An Empirical Analysis of the Impact of Export Trade on the Environment in the Context of Financial Crisis: By Comparison of Guangdong and Guangxi

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Abstract: The environmental problem is becoming more and more serious with the growing export trade. The paper selects two provinces, Guangdong and Guangxi, to test the applicability of *Pollution Heaven* under the background of the development gap by using the time series data in 1998-2015. Both Guangdong and Guangxi have negative scale effects. Investment on the industrial pollution government spent will deteriorate the quality of the environment and per capita GDP alleviate it. Guangxi technology effect is smaller and the governance is more effective than Guangdong. So it is necessary to adopt a different policy measures: Guangdong province should focus on strengthening the supervision of polluting enterprises, and strictly control key points of pollution. Guangxi can restructure while expanding export scale and increase environmental protection investment on technology and offer green industry support.

Keywords: export trade; environmental pollution; impact and effect; pollution governance

1. Introduction and Question Raising

Environmental contingencies such as Taihu cyanobacteria incident, Songjiang events, haze weather are mounting in China in recent years. The "2013 China Environmental Status Bulletin" shows that air quality which exceeds standards in Chinese cities account for 95.9%. A report in "Washington Post" in 2014 compared with the ten big cities between America and China in terms of serious air pollution, Xingtai City in China ranked first where the emission concentration of PM2.5 is 155.2 g/m^3 with the comparison of 18.2 g/m3 in Bakersfield, first place in the United States. In the government work report of 2015, the premier Li Keqiang stressed that it is necessary to fight against energy conservation, emission reduction and environmental governance. In 2015, China's environmental status bulletin showed that 21.6% of the 338 cities in China were qualified for air quality. The Ministry of Environmental Protection announced the air quality in the key areas and 74 cities in 2016. It showed that the air quality was down in some cities. As a developing country, China makes a "natural" choice between the environment and hunger at the cost of heavy environmental burden. Since the reform and opening up of the last century, the export has become the most powerful "engine". However, exports will produce emissions in the process of production, transportation and import of inputs. Therefore, the negative impact on the atmosphere, soil and natural environment is inevitable. The study of the impact of trade on the environment has always been a concern for the academic community.

Grossman & Krueger (1991) [1]& Kurgan P (1995) [2]take NAFTA as an example to study the analysis framework of the impact of trade policy on the environment. They divided the environmental impact into scale effect, structural effect and technological effect, and concluded that the impact of trade on environment is the result of those aspects. Panayotou (1997) [3] added the government factor and formed the basic model of the follow-up empirical researches. Since then, study on Trade and environment in academia has been expanded and extended from different dimensions. They have studied the mechanism of the impact of trade on the environment and drawn different conclusions. The view that international trade will improve the quality of environment raised by Antweiler et al. (2001) [4] who established the theory of pollution demand-supply to measure the size of the effect. The results showed that although the trade structure effect caused was relatively small, trade would affect pollution emission through output and income and further through economies of scale and technology. The impact of trade on the environment, on the whole, is favorable.

Copeland & Taylor (1994 [5], 2003 [6]), Chichilnisky, G.(1994) [7] and YIN Sixia (2011) [8] theoretically analyzed environmental effects of international trade with North-South trade model and they held that trade liberalization could improve environment due to higher environmental standards in developed countries. But developing countries have become "PPH" either because the lower standard or the polluting industries shift by developed nations through investment or simply imports

from developing ones. That is, the influence of trade on the environment has national characteristics which cannot be generalized. The comparative advantage of developing countries is formed by pollution intensive industries. Trade liberalization promotes production structure to turn into comparative advantage industries, thereby increasing the production of polluting products which in turn worsens the environment while increasing trade revenue and increasing production capacity. There is a fact of regional imbalance in the development process of China, both high income provinces, such as Guangdong and poverty-stricken provinces, such as the western provinces like Guangxi. Exports account for large part of their economy and improve people's living standard and social welfare. Is there any "PPH" at the same time? Is the export of Guangxi province with the same impact on the environment in the eastern developed areas of Guangdong? The purpose of this article aims to answer these questions.

