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# Fiscal and taxation policies, economic growth and environmental quality: An analysis based on PVAR model

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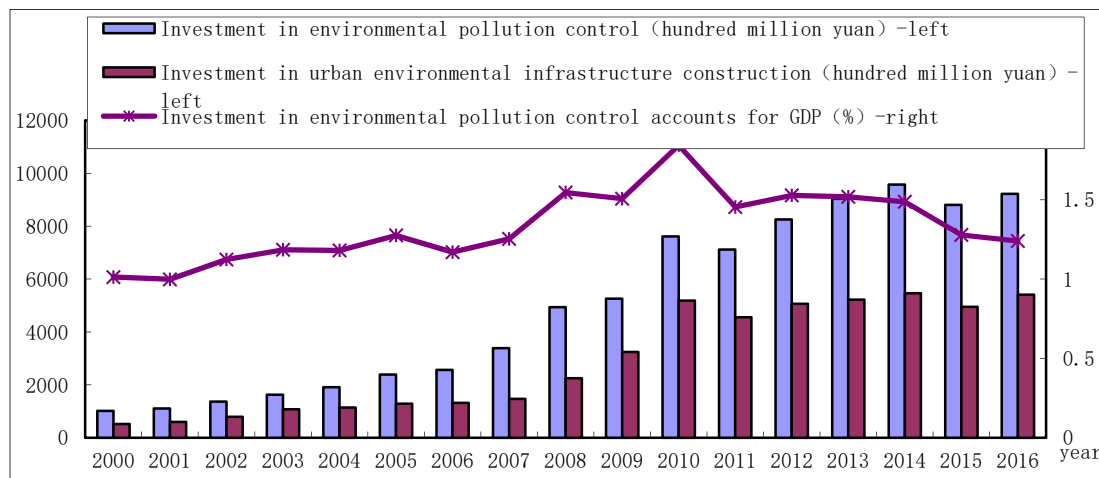
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**Abstract.** Taking the investment in environmental pollution control as the representative of the environmental fiscal policy, taking sewage charge as the representative of the environmental tax policy, using the provincial panel data of China from 2003 to 2015, this paper uses the PVAR model to test the interaction relationship among China's fiscal and taxation policies, economic growth and environmental quality. The results show that there is a long-term interaction among environmental pollution control investment, sewage charge, economic growth and environmental quality, and the variance decomposition results show the contribution degrees of pollution control investment to the industrial "three wastes" emission intensity are 0.6 percent, 46.6 percent and 11.7 percent. The contribution degrees of sewage charge to the industrial "three wastes" emission intensity are 15.5 percent, 70.9 percent and 8.3 percent in turn. The contribution degrees of the economic development level to the industrial "three wastes" emission intensity are 2.5 percent, 7.1 percent and 0.5 percent in turn. The internal mechanism that investment in environmental pollution control and sewage charge first affect economic development and then indirectly affect environmental quality is set up. On this basis, this paper puts forward policy proposals on how to enhance the positive interaction among fiscal and taxation policies, economic growth and environmental quality.

## 1. Introduction

Among the fiscal expenditure policies of environmental governance, the most direct and effective one is investment in environmental pollution control in China [1]. The investment in environmental pollution control consists of three parts: the first is the investment in urban environmental infrastructure construction, the second is the investment in industrial pollution source control, and the third is the investment in environmental protection in the "three simultaneous" construction projects. The total investment in environmental pollution control has been increasing steadily since 2000 in China (Figure 1). It reached 101.49 billion yuan in 2000, and 921.98 billion yuan in 2016, with an average growth rate of 14.79 percent. From the specific composition of investment in environmental pollution control, urban environmental infrastructure construction investment accounted for the largest proportion, more than 50 percent annually. From the proportion of investment in environmental pollution control to GDP, it also showed an upward trend, 1.84 percent in 2010, and then fell back, with an average of 1.33 percent in the sample period.





**Figure 1.** Investment in China's environmental pollution control.

In the field of environment, the main function of taxation is to improve the financial resources of environmental public services, support and guide the rational allocation of environmental resources. China's formal environmental protection tax has not been put into practice until recently (January 1st, 2018). The most significant environmental tax before that was the pollution charge. Since 1996, the state's pollution charge has been increasing continuously. In 1996, it was 4.096 billion yuan, reached a peak in 2013 (20.481 billion yuan), and it was 17.85 billion yuan in 2015, the average growth rate of the state's pollution charge was 8.06 percent in the past 20 years.

Investment in environmental pollution control and pollution charges affect the behavior of local governments to a certain extent, thus affect the development of local economy [2]. As a kind of public goods, environmental quality will undoubtedly be subject to the resources and environment problems. High-speed economic growth still can't cover up the pain caused by environmental pollution. Do the increasing investment in environmental pollution control and pollution charges bring about sustained improvement in environmental quality? Do China's environmental pollution control investment and sewage charges have long-term impact on environmental quality? Is it because of the increasing level of environmental pollution behind the large-scale increase in investment in environmental pollution control and pollution charges in China? Are China's investment in environmental pollution control and pollution charges indirectly affect environmental quality by affecting local economic development? From the long-term impact of fiscal and taxation policies on environmental quality, this paper analyzes the internal mechanism of environmental pollution control investment and pollution charges affecting environmental quality, and explores the environmental problems and institutional roots behind the rapid growth of environmental fiscal expenditure and taxation in China.

## 2. Literature review

Fiscal and taxation policies play a key role in the improvement of environmental quality. The implementation of environmental tax can not only promote economic development but also improve environmental quality [3]. In the literature [4], charging for air and water pollution can help businesses reduce pollutant emissions. Fischer et al. pointed that the tax and financial subsidy are most representative two environmental policies in improving environmental quality [5]. The fiscal expenditure structure which focuses on public services is helpful to improve the environmental quality [6]. The implementation of expansionary fiscal spending provides an alleviating effect on emissions from both sources of the pollutant [7]. The empirical results of Chinese scholars are inconsistent. Cui Yafei and Liu Xiaochuan found that China's sewage charge system has a certain inhibitory effect on industrial wastewater and industrial solid waste, but has no inhibitory effect on industrial sulfur dioxide emissions [8]. The positive direct effect of local fiscal expenditure on environmental

governance is small and not significant, mainly indirect effect, and is affected by economic development [9]. The emission charges aggravated the increase of industrial waste emissions [10]. In the literature [11], China's current fiscal and taxation policies have abnormal effects on promoting air pollution. Different environmental taxes have different impacts on different countries. In countries with particularly high PM<sub>2.5</sub> concentration, NO emission and NO<sub>2</sub> concentration, carbon tax plays a significant role in improving air quality, while in countries with poor air quality, raising environmental tax on automobiles can't reduce environmental pollution emissions [12].

