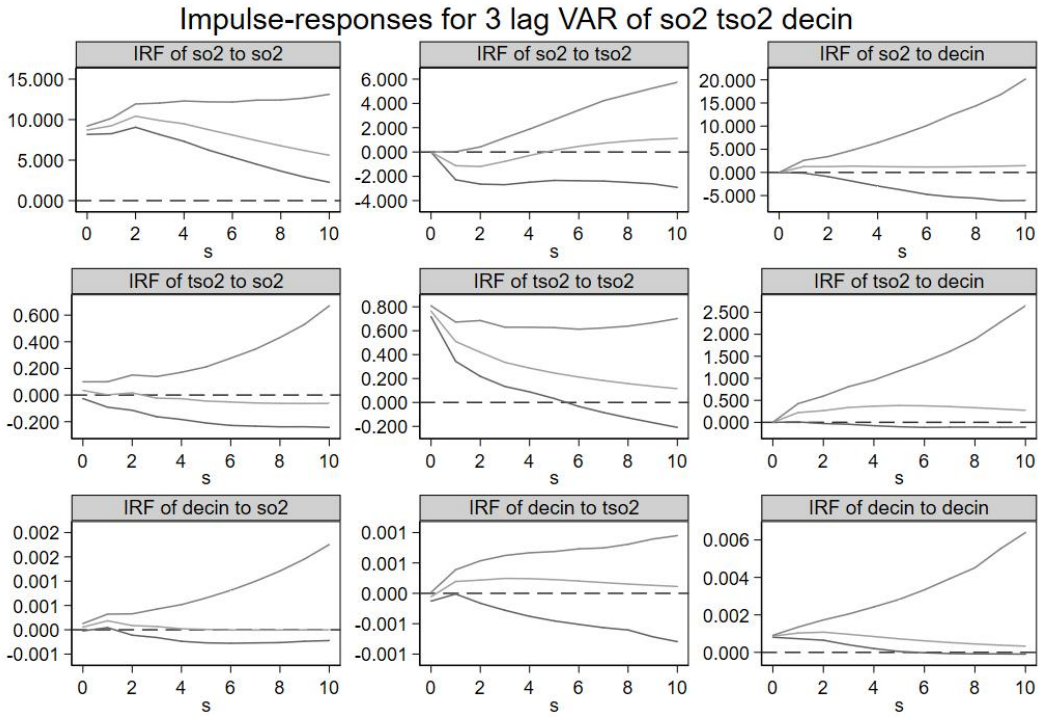

Figure 1. Pulse Response Diagram of SO_2 Emissions, SO_2 Tax Rates, and Fiscal Revenue Decentralization

Figure 2 shows the pulse response graph of sulfur dioxide emissions, sulfur dioxide tax rates, and fiscal expenditure decentralization. It can be concluded from the graph that, firstly, the sulfur dioxide tax rate responds negatively in the early stage after being impacted by sulfur dioxide emissions, and then changes from negative to positive after the fourth stage. In a very short period of time, the sulfur dioxide tax rate will decrease with the increase of sulfur dioxide emissions, but in the long run, the emissions will increase with the increase of sulfur dioxide tax rate. Secondly, fiscal expenditure decentralization has a weak positive response after being impacted by sulfur dioxide emissions. After the third period, there is no significant fluctuation, indicating that in the short term, an increase in sulfur dioxide emissions will exacerbate the degree of fiscal expenditure decentralization. However, in the long run, it won't affect the decentralization of fiscal expenditures. Thirdly, sulfur dioxide emissions respond negatively to the impact of sulfur dioxide tax rates, indicating that an increase in sulfur dioxide tax rates can reduce sulfur dioxide emissions in the long run. Fourthly, sulfur dioxide tax rates and the decentralization of fiscal expenditures are positively correlated, as evidenced by the positive response of fiscal expenditure decentralization to the impact of sulfur dioxide tax rates. The decentralization of fiscal expenditures will result in higher sulfur dioxide tax rates. Fifthly, after being impacted by fiscal expenditure decentralization, sulfur dioxide emissions show a positive response in the early stage, with no significant fluctuations over time, indicating that an increase in fiscal expenditure decentralization will lead to an increase in sulfur dioxide emissions in the short term. Sixth, after being impacted by fiscal expenditure decentralization, the sulfur dioxide tax rate has responded positively in the early stage and has not fluctuated significantly over time, indicating that an increase in fiscal expenditure decentralization in a short period of time will lead to an increase in sulfur dioxide tax rate.