2. Trade and Environmental Characteristics in Guangxi and Guangdong

2.1. Status Quo of Export Trade in Guangdong and Guangxi

Guangdong not only has multiple location advantages, but also has multiple policy advantages. It has been integrated into the international production network earlier than other regions, and the foreign trade has developed rapidly and topped the list of China's export composition. The total exports in 2005 and 2014 were 238.2 and 646.1 billion US dollars respectively and that of 2.7 times of 2005.Affected by the financial crisis, the growth rate dropped slightly decreased but still accounts for as high as 29.87% of total volume of Chinese export. Guangdong province stands out in terms of Chinese regional export. Guangxi is not comparable with Guangdong in export volume where sees a fluctuating growth trend. It failed to reach the peak in 1998 in spite of the rising tone (see Table 1).

Table 1. Exports in Guangdong, Guangxi and the share of the country (unit: $100 million)

year	Export in Guangdong	Export in Guangxi	Export in China	The share of Guangdong (%)	The share of Guangxi (%)
1998	756	24	1837	41.16	1.31
1999	777	12	1949	39.87	0.62
2000	919	15	2492	36.89	0.60
2001	954	12	2661	35.86	0.45
2002	1185	15	3656	36.38	0.41
2003	1528	20	4382	34.88	0.46
2004	1916	24	5933	32.29	0.40
2005	2382	29	7620	31.26	0.38
2006	3019	36	9690	31.16	0.37
2007	3692	51	12205	30.25	0.42
2008	4042	74	14307	28.25	0.52
2009	3590	84	12016	29.87	0.70
2010	4532	96	15778	28.72	0.61
2011	5318	125	18984	28.01	0.66
2012	5741	155	20487	28.02	0.76
2013	6364	186	22090	28.81	0.84
2014	6461	243	23423	27.58	1.04
2015	6435	280	22734	28.31	1.23

In terms of export growth, Guangdong's exports are growing every year except for 2009 affected by the crisis. The growth rate of Guangxi's export has exceeded the national average since 2000, and has also presented good performance during the crisis. In 2014, the national growth rate was -2.94%, and Guangxi still contributed 15.23 percentage points of growth.

From the point of view of export independence rate, Guangdong hits a record high in 2006, reaching a 90.51% since the revision of *the foreign trade law of 2004* and the liberalization of trade entities and the establishment of the Trinity-as-one trade mode. And then the rate began to decline. Affected by the financial crisis in 2008, it dropped to 62% in 2009. Since then, the decline has slowed to the lowest level for 10 years in 2015. But it is higher than the eastern developed provinces such as Jiangsu and Zhejiang. Guangxi has been lower than national average, but the gap has narrowed since 2005. The turning point occurred in 2009. The crisis had a greater impact on exports of the whole country including Guangdong. Guangxi was exceptionally gradually converging with the national average level and also with Guangdong level.