On the impact of fiscal and taxation policies on the economy, Heyes first established a theoretical model to explain the relationship among fiscal expenditure, economic growth and the environment [13]. Economides et al. used the general equilibrium model containing renewable natural resources to analyze Ramsey second-best optimal fiscal policy, believing that environmental expenditure monotonously positively affects the balanced growth rate [14]. Many other scholars also believe that environmental fiscal and taxation policies affect economic growth [15-18].

The relationship between economic growth and environmental quality has long been a hot topic of environmental economists. The 1992 World Bank Development Report, Grossman and Krueger both found that per capita income levels have an inverted U-shaped relationship with environmental pollution [19]. Later, experts who use different theoretical models to prove the inverse U-shaped relationship between environmental pollution and economic growth are Andreoni and Levinson [20], Brock and Taylor [21]. Lindmark explored the main causes (scale effect, structural effect and technical effect) of economic activities affecting environmental pollution [22]. Magazzino explored that the first lag of CO<sub>2</sub> (with a negative coefficient) is statistically significant in the real GDP equation [23]. The studies of Chinese scholars mostly support the existence of EKC curves [24-27].

The above researches are still inadequate to some extent, this paper intends to expand from the following two aspects. Firstly, from the research perspective, fiscal and taxation policies not only directly affect the environmental quality, but also indirectly affect environmental quality through economic growth. Regrettably, the direct and indirect impacts of "fiscal and taxation policies - environmental quality" and "fiscal and taxation policies - economic growth - environmental quality" have not been comprehensively considered in Chinese studies. This paper attempts to explore the dual impacts of fiscal and taxation policies on environmental quality. Secondly, the panel vector auto regressive (PVAR) model is established to analyze the dynamic relationship among fiscal and taxation policies, economic development level and environmental quality in China, the impulse response functions (IRFs) and variance decomposition are also used to analyze the dynamic effects among fiscal and taxation policies, economic growth and environmental quality. Granger causality test is used to analyze the causal relationship among fiscal and taxation policies, economic development level and environmental quality, comprehensively examines the long-term impact of China's fiscal and taxation policies on environmental quality. The results of this study are intended to analyze the internal mechanism of China's fiscal and taxation policies on environmental quality and explore the environmental problems behind the rapid growth of China's environmental fiscal and taxation, provide a basis for the root of the system as well.

### 3. Methodology and data

#### 3.1. Methodology

This paper uses panel vector auto regressive (PVAR) model to test the long-term effect of fiscal and taxation policies on environmental quality. PVAR model is proposed by Holtz-Eakin et al [28]. Love and Zicchino further improve it [29], and it is relatively mature analytical tool, especially in the test and prediction of the implementation effect of public policies. Compared with ordinary VAR, PVAR requires much less time length. Based on the estimation method of PVAR and the criterion of impulse response function Schwarz information criterion (SIC) and Akaike information criterion (AIC), the lag first-order model is adopted in this paper, because  $13 \geq 1+3$ , it can be estimated, further  $13 \geq 2 \times 1+2$ ,

the lag parameter in steady state can be estimated [30]. In view of the above analysis, the following model is set up:

$$y_{it} = \alpha_i + \sum_{j=1}^k \alpha_j y_{i,t-j} + \eta_i + \varphi_t + \varepsilon_{it} \quad (1)$$

$i$  and  $t$  respectively denote province and year.  $y_{it} = \left\{ \overset{1}{env}_{it}, \overset{2}{wrtz}_{it}, \overset{3}{pwf}_{it}, \overset{4}{GDP}_{it} \right\}$ ,  $y_{it}$  is a vector

containing four variables,  $env$  indicates environmental quality,  $wrtz$ 、 $pwf$ 、 $GDP$  represent investment in environmental pollution control, pollution charges and economic growth. Considering the heterogeneity of environmental quality, investment in environmental pollution control, pollution charges and economic growth,  $\eta_i$  is used to represent the regional fixed effect, and to characterize the possible missing factors related to regional characteristics such as location and natural conditions. The time effect  $\varphi_t$  is used to control the time trend characteristics of explanatory variables.  $\varepsilon_{it}$  represents a random error. Because VAR is applied to panel data, it is necessary to impose restrictions. For any cross-section element, the underlying structure is the same. This restriction is often unsuitable in practice. The problem can be solved by introducing a fixed effect  $\eta_i$ . However, the lag term of the dependent variable will lead to the correlation with the independent variable. Helmert process, which is the forward mean difference, is used to eliminate the individual fixed effect and time effect. The data in this paper belongs to large N and small T type. The estimation is carried out in four steps: PVAR estimation, impulse response function estimation, variance decomposition and Granger causality test. This paper mainly focuses on the relationship among investment in environmental pollution control, pollution charges and environmental quality in China. Therefore, investment in environmental pollution control, pollution charges and environmental quality are set as the main observation variables, and then economic growth is added as a participating variable according to the relationship existing in economic operation.

### 3.2. Data

Considering the principle of data comprehensiveness and availability, this paper selects the provincial panel data of China from 2003 to 2015 as a sample. The original data came from China Statistical Yearbook, China Environmental Yearbook and China Environmental Statistical Yearbook from 2004 to 2016.

**Table 1.** Definitions of variables.

index	symbol	economic meanings
Industrial wastewater emission intensity	$fs$	Industrial wastewater emissions / industrial GDP, Natural logarithm
Industrial sulfur dioxide emission intensity	$so_2$	Industrial sulfur dioxide emissions / industrial GDP, Natural logarithm
Emission intensity of industrial solid waste	$gf$	Industrial solid waste emissions / industrial GDP, Natural logarithm
Investment in environmental pollution control	$wrtz$	Investment in environmental pollution control /GDP
Sewage charge	$pwf$	Sewage charge / total tax
Economic growth	$GDP$	Per capita GDP, Natural logarithm

Environmental quality variables, consistent with existing literatures, are measured by environmental pollutant emissions. Considering that the economic growth will have an impact on the emissions of various environmental pollutants, the emission intensity is represented by the pollutants produced per unit GDP, i.e. industrial waste emission is divided by industrial GDP to indicate the industrial wastewater emission intensity, industrial sulfur dioxide emissions are divided by industrial GDP to indicate industrial sulfur dioxide emission intensity and industrial solid waste emissions are divided by industrial GDP to indicate the industrial solid waste emission intensity.