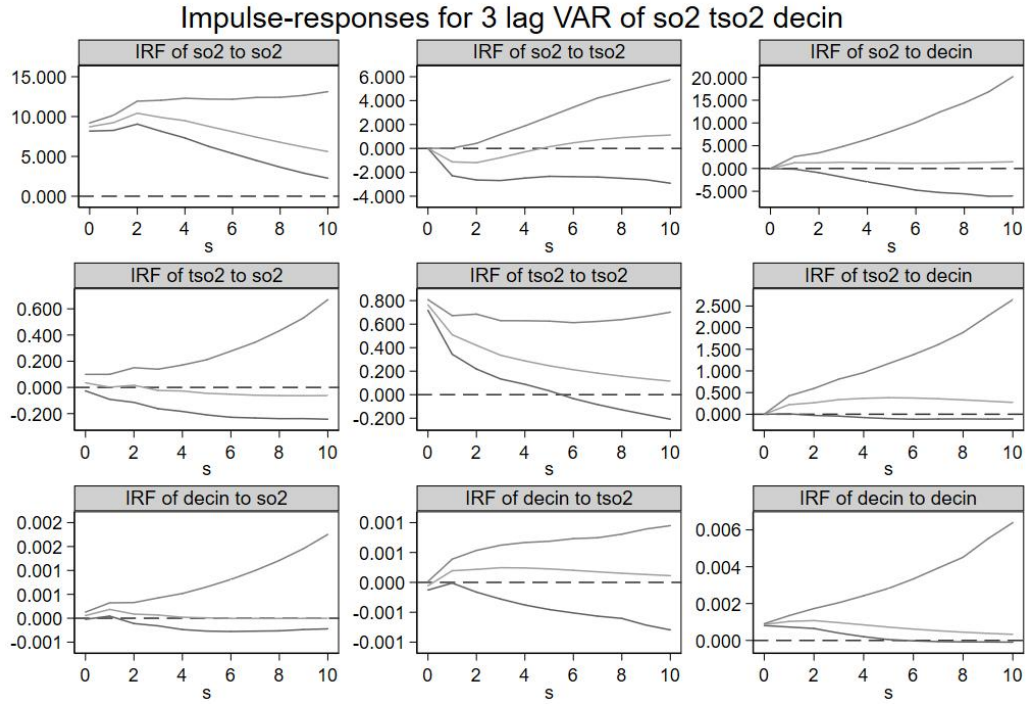

Figure 2. Pulse Response Diagram of SO_2 Emissions, SO_2 Tax Rates, and Fiscal Expenditure Decentralization

4.6. Variance Decomposition

Variance decomposition is the process of expressing the reasons for variable changes in numerical form more clearly. Table 7 shows the results of variance decomposition for the next 30 periods. It is evident that the main factors influencing sulfur dioxide emissions are those that affect them directly. As the number of periods increases, sulfur dioxide emissions will increase with tax rates, and then maintain a stable state. The sulfur dioxide tax rate is most affected by fiscal revenue decentralization in the next 30 forecast periods, This indicates that there has been a long-term relationship between sulfur dioxide tax rates and fiscal revenue decentralization. Fiscal revenue decentralization and fiscal expenditure decentralization are mainly influenced by their own factors, and their relationship with other factors is very stable.