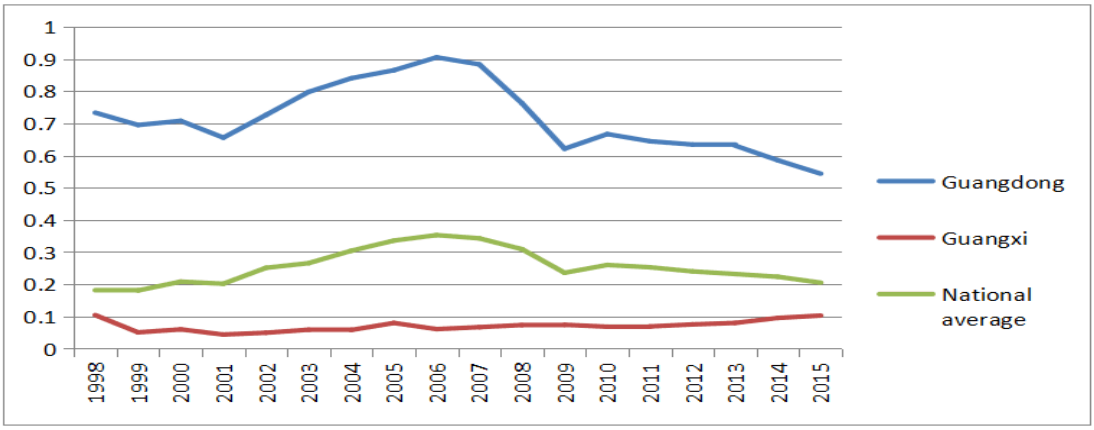

Figure 1. Export independence rate of national level, Guangdong, Guangxi

2.2. Pollution Situation in Guangdong and Guangxi

With the rapid growth of Guangdong's export, environmental conditions have been deteriorating. Industrial pollution is serious in Guangdong 2014. Industrial wastewater emissions decreased to 17.76 tons compared with 24.63 tons in 2007, but it's still a huge volume; Industrial gas emissions amounted to 2979.3 billion cubic meters in 2014, which is 1.75 times than that of 2007; Industrial solid wastes generated to 56.7 million tons in 2014 increased from 38.5 million tons in 2007. The fact that the export trade is in significantly positive proportion of the total industrial output value on 1% level in the regression model means that the positive relationship between high export and high emission intensity. And that the emission intensity of exports is higher than the industry average means that domestic sales are cleaner than export to achieve equivalent economic growth. Guangdong province boasts a large scale of export, high independence and a large amount of pollution. The industrial solid wastes produced in Guangxi are higher than those of Guangdong every year due to different industrial production structure of Guangdong and Guangxi. According to statistics, form 2010 to 2015, Guangdong mainly exported mechanical and electrical equipment products, textile raw materials and products, base metals and their products as well as miscellaneous products. We draw that the "developed" province failed to transform from labor-intensive to technology intensive and capital intensive products where gains scale expansion relying on high investment and high pollution. It is close to the "growth limit" (Shen Haicheng, 2015 [9]; Wang, Z.X.and Tang, H.Q. 2009 [10]; Xie, Y. 2013 [11]; Shi, L. 2013 [12]).

2.3. Government Investment in Environment Protection and Effects

With the development of Guangdong's economy and the worsening of environmental conditions, the government of Guangdong regulates investment in industrial pollution. Before the crisis, the amount of investment in industrial pollution control in Guangdong Province kept rising and reached the highest in 2007. The government invested less in 2009 right after the outbreak of the financial crisis. The government increased investment in environmental governance in the light of the Asian Games held in Guangdong which required higher environmental quality. After falling to the lowest value in 2011, it showed an upward trend and reached 3 billion 786 million CNY in 2014. It's nearly two times higher than Guangxi. The amount of investment in pollution control is declining overall, and the growth rate fluctuates greatly. Although the pollution is more serious in Guangdong, the investment of the government is higher than that of Guangxi. In summary, import and export growth rate shows a downward trend after the crisis in both regions, the discharge of industrial wastewater waste emissions volume also shared the same trend, and industrial emissions reduction lags behind the government investment. The possible reason of Guangxi longer lags lies in investment time government intensifies. Guangxi takes the powerful measures in 2011, an increase of 409%, but Guangdong does earlier in 2009. The policy effect of Guangdong's environmental pollution is still on the road, although the industrial wastewater pollution control has achieved some accomplishments. Industrial waste gas pollution in Guangdong is still under severe situation. The generation of industrial solid waste shows a slight decline in 2011 and to improve the environmental quality means an arduous task. A phenomenon worthy of pondering is that after Guangxi's investment-increase results in a sharp drop of pollution the following one year and rebound after that. All the governance measures gain a short-term effect. So Guangxi should learn from Guangdong's practice in long-term environmental governance.