The investment in environmental pollution control is measured by the ratio of the investment in environmental pollution control to GDP in each province. Sewage charges are measured by the proportion of sewage charges in each province to the total tax revenue. Economic growth is measured by the actual per capita GDP after price reduction. Table 1-2 show the definitions and descriptive statistical values of variables in this paper.

**Table 2.** Descriptive statistics of variables.

variable	Mean	Std.dev	Min	Max
<i>fs</i>	2.69	0.75	0.88	4.99
<i>so<sub>2</sub></i>	4.94	0.96	1.78	7.44
<i>gf</i>	-0.01	5.52	-12.47	8.81
<i>wrtz</i>	0.01	0.01	0.00	0.07
<i>pwf</i>	0.01	0.01	0.00	0.07
<i>GDP</i>	9.93	0.69	8.22	11.76

## 4. Empirical results

### 4.1. Unit root test

In order to avoid pseudo-regression, the unit root test is performed. The results are shown in Table 3. In this paper, *LLC* test and *PP-fisher* test are used respectively. The original hypothesis of the above two tests are that there is a unit root in the original sequence of numbers. If *p* value is less than 0.05, the original hypothesis is rejected. The unit root test results show that the variables selected in this paper are stationary variables, which can be used for PVAR estimation and analysis.

**Table 3.** Unit root test of variables.

variable	Test results	<i>LLC</i>	<i>PP-Fisher chi-square</i>
<i>fs</i>	statistics	-7.138	98.374
	<i>P</i> value	0.000	0.000
<i>so<sub>2</sub></i>	statistics	-7.731	120.597
	<i>P</i> value	0.000	0.000
<i>gf</i>	statistics	-17.194	208.210
	<i>P</i> value	0.000	0.000
<i>wrtz</i>	statistics	-10.031	88.395
	<i>P</i> value	0.007	0.010
<i>pwf</i>	statistics	-7.926	163.830
	<i>P</i> value	0.037	0.000
<i>GDP</i>	statistics	-6.868	113.878
	<i>P</i> value	0.006	0.000

### 4.2. Regression analysis of PVAR model

This paper uses Stata13.1 to analyze the industrial "three wastes" emissions intensity, investment in environmental pollution control, pollution charges and economic growth by PVAR. All variables are considered as endogenous variables. Table 4~6 show the results. According to the judgment results of AIC, BIC and HQIC values, the optimal lag period is one. The *L* in the table indicates lag period. The *h* before each variable represents that "forward mean difference" is used to remove the fixed effect and time effect.

**Table 4.** PVAR estimation results (industrial wastewater emission intensity).

	<i>h_fs</i>	<i>h_wrtz</i>	<i>h_pwf</i>	<i>h_GDP</i>
<i>L.h_fs</i>	1.208*** (15.23)	0.004* (1.70)	0.004** (2.51)	-0.246*** (-9.08)
<i>L.h_wrtz</i>	0.993 (0.28)	0.053 (0.63)	0.182** (2.23)	-2.190** (-1.96)
<i>L.h_pwf</i>	5.672 (1.32)	-0.174* (-1.78)	1.021*** (4.96)	-4.879*** (-3.19)
<i>L.h_GDP</i>	0.552*** (4.79)	0.007** (2.06)	0.005*** (2.70)	0.470*** (12.48)

Note: Within the parentheses are t statistics, \*, \*\*, \*\*\* respectively represent  $p < 0.1$ ,  $p < 0.05$ ,  $p < 0.01$ .

From the second column of Table 4, it can be seen that with the change of industrial wastewater emission intensity, the investment in environmental pollution control does not change significantly at the level of lagging behind the first stage, and the pollution charges are similar. Conversely, as far as the change of investment in environmental pollution control and the charge for sewage discharge, the third and fourth columns show that the investment in environmental pollution control and the charge for sewage discharge have changed in the current period, and industrial wastewater emission intensity has changed positively at a lagging level, which indicates that the change of the industrial wastewater emission intensity is positive. The impacts of investment in environmental pollution control and pollution charges are not significant, but the changes of investment in environmental pollution control and pollution charges have a significant impact on the change of industrial wastewater emission intensity. In order to further test the interaction among the industrial wastewater emission intensity, investment in environmental pollution control, sewage charges and economic growth, the fifth column shows that with the positive change of economic growth, the intensity of industrial wastewater emission is significantly negative at a lagging level. It can be concluded that investment in environmental pollution control and pollution charges affect the environmental quality through the following ways: “investment in environmental pollution control and pollution charges increase - economic development level rise - industrial wastewater emission intensity decline.”

**Table 5.** PVAR estimation results (industrial sulfur dioxide emission intensity).

	$h_{so_2}$	$h_{wrtz}$	$h_{pwf}$	$h_{GDP}$
$L.h_{so_2}$	1.891*** (3.71)	-0.016 (-1.60)	0.023** (2.18)	-0.804***(-2.62)
$L.h_{wrtz}$	4.585(1.03)	0.013 (0.12)	0.240** (2.27)	-4.219* (-1.70)
$L.h_{pwf}$	2.865 (0.41)	-0.163(-1.50)	1.017*** (5.06)	-4.922(-1.58)
$L.h_{GDP}$	1.466** (2.08)	-0.019(-1.37)	0.031** (2.18)	-0.304(-0.72)

Note: Within the parentheses are t statistics, \*, \*\*, \*\*\* respectively represent  $p < 0.1$ ,  $p < 0.05$ ,  $p < 0.01$ .

**Table 6.** PVAR estimation results (industrial solid waste emission intensity).

	$h_{gf}$	$h_{wrtz}$	$h_{pwf}$	$h_{GDP}$
$L.h_{gf}$	0.304 (1.49)	-0.001**(-2.50)	0.001** (2.54)	-0.019***(-3.73)
$L.h_{wrtz}$	105.424*** (2.61)	0.136* (1.68)	0.111 (1.48)	0.561 (0.39)
$L.h_{pwf}$	157.883*** (2.70)	-0.093(-0.95)	0.962*** (4.48)	-2.752(-1.49)
$L.h_{GDP}$	-2.691 (-1.63)	-0.001 (-0.73)	0.003* (1.82)	0.670*** (15.92)

Note: Within the parentheses are t statistics, \*, \*\*, \*\*\* respectively represent  $p < 0.1$ ,  $p < 0.05$ ,  $p < 0.01$ .