Table 7. Variance Decomposition Results

S		pSO_2	tSO_2	Decin		pSO_2	tSO_2	Decex
10	pSO_2	0.973	0.008	0.019	pSO_2	0.984	0.014	0.002
10	tSO_2	0.008	0.582	0.410	tSO_2	0.005	0.683	0.312
10	Decin	0.008	0.057	0.936	Decex	0.012	0.091	0.897
20	pSO_2	0.934	0.020	0.046	pSO_2	0.942	0.047	0.011
20	tSO_2	0.015	0.521	0.464	tSO_2	0.009	0.651	0.339
20	Decin	0.007	0.060	0.933	Decex	0.012	0.093	0.895
30	pSO_2	0.912	0.025	0.063	pSO_2	0.923	0.058	0.019
30	tSO_2	0.016	0.518	0.466	tSO_2	0.010	0.650	0.340
30	Decin	0.007	0.060	0.933	Decex	0.012	0.093	0.895

5. Conclusion and Suggestions

After analyzing the dynamic relationship between the panel data of sulfur dioxide emissions, sulfur dioxide tax rate, fiscal revenue decentralization and sulfur dioxide emissions, sulfur dioxide tax rate, and fiscal expenditure decentralization in 30 provinces other than Xizang from 2004 to 2020, the following conclusions are drawn:

There is a significant dynamic relationship between the emission of sulfur dioxide, sulfur dioxide tax rate, and fiscal revenue decentralization. With the increase of sulfur dioxide tax rate, the emission of sulfur dioxide

will significantly decrease, indicating that sulfur dioxide tax rate has a significant effect on emission reduction. The higher the degree of fiscal revenue decentralization, the higher the sulfur dioxide tax rate, and the decreasing trend of sulfur dioxide emissions, The reason may be that the higher the disposable income of local governments, the higher the maintenance costs in environmental protection will also have a trend of increasing, thereby achieving better air governance effects. The higher the level of air pollution control, the decreasing trend of emissions. The higher the degree of fiscal decentralization of local governments, the more efforts they will make to deal with air pollution. This is reflected in increasing the collection of pollution fees, which are achieved by increasing the sulfur dioxide tax rate. Therefore, when carrying out emission reduction work, adjusting the sulfur dioxide tax rate appropriately will have a more significant governance effect.

The dynamic relationship between sulfur dioxide emissions, sulfur dioxide tax rates, and fiscal expenditure decentralization is not significant. The reason may be that, firstly, competition between local governments indirectly exacerbates the level of air pollution, which is reflected in the local government's pursuit of development by maintaining the concept of "heavy industry, light governance". The investment and expenditure in regional development are relatively large, while the expenditure on air pollution control is relatively small, thus showing a negligent governance behavior, leading to an increase in pollution levels instead of a decrease. Secondly, local governments have more expenditure responsibilities, but in the absence of sufficient financial resources, they will increasingly rely on transfer payments, which will weaken the efficiency of local governments in regulating public goods and result in unsatisfactory environmental governance effects.

Based on the above conclusions, several feasible suggestions are proposed. Firstly, (1) improve the local tax system and increase fiscal revenue. In the absence of a local tax system, the corresponding local government fiscal revenue will decrease, and when fiscal expenditure is on the rise, it is necessary to reduce spending on public goods, leading to ineffective control of air pollution. Therefore, improving the main tax categories of local governments, strictly implementing tax policies, and maintaining a long-term stable fiscal revenue state can effectively reduce air pollutant emissions, Improve the efficiency of air governance. (2) Appropriately increase the environmental protection tax rate. On the one hand, although adhering to the principle of "shifting tax burden" and achieving a good connection between environmental protection tax and pollution control fees, there is still a certain gap between the tax amount and the cost of air pollution control. An appropriate increase in tax rates can effectively fill the cost gap. Moreover, under the pressure of tax burden, heavy industrial enterprises will also transform into green environmental protection enterprises, which can increase the strength of environmental protection tax in pollution control, Jointly usher in a new era of nationwide air governance.

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