3. Empirical Analysis and Test

3.1. Model Design

To clearly reflect the relationship between the pollution indicator and the four variables and its law of change, the paper sets the model of vector auto regression based on the work of Shi Lu (2013)

$$Z = T_1 G + T_2 K + T_3 D + T_4 F$$

Here the scale of the export, the ratio of capital to

labor, the per capita GDP, and the influence of the government are independent variables on the environment pollution. The variables are normalized to ensure the stability of the time series, and the variables are processed logarithmically. The improved model is as follows:

$$\mathrm{Ln}SO_2 = P + T_1 Ln\mathrm{PCGDP} + T_2 LnK_L + T_3 LnINVE + T_4 LnEXP + u$$

P is intercept, Ti (i=1, 2, 3, 4) indicates the proportion of variables, SO2 pollution index, PCGDP GDP per capita, K _L indicates capital labor ratio, INVE indicates policy tendency, EXP indicates export scale, u indicates error term.

3.2. Variable Selection and Data Sources

Based on 21 consecutive years' data of Guangdong and Guangxi from 1995 to 2015, this paper makes an empirical analysis of the environmental impact of two provinces' export trade. The data excerpt from Guangdong statistical yearbook, Guangxi statistical yearbook and China Statistical Yearbook. The environmental pollution index quoted from the variable of Shi Lu (2013) [13] and Wang, S.Y., Guo, Q., Li, Q.Y. (2015) [14] and selected the emission of sulfur dioxide as the index of environmental pollution. Because of the close relationship between sulfur dioxide and export trade, the information is published every year the data is continuous, true and reliable. Total exports, capital labor ratio, per capita GDP referred from work of Guo Qiang (2014) [13]. Using exports to represent scale effect, investment to fixed assets and the proportion of employees to express the structure effect, it reflects the change in the mode of production; technology effect by GDP per capita, because the higher GDP per capita, people will be more willing to the purchase of environmentally friendly products and to invest in new technology products which reduce the amount of pollution emissions during the production; policy effect is represented by the amount of investment of government spent in industrial pollution governance.

3.3. Model Tests

Table 2. Results report of ADF test

		Level value		Second-order difference	
	variables	**Test results**	**critical**	**Test results**	**critical**
Guang dong	lnSO2	-0.2742	-4.5326*	-4.9126	-4.6162*
	lnEXP	-1.0385	-4.5326*	-4.9856	-4.6162*
	lnK_L	-2.3276	-4.5716*	-5.4263	-4.6162*
	lnPCGDP	-1.7729	-4.5716*	-4.9511	-4.6162*
	lnINVE	-0.2742	-4.5326*	-4.9126	-4.6162*
Guangxi	lnSO2	-1.4310	-4.6679	-5.5947	-4.8001*
	lnEXP	-3.9128	-4.6679	-2.5544	-1.9684*
	lnK_L	-2.3212	-4.6679	-3.4983	-3.3423**
	lnPCGDP	-2.0276	-4.5716*	-5.5990	-4.8001*
	lnINVE	-2.3029	-4.6679	-3.9112	-3.7912*

3.3.1. Unit root test

Since most of the time series data are not stable, the statistics stationary test of time series is more accurate than that of histogram. Unit root test is a commonly used test method in statistical test. Generally speaking, checking the stationarity of a time series X_t can check whether the parameter beta in a first-order autoregressive model with intercept term is less than 1 in $X_t=\alpha+\beta X_t+\mu$, or check whether the parameter in the equivalent variable form $\Delta X_t=\alpha+\delta X_{t-1}+\mu$ is less than 0. Therefore, for the equivalent deformation equation, the test is: Zero hypothesis $H0:\delta=0$ or $H1:\delta<0$. However, under the zero hypothesis (sequence nonstationary), the general t test cannot be used because the statistic is also biased (down bias) in spite of the large sample. If the value of the t statistic is less than the critical, which means that the delta is small enough, it refuses $H0:\delta=0$ to think that there is no unit root in the time series, and it is stationary. In order to ensure the characteristics of white noise random interferences in DF test, Dickey and Fowler expanded DF test to ADF test. The ADF test is completed by the following three models.