Table 5 reports the regression results of industrial  $SO_2$  emission intensity, investment in environmental pollution control, pollution charge and economic growth. Observing the second column, it is found that the industrial sulfur dioxide emission intensity changes, the investment of environmental pollution control and the charge of sewage discharge do not pass the significant test at the lagging level. The third and fourth columns show that, conversely, with the change of investment in environmental pollution control, the industrial sulfur dioxide emissions intensity does not change significantly at a lagging level, but with the change of pollution charges, industrial sulfur dioxide emissions intensity changes significantly at a lagging level. After adding the variable of economic growth, it can be seen from the fifth column that with the change of economic growth, the change of industrial sulfur dioxide emission intensity is significantly negative at the lagging level. It can be seen that the way of sewage charges affecting the industrial sulfur dioxide emissions intensity is: “the proportion of sewage charges in the total tax increases - the level of economic development rises - the industrial sulfur dioxide emissions intensity decreases.”

Table 6 reports the results of the PVAR of the relationship among the industrial solid waste emissions intensity, investment in environmental pollution control, pollution charges and economic growth. Compared with the interaction among industrial waste water, industrial sulfur dioxide and environmental pollution control investment and sewage charges, there is a certain difference between the interaction among the intensity of industrial solid waste discharge and investment in environmental pollution control and sewage charges. Specifically, with the positive change of industrial solid waste

emission intensity, it directly leads to the increase of investment in environmental pollution control and pollution charges. The third and fourth columns show that investment in environmental pollution control and charges for sewage discharge are changing positively in the current period, and the industrial solid waste discharge intensity is changing negatively and positively respectively after lagging behind the first period. After adding the variable of economic growth, it is in line with the change of industrial waste water emissions intensity and industrial sulfur dioxide emissions intensity, the industrial solid waste emissions intensity changes in the opposite direction.

#### 4.3. Impulse response functions (IRFs) analysis

In this paper, the panel data of environmental quality (including industrial wastewater discharge intensity, industrial sulfur dioxide discharge intensity, and industrial solid waste discharge intensity), investment in environmental pollution control, sewage charge and economic development level are analyzed by using Stata13.1. The orthogonal impulse response function of each variable is obtained by Monte Carlo simulation for the 1000 time. Figure 2~4 show the *IRFs* figures.

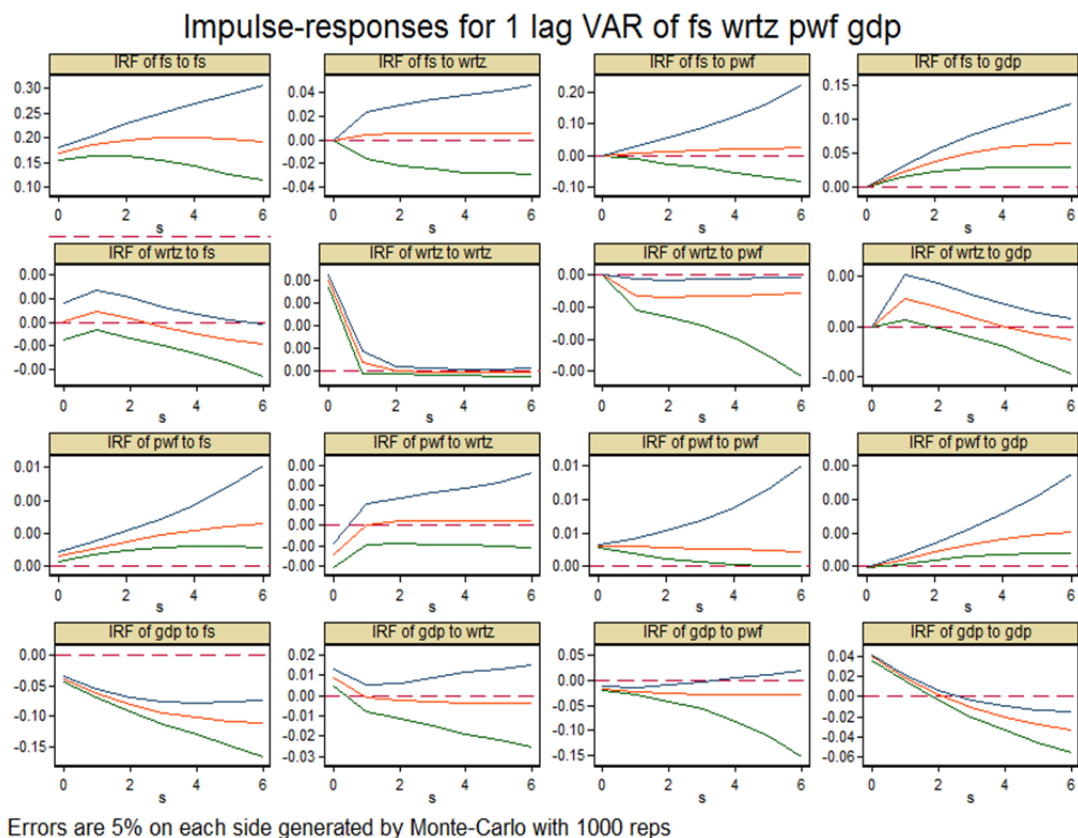
The orthogonal impulse response function diagram of Figure 2 (intensity of industrial wastewater discharge) is taken as an example for analysis and explanation.

Firstly, the direct relationship among the investment in environmental pollution control and the charge of pollutant discharge and the industrial "three wastes" discharge intensity is discussed. Let's look at the relationship between the intensity of industrial wastewater discharge and investment in environmental pollution control. Facing the orthogonal information of investment in environmental pollution control, the industrial wastewater discharge intensity in the first phase increases by 0.0046, in the second phase increases by 0.0055, and in the third to sixth phases increases by 0.0058, 0.0059, 0.0059 and 0.0059 respectively. The proportion of investment in GDP has promoted the increase of industrial wastewater discharge intensity. According to the relationship between the industrial wastewater discharge intensity and the charges for pollutant discharge, figure 2 shows that, facing the orthogonal information of the charges for pollutant discharge, the variation trend of the industrial wastewater discharge intensity in each period is consistent with that of the investment for environmental pollution control. The industrial wastewater discharge intensity in the first to sixth periods increases by 0.0079, 0.0135, 0.0175, 0.0205, 0.0225, and 0.0239. Therefore, the increases of the investment in environmental pollution control and sewage charges have promoted the raise of industrial wastewater discharge intensity. The reason may be that the proportion of investment used in urban infrastructure construction is larger (more than 50 percent) in the investment of environmental pollution control, but the investment related to industrial wastewater treatment is not much, the charges for sewage treatment do not have the nature of taxation, and the charges are generally low. Therefore, both environmental pollution control investment and sewage charges have limited roles on the comprehensive treatment of industrial wastewater discharge intensity.