$$\Delta X_t = rX_{t-1} + \sum_{j-1}^{p} \beta_j \Delta X_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta X_t = \alpha + rX_{t-1} + \sum_{j-1}^{p} \beta_j \Delta X_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta X_t = \alpha + rX_{t-1} + \sum_{j-1}^{p} \beta_j \Delta X_{t-1} + ct + \varepsilon_t \quad (3)$$

The actual test starts reversely from the model (3), then the model (2), and finally the model (1). When the test refuses zero hypotheses, that is, the sequence does not have the unit root, it means a stationary sequence, and then the test can be stopped. The pollution index of Guangdong and Guangxi and the ADF test results of four variables, see herein Table 2. The results of significant level are all less than the ADF test values of the original variables. The pollution index and four variables are unstable; the second-order difference is stable afterwards.

3.3.2. Cointegration test

To identify the correlation between variables is whether or not the existence of long-term equilibrium relationship, we use Johansen Cointegration test method.

Set the VAR model as follows:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_p Y_{t-p} + U_t \quad (4)$$

Here Y_t is a m- dimension random vector, $B_i\ (i=1,2,...,p)$ is a m x m order parameter matrix,

U_t~IID (0, sigma). We convert (1) to

$$\triangle \boldsymbol{Y}_t = \sum_{i=1}^{P} \boldsymbol{\phi}\boldsymbol{\delta}\boldsymbol{Y}_{t-1} + \boldsymbol{\phi}\boldsymbol{Y}_{t-p} + \mathbf{U}_t \quad (5)$$

Table 3. Johansen cointegration test results

	Null hypo.	Eigen-value	Trace test			Max root test		
			Trace	5%critical	Probability	Max root	5%critical	Probability
Guangdong	None*	0.9446	110.92	69.819	0.0000	54.983	33.8769	0.0000
	At most 1*	0.7644	55.941	47.856	0.0073	27.466	27.5843	0.0518
	At most 2	0.6610	28.475	29.797	0.0704	20.550	21.1316	0.0601
	At most 3	0.3244	7.9250	15.495	0.4734	7.4499	14.2646	0.4374
	At most 4	0.0247	0.4751	3.8415	0.4906	0.4751	3.84147	0.4906
Guangxi	None*	0.9876	151.71	69.819	0.0000	70.258	33.8769	0.0000
	At most 1*	0.8924	81.447	47.856	0.0000	35.669	27.5843	0.0037
	At most 2*	0.7421	45.778	29.797	0.0003	21.685	21.1316	0.0418
	At most 3*	0.6639	24.093	15.495	0.0020	17.444	14.2646	0.0152
	At most 4*	0.3400	6.6482	3.8415	0.0099	6.6482	3.84147	0.0099

According to the cointegration test results, Guangdong sulfur dioxide and the four variables exist at most one cointegrating vector at the 5% significant level. While Guangxi has at most four cointegrating vectors, root trace statistic and the maximum statistic eigenvalues greater than 5% level's threshold. The results indicate that at 5% significance levels refused "no cointegration relationship", null hypnosis.

As follows are Guangdong (6) and Guangxi cointegration (7) equations, and the parenthesis is the corresponding standard error:

$$\ln SO_2 = 6.0535 - 3.48922 \ln PCGDP + 2.490271 nk\_L + 0.057621 nINVE + 0.752031 nEXP \quad (6)$$

(0.22647) (0.3225) (0.16465) (0.02018) (0.15157)

$$\ln SO_2 = -4.962914 - 1.837587 \ln PCGDP + 0.9763531 nk\_L - 0.1270001 nINVE + 0.4688961 nEXP \quad (7)$$

(0.42721) (0.24030) (0.10390) (0.00762) (0.07868)

The Guangdong cointegration equation tells that under long-term stability condition, increase of 1 percentage points of export scale results in government investment in industrial pollution control, capital labor ratio increased, sulfur dioxide emissions growth by 0.75, 0.05 and 2.49 percentage points, increase by one percentage point of the average per capita GDP, sulfur dioxide emissions will be reduced by 3.4892 percent. The processing trade is the main trade mode in Guangdong province. Low added value and the core technology at the control of the foreign parent company may have low technology effect on environmental governance for enterprises have lower stimulation to new technological consumption and less investment in technology update. Efficiency of government investment is not up to be desired. 1 percent of increase in Guangdong's export leads to sulfur dioxide emissions increase by 0.7520 percentage points. The export trade dominated by manufacturing industries not services pollutes the environment greatly in Guangdong province. Guangxi cointegration equation shows that 1 percent increase of export trade under long-term stable situation and 1 percent improvement of trade structure make sulfur dioxide emissions increase by 0.4689, 0.9764 percentage points. On the contrary, every one percent increase of GDP per capita and government governance of industrial pollution, sulfur dioxide emissions will be reduced by 1.8376 and 0.1270 percentage points respectively.

The increase of the total export volume, capital labor ratio and government investment in industrial pollution will lead to the increase of sulfur dioxide with the development of Guangdong's export trade. The increase of per capita GDP will reduce sulfur dioxide emissions. The total effect is positive, and the technical effect is greater than the sum of other effects. The increase of government investment in industrial pollution will lead to the increase of sulfur dioxide emission. The possible reason is that the government measure taken is not strong enough to control emissions, and the investment in industrial pollution control is far from sufficient.

Compared with Guangdong, the Guangxi governmental governance of industrial pollution investment is negatively correlated with SO_2, which is verified by the Guangxi environmental protection department's governance of industrial emissions. The publicity and punishment of enterprises with excessive monitoring points reduce the public trust of enterprises, which has played a certain deterrent role in pollution governance.

3.3.3. Impulse response analysis

Based on the above analysis, we build a VAR regression model including sulfur dioxide and per capita GDP, export scale, capital labor ratio and government investment in industrial pollution, and study the impact response of pollutants to other variables. According to the minimum principle of AIC and SC, through repeated tests, the optimal lag period of the model is established as 2. i.e, to establish VAR (2) model, and the overall

fitting of the model is over 90%, which means the high interpretation degree. In the process of checking all the eigenroots, the reciprocal of the roots of VAR (2) model based on sulfur dioxide and various variables all fall within the unit circle, indicating that the structure of the model is stable. Considering the effect of variable sequence variation on the impulse response, the generalized impulse response function (GIRF) method is used to eliminate the negative impact. By setting the impact period as ten, the response of sulfur dioxide to the export scale, per capita GDP, capital labor ratio and the government's impact on industrial pollution investment is shown in Figures 2 and 3.