Secondly, let's see the indirect relationship among investment in environmental pollution control, pollution charges and environmental quality. After adding the variable of economic growth, the interactive relationship among investment in environmental pollution control, sewage charges and the intensity of industrial wastewater discharge is clearer. Figure 2 shows that, facing of the orthogonal information of investment in environmental pollution control, GDP in the first period is - 0.0011, and the subsequent periods are - 0.0027, - 0.0032, - 0.0035, - 0.0037, - 0.0038. Therefore, the increase of investment in environmental pollution control has a negative impact on economic development. The reason is that the investment in environmental pollution control occupies the productive investment in a short period of time, so the incentive for economic development is insufficient. Facing the orthogonal information of economic development, the industrial wastewater discharge intensity increased by 0.0219 in the first stage, the subsequent stages are 0.0382, 0.0497, 0.0576, 0.0626 and 0.0654. The values are positive and gradually increased. It can be seen that investment in environmental pollution control affects economic development and indirectly affects the industrial wastewater discharge intensity. Facing the orthogonal information of sewage charges, the first period of GDP is - 0.0224, and the subsequent periods are - 0.0256, - 0.0277, - 0.0290, - 0.0297, - 0.0300. It



can be seen that the increase of the proportion of sewage charges to the total tax has a negative impact on economic development, and economic development will have an impact on the industrial wastewater discharge intensity. Facing the orthogonal information of economic development, industrial wastewater discharge intensity changes gradually. Therefore, the indirect relationship between pollution charges and environmental quality is similar to the relationship between investment in environmental pollution control and environmental quality. It can be seen that China's investment in environmental pollution control and pollution charges have an indirect impact on the industrial wastewater discharge intensity by affecting the economic development.