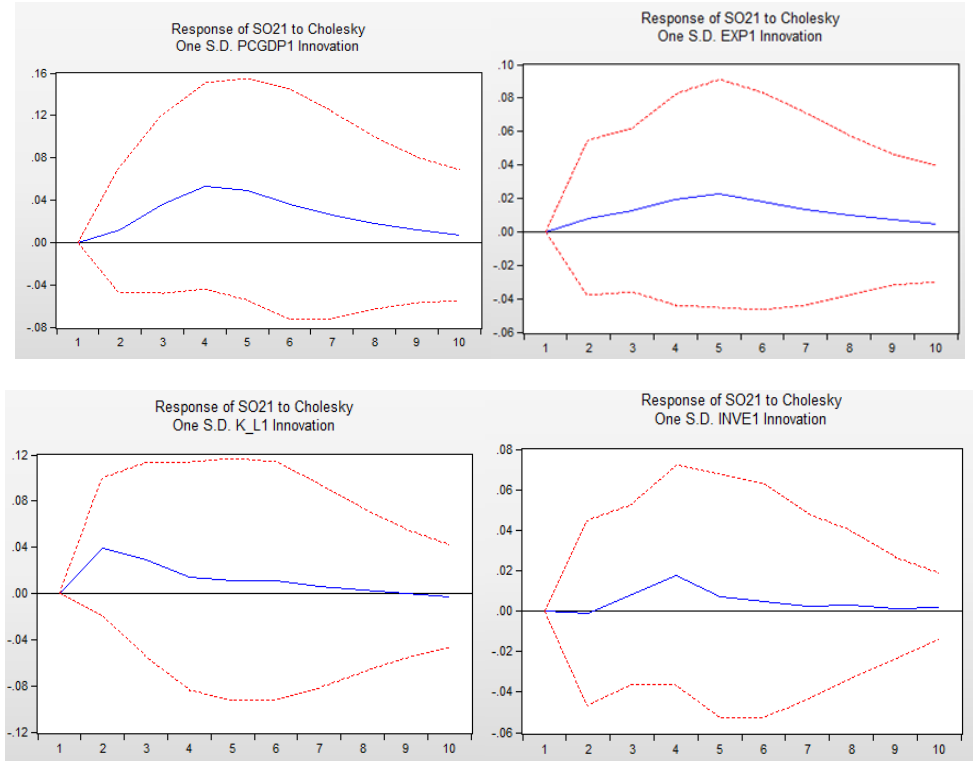

Figure 2. Impulse response analysis of Guangdong

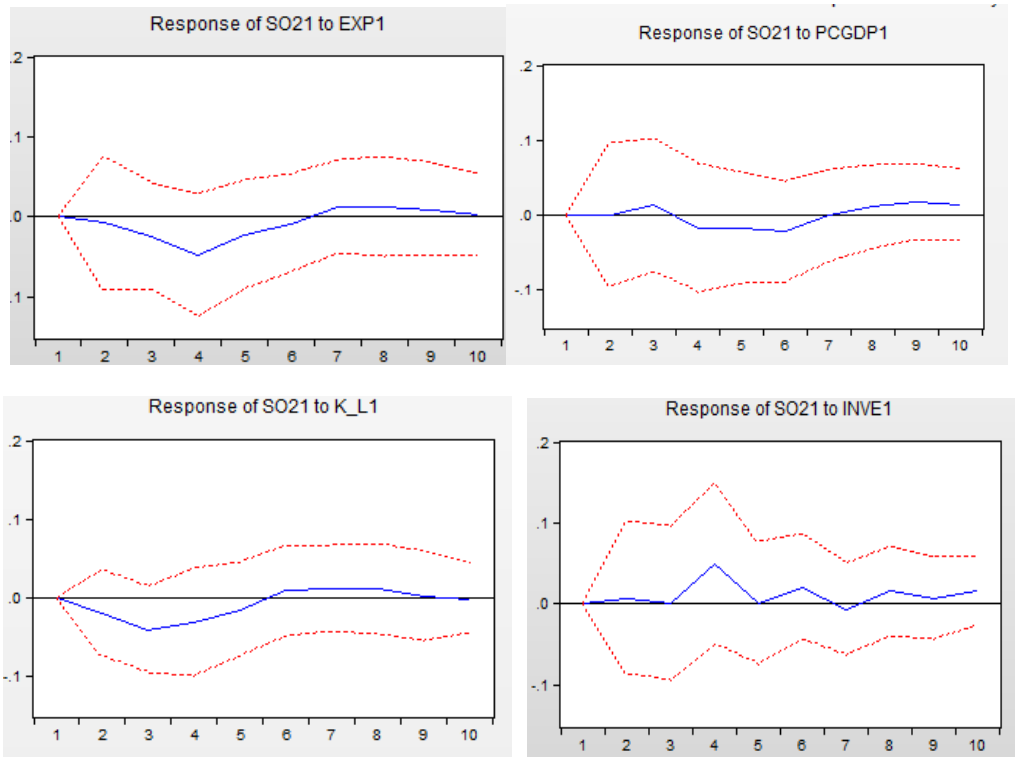

Figure 3. Impulse response analysis of Guangxi

Guangdong impulse response charts say that one standard deviation of sulfur dioxide begins to amplitude shocks on GDP per capita from the second period. The fourth period has reached its peak to 0.0529, after the rapid decline in the overall trend of convergence. An inverted V-shape has been formed. The fact that discharge of pollutants reduces gradually until the fourth period may attribute the lagged technological effect indicating that technology effect has been gradually weakened and technology still needs to be updated. In the analysis of Guangxi, one shock on per capita GDP during current period arises sulfur dioxide varies in the third period with a smaller margin around the horizontal line and goes above the line until the eighth stage and finally tends to convergence. Guangxi technology effect initially does not play the role of improving the environment, which may share the same reason with Guangdong, time lag effect of technology. Pollutant emission rate gradually decreases on the third phase and the technical effect to improve the environment disappears more slowly than Guangdong. Compared to the technical effects of Guangdong and Guangxi, the impact on the former is greater, indicating that the environmental and technical effects of Guangdong are stronger, which is in accordance with the earlier analysis.

One standard deviation of the impact of Sulfur dioxide on Guangdong export scale is null at the first period, with the similar trend of per capita GDP. Both are gradually positive correlation at the fifth period up to the peak of 0.022 followed by a slow decline. The overall impact is not evident. The expansion of exports will compound the sulfur dioxide emissions growth, the small scale of the effect and the trend of convergence formed with the passage of time. When one shock is given to Guangxi exports at the current period, sulfur dioxide emissions fluctuates below zero line before sixth stage and then fluctuates near the horizon. But pollutant emissions increased gradually from the fourth period. The larger the export scale will make sulfur dioxide emissions growth proves that PHH hypothesis does exist in Guangxi. At the same time to verify the conclusion of Cai Fang (2008) [15], Zhang, C. (2014) [16], Chou, H.F. (2014) [17], Wang, W.J. (2012) [18]on the environmental effects of East West China: in the environmental Kuznets curve (EKC) in the area on the left side and the turning point has not yet arrived.