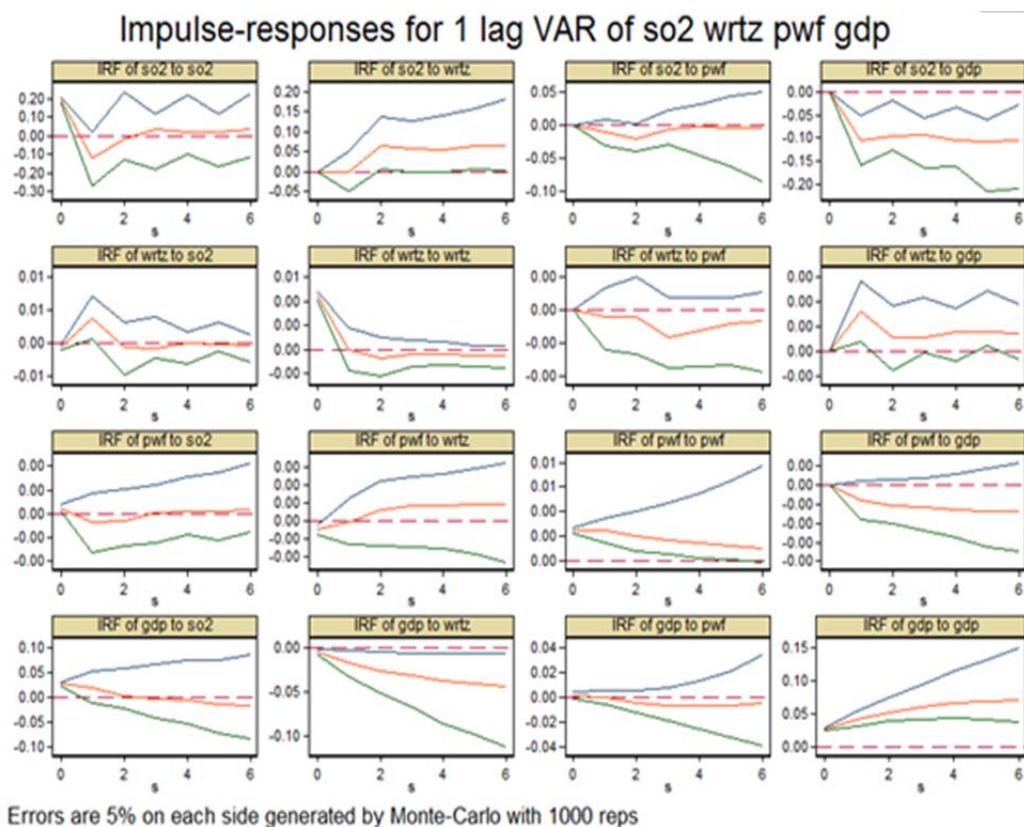


**Figure 2.** Orthogonal pulse response function diagram (industrial wastewater discharge intensity)

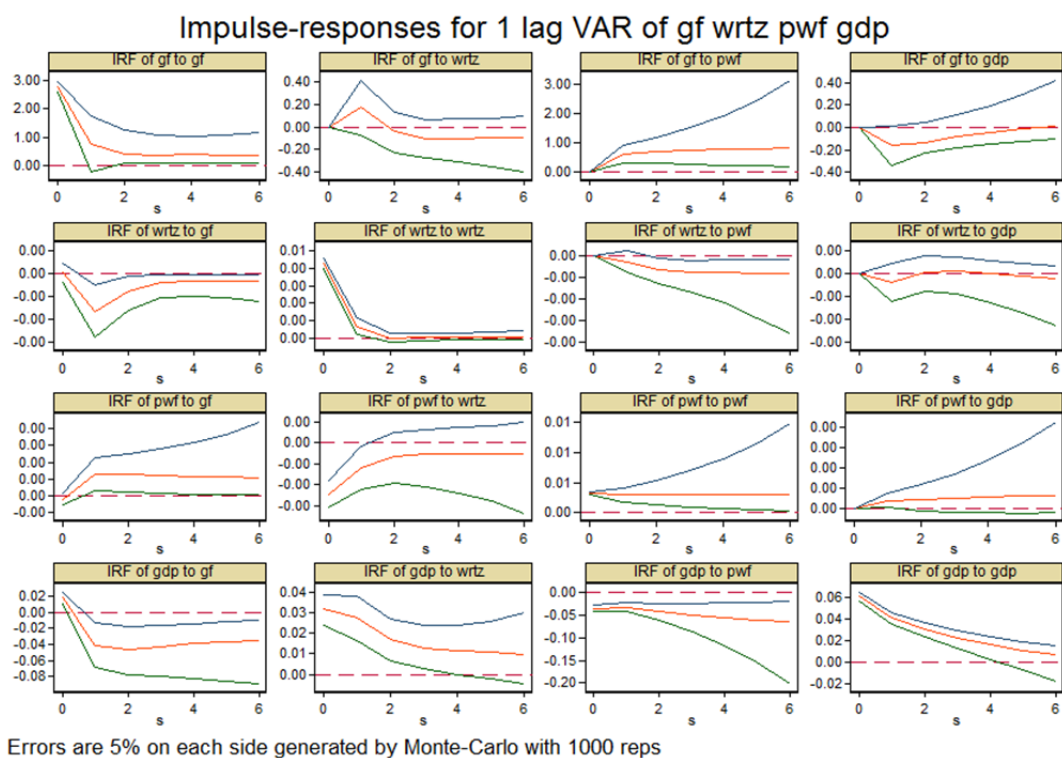
#### 4.4. Analysis of variance decomposition results of PVAR

By using Stata13.1 and Monte Carlo simulation 1000 times, the contribution degrees of variance of each control variable to variance of observation variables in six periods are obtained. By calculating its average contribution degree, the mutual influence degree of investment in environmental pollution control, pollution charge, environmental quality and economic growth is judged.

Table 7 shows the variance decomposition results, the change of industrial wastewater discharge intensity mainly comes from itself, with an average contribution of 97.2 percent. However, in terms of the time change trend, the impact of the first stage of sewage charges on the intensity of industrial wastewater discharge was 4.1 percent, and then gradually increased to 27.2 percent in the sixth stage, with an average contribution of 15.5 percent. The impact of investment in the first phase of environmental pollution treatment on the intensity of industrial wastewater discharge was 0, increased to 0.4 percent in the third phase, further increased to 1.5 percent in the sixth phase, with an average of 0.6 percent. With the increase of the forecast period, the impact of investment in environmental pollution control and the change of sewage discharge fee on themselves are gradually decreasing.



**Figure 3.** Orthogonal pulse response function diagram (industrial sulfur dioxide emission intensity).



**Figure 4.** Orthogonal impulse response function diagram (industrial solid waste emission intensity).

**Table 7.** Variance decomposition results (industrial wastewater discharge intensity).

	<i>s</i>	<i>fs</i>	<i>wrtz</i>	<i>pwf</i>	<i>GDP</i>
<i>fs</i>	1	1.000	0.000	0.000	0.000
<i>fs</i>	2	0.991	0.000	0.001	0.008
<i>fs</i>	3	0.978	0.000	0.002	0.019
<i>fs</i>	4	0.965	0.001	0.004	0.030
<i>fs</i>	5	0.953	0.001	0.005	0.041
<i>fs</i>	6	0.943	0.001	0.006	0.050
mean	—	0.972	0.001	0.003	0.025
<i>GDP</i>	1	0.445	0.021	0.079	0.455
<i>GDP</i>	2	0.665	0.009	0.094	0.232
<i>GDP</i>	3	0.778	0.005	0.093	0.124
<i>GDP</i>	4	0.828	0.004	0.087	0.081
<i>GDP</i>	5	0.847	0.003	0.083	0.067
<i>GDP</i>	6	0.854	0.002	0.078	0.065
mean	—	0.736	0.007	0.086	0.171
<i>pwf</i>	1	0.041	0.053	0.906	0.000
<i>pwf</i>	2	0.079	0.026	0.892	0.002
<i>pwf</i>	3	0.128	0.018	0.847	0.008
<i>pwf</i>	4	0.179	0.013	0.792	0.015
<i>pwf</i>	5	0.228	0.011	0.738	0.024
<i>pwf</i>	6	0.272	0.009	0.687	0.032
mean	—	0.155	0.022	0.810	0.014
<i>wrtz</i>	1	0.000	1.000	0.000	0.000
<i>wrtz</i>	2	0.004	0.967	0.025	0.005
<i>wrtz</i>	3	0.004	0.938	0.052	0.007
<i>wrtz</i>	4	0.004	0.913	0.076	0.007
<i>wrtz</i>	5	0.008	0.889	0.096	0.007
<i>wrtz</i>	6	0.015	0.864	0.114	0.007
mean	—	0.006	0.929	0.061	0.006

The change of industrial SO<sub>2</sub> emission intensity mainly comes from itself (Appendix table 1), but with the increase of the forecast period, the impact on itself gradually declines, with an average contribution of 86 percent. The impact of investment in environmental pollution control on the industrial sulfur dioxide emission intensity gradually increased from 31.9 percent in the first phase to over 50 percent after the fourth phase, with an average of 46.6 percent. The impact of sewage charges on the industrial sulfur dioxide emission intensity is gradually increasing, 60.1 percent in the first phase and more than 70 percent in the second phase, but the increase is small, with an average of 70.9 percent. The change of industrial solid waste emission intensity is mainly due to itself (Appendix table 2). With the increase of the forecast period, the impact on itself shows a slow downward trend, with an average of 87.7 percent. The impact of investment in environmental pollution control on the intensity of industrial solid waste discharge has been maintained at about 14 percent from the third stage, with an average of 11.7 percent. The impact of sewage charges on the intensity of industrial solid wastes discharge gradually increased, with the first stage being only 0.3 percent, and then increased rapidly, exceeding 10 percent from the fourth stage, with an average contribution degree of 8.3 percent.

From the average contribution degree, the contribution degrees of investment in environmental pollution control to the intensity of industrial "three wastes" (waste water, sulfur dioxide, solid waste) discharge are 0.6 percent, 46.6 percent and 11.7 percent respectively. The contribution of sewage charge to the intensity of industrial "three wastes" emission are 15.5 percent, 70.9 percent and 8.3 percent respectively. The contribution degrees of economic development level to "three wastes" emission intensity are 2.5 percent, 7.1 percent and 0.5 percent respectively. It can be seen that investment in environmental pollution control will affect the intensity of industrial sulfur dioxide emission more, the second is industrial solid waste intensity, and the last is industrial waste water

intensity. Different from the investment in environmental pollution control, the impact of pollution charges on industrial "three wastes" is first industrial sulfur dioxide, then industrial wastewater, and finally industrial solid waste. According to the influence of economic development on industrial "three wastes", the first is industrial sulfur dioxide, the second is industrial wastewater, and the last is industrial solid waste. Investment in environmental pollution control can explain about 50 percent of the changes in industrial sulfur dioxide emission intensity in the long run, and pollution charges can explain more than 70 percent of the changes in industrial sulfur dioxide emission intensity in the long run. To do this, we need to change the current local government "GDP-only" behavior tendency. Because it will lead to inadequate of the environmental fiscal investments and charges that affect environmental quality in the long run.

#### 4.5. Granger causality test

**Table 8.** Granger causality test.

hypothesis	<i>F</i> test	<i>P</i> value	conclusion
<i>wrtz</i> is not Grainger reason for <i>fs</i>	5.187	0.023	refuse
<i>pwf</i> is not Grainger reason for <i>fs</i>	1.741	0.187	accept
<i>wrtz</i> is not Grainger reason for <i>so<sub>2</sub></i>	1.865	0.172	accept
<i>pwf</i> is not Grainger reason for <i>so<sub>2</sub></i>	0.170	0.680	accept
<i>wrtz</i> is not Grainger reason for <i>gf</i>	6.791	0.009	refuse
<i>pwf</i> is not Grainger reason for <i>gf</i>	7.278	0.007	refuse
<i>wrtz</i> is not Grainger reason for <i>GDP</i>	3.849	0.050	refuse
<i>pwf</i> is not Grainger reason for <i>GDP</i>	10.147	0.001	refuse
<i>GDP</i> is not Grainger reason for <i>fs</i>	22.944	0.000	refuse
<i>GDP</i> is not Grainger reason for <i>so<sub>2</sub></i>	4.318	0.038	refuse
<i>GDP</i> is not Grainger reason for <i>gf</i>	2.650	0.004	refuse
<i>Wrtz, pwf, GDP</i> are not Grainger reasons for <i>fs</i>	23.474	0.000	refuse
<i>Wrtz, pwf, GDP</i> are not Grainger reasons for <i>so<sub>2</sub></i>	4.518	0.000	refuse
<i>Wrtz, pwf, GDP</i> are not Grainger reasons for <i>gf</i>	13.930	0.003	refuse

Theoretically, investment in environmental pollution control, pollution charges, economic growth, industrial "three wastes" emission intensity influence each other. Does the actual data support the above conclusion? The Grainger causality test of panel data will be conducted in this paper. Because the purpose of Granger causality test is to test the joint effect of the x-lag term on y, it is not necessary to stick to the selected lag order. In this paper, the lag period is set to one. This paper focuses on whether the internal mechanisms are tenable, such as the direct impact of investment in environmental pollution control and pollution charges on environmental quality, and indirectly affects of investment in environmental pollution control and pollution charges on economic development which affects environmental quality. Therefore, the results of the above tests are mainly reported (Table 8).

Results in Table 8 imply that in the case of lagging one period, only *pwf* is not the Granger reason for *fs*, *wrtz* is not the Granger reason for *so<sub>2</sub>*, and *pwf* is not the Granger reason for *so<sub>2</sub>* accept the original hypothesis, indicating that sewage charges are not the statistics cause of industrial wastewater discharge intensity and industrial sulfur dioxide emission intensity. Because the sewage charges are low, and the management is not strict, even lower than the cost of pollution control, so enterprises still expand production and discharge pollutants. Investment in environmental pollution control is not a statistical reason for the intensity of industrial sulfur dioxide emissions, but it is indeed Granger's reason for the intensity of industrial wastewater discharge and industrial solid waste discharge, possibly because the government has concentrated investment in environmental pollution control on some environmental pollution indicators and neglected the treatment of other pollution indicators. For example, the key treatment of industrial wastewater and industrial solid waste will give industrial enterprises more opportunities to discharge sulfur dioxide. Other causal tests rejected the original hypothesis, indicating that the internal mechanism of indirect impact of investment in environmental pollution control and pollution charges on economic growth on environmental quality are established.

## 5. Conclusions and policy implications

Based on the panel data from 2003 to 2015 of 30 provinces (autonomous regions and municipalities directly under the central government) in China, this paper takes the investment in environmental pollution control as the representative of the environmental fiscal expenditure policy, and the pollutant discharge fee as the representative of the environmental tax policy, does the empirical analysis using PVAR model, the conclusions are as follows.

Firstly, there is a long-term interaction among investment in environmental pollution control, pollution charges, economic development and environmental quality. Among them, investment in environmental pollution control and pollution charges affect environmental quality by increasing investment in environmental pollution control and pollution charges - increasing the level of economic development - decreasing the intensity of industrial wastewater discharge. Compared with the interaction among industrial waste water, industrial sulfur dioxide and environmental pollution control investment and sewage charges, there is a certain difference between the interaction among the intensity of industrial solid waste discharge and investment in environmental pollution control and sewage charges.

Secondly, orthogonal impulse response function diagram shows that the increase of investment in environmental pollution control and pollution charges both promote the increase of industrial wastewater discharge intensity. After adding the variable of economic development level, the interactive relationship among investment in environmental pollution control, sewage charges and the intensity of industrial wastewater discharge are clearer.

Thirdly, the variance decomposition results show that the contribution degrees of investment in environmental pollution control to the intensity of industrial "three wastes" emission are 0.6 percent, 46.6 percent and 11.7 percent respectively. The contribution degrees of sewage charge to the intensity of industrial "three wastes" emission are 15.5 percent, 70.9 percent and 8.3 percent respectively. The contribution degrees of economic development to the intensity of industrial "three wastes" emission are 2.5 percent, 7.1 percent and 0.5 percent respectively.

Finally, granger causality test shows that only  $pwf$  is not the Granger reason for  $fs$ ,  $wrtz$  is not the Granger reason for  $so_2$  and  $pwf$  is not the Granger reason for  $so_2$  accept the original hypothesis. Other causal tests reject the original hypothesis, indicating that the internal mechanism of indirect impact of investment in environmental pollution control and pollution charges on economic development on environmental quality are established.

The results have important policy implications, investment in environmental pollution control should be increased. According to World Bank estimates, when a country's investment in environmental pollution control accounts for 1 percent-1.5 percent of GDP, it can basically control the trend of pollution deterioration, and when the proportion is more than 2 percent, it will help to improve the country's environmental quality. In absolute terms, China's investment in environmental pollution control increased more than eight times from 2000 to 2016, it was only 101.49 billion yuan in 2000, and it reached 921.98 billion yuan in 2016. In terms of relative indicators, the proportion of investment in environmental pollution control to GDP was 1.84 percent in 2010, reaching the maximum, and then began to decline gradually. But in 2016, the proportion was reduced to 1.24 percent, far from the World Bank's ratio of more than 2 percent. Inadequate investment in environmental protection will certainly restrict the improvement of environmental quality in China.

On the other hand, improving environmental tax policy is very necessary. Firstly, we should build a green tax system. Deng Xiaolan and Wang Yunjie studied that China's current environmental protection and environmental governance directly related to the level of tax greening is low, only 0.5 percent [31], compared with developed countries there is a large gap. The reason is that the existing taxes related to environmental protection and environmental governance do not aim at environmental protection, and the design of differential tax rates is not detailed enough, the structure of tax burden is unreasonable and so on. Secondly, we should improve the environmental protection tax. The current environmental protection tax is derived from the translation of pollutant discharge fee. Its design is too conservative, the tax rate is too low and regional differences should be considered. Local governments

can't set higher tax rates according to their own energy conservation and emission reduction, and can't ensure that environmental protection tax can promote local governments to save energy and emission reduction. In the future, we should reserve a place to give greater space for change in the dynamic optimization of the law, substitution and replacement of original regional tax adjustment.

Fiscal and taxation policies can indirectly affect the industrial "three wastes" emissions intensity through economic growth as well. In the process of promoting the economic development, the government should change the direction of "the hero of GDP only", pay attention to the quality of economic development, protect the environment, realize the coordinated development of economy and society, and truly realize the "harmonious coexistence of man and nature".

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## Appendix:

**Table 1.** Variance decomposition results (industrial sulfur dioxide emission intensity).

	<i>s</i>	<i>so<sub>2</sub></i>	<i>wrtz</i>	<i>pwf</i>	<i>GDP</i>
<i>GDP</i>	1	0.784	0.052	0.040	0.124
<i>GDP</i>	2	0.902	0.028	0.016	0.054
<i>GDP</i>	3	0.889	0.036	0.012	0.063
<i>GDP</i>	4	0.848	0.047	0.019	0.087
<i>GDP</i>	5	0.807	0.056	0.029	0.107
<i>GDP</i>	6	0.772	0.063	0.043	0.122
mean	—	0.834	0.047	0.027	0.093
<i>pwf</i>	1	0.601	0.072	0.327	0.000
<i>pwf</i>	2	0.714	0.038	0.202	0.046
<i>pwf</i>	3	0.745	0.040	0.121	0.093
<i>pwf</i>	4	0.744	0.047	0.079	0.129
<i>pwf</i>	5	0.732	0.055	0.059	0.154
<i>pwf</i>	6	0.715	0.062	0.052	0.171
mean	—	0.709	0.052	0.140	0.099
<i>so<sub>2</sub></i>	1	1.000	0.000	0.000	0.000
<i>so<sub>2</sub></i>	2	0.937	0.023	0.007	0.033

	<i>s</i>	<i>so<sub>2</sub></i>	<i>wrtz</i>	<i>pwf</i>	<i>GDP</i>
<i>so<sub>2</sub></i>	3	0.874	0.040	0.019	0.067
<i>so<sub>2</sub></i>	4	0.822	0.052	0.033	0.093
<i>so<sub>2</sub></i>	5	0.780	0.061	0.049	0.110
<i>so<sub>2</sub></i>	6	0.746	0.067	0.065	0.122
mean	—	0.860	0.041	0.029	0.071
<i>wrtz</i>	1	0.319	0.681	0.000	0.000
<i>wrtz</i>	2	0.431	0.536	0.000	0.033
<i>wrtz</i>	3	0.487	0.446	0.003	0.064
<i>wrtz</i>	4	0.513	0.390	0.009	0.088
<i>wrtz</i>	5	0.523	0.356	0.017	0.104
<i>wrtz</i>	6	0.524	0.336	0.026	0.115
mean	—	0.466	0.458	0.009	0.067

**Table 2 .** Variance decomposition results (industrial solid waste emission intensity).

	<i>s</i>	<i>gf</i>	<i>wrtz</i>	<i>pwf</i>	<i>GDP</i>
<i>GDP</i>	1	0.050	0.160	0.202	0.588
<i>GDP</i>	2	0.173	0.152	0.204	0.470
<i>GDP</i>	3	0.251	0.122	0.247	0.380
<i>GDP</i>	4	0.276	0.102	0.308	0.314
<i>GDP</i>	5	0.279	0.087	0.370	0.263
<i>GDP</i>	6	0.274	0.076	0.427	0.223
mean	—	0.217	0.117	0.293	0.373
<i>gf</i>	1	1.000	0.000	0.000	0.000
<i>gf</i>	2	0.951	0.004	0.042	0.003
<i>gf</i>	3	0.898	0.003	0.094	0.005
<i>gf</i>	4	0.848	0.004	0.142	0.005
<i>gf</i>	5	0.803	0.005	0.187	0.005
<i>gf</i>	6	0.761	0.006	0.229	0.005
mean	—	0.877	0.004	0.116	0.004
<i>pwf</i>	1	0.003	0.127	0.870	0.000
<i>pwf</i>	2	0.072	0.082	0.844	0.002
<i>pwf</i>	3	0.098	0.058	0.841	0.003
<i>pwf</i>	4	0.105	0.046	0.845	0.004
<i>pwf</i>	5	0.108	0.038	0.849	0.005
<i>pwf</i>	6	0.109	0.033	0.852	0.005
mean	—	0.083	0.064	0.850	0.003
<i>wrtz</i>	1	0.000	1.000	0.000	0.000
<i>wrtz</i>	2	0.123	0.873	0.003	0.000
<i>wrtz</i>	3	0.143	0.837	0.020	0.000
<i>wrtz</i>	4	0.145	0.812	0.043	0.000
<i>wrtz</i>	5	0.145	0.789	0.066	0.000
<i>wrtz</i>	6	0.145	0.767	0.088	0.000
mean	—	0.117	0.846	0.037	0.000