Sulfur dioxide of the pulse response curve for Guangdong capital-labor ratio displays that the peak of 0.039 appears at the second period and decreased rapidly at the third and the fourth stage and then a trend of convergence. We learn from the chart that due to unreasonable trade structure and cumulated pollutants, the emissions will continue to rise. Then it gradually converges to the horizontal line, which may be related to the industrial restructuring. The increase in the ratio of capital-labor means that the industrial structure has being transforming from labor intensive to capital intensive. The increase of the emission of the corresponding pollutants may slow down as the production technology is up to the state of the art. It is known from Guangxi chart that before the fifth phase, the shock response of sulfur dioxide fluctuates below the horizontal line. From the sixth period, the response to the ratio of capital labor has been changed slightly above the horizontal line. Before the second period, the emission of pollutants gradually increases and after the third period, the decrease was diminishing. This may have arisen from certain delay in the impact of the irrational industrial structure. In the early stages of the transformation, the structural transformation has little and unobvious impact on environment. As time goes by, the emission of pollutants increases gradually and will last for some period of time.

The response of sulfur dioxide in Guangdong's investment from industrial pollution has gradually increased to positivity in the third period and has reached its peak of 0.017 at the fourth period. With the rapid emission of pollutants, the environmental quality will continue to be deteriorated rather than to be improved if the related investment does not increase proportionally with the growth of pollutants. This shows that the government of Guangdong takes measures not strong enough in dealing with industrial pollution. The impact of sulfur dioxide on Guangxi's environmental policy is not obvious in the first three periods. It is more fluctuating at the fourth period, and the impact value is changing positively. After reaching the two peaks, it begins to fluctuate below the zero level for a short period of time. The initial volatility is not obvious because of the lag of environmental policy. But with the expansion of trade and the development of economy, the effect of the same policy will weaken the environment protection, so government should innovate policies to deal with the policy effect decreasing. Although environmental policies are conducive to the improvement of the environment, the effect will be “marginal diminishing” if the policy measures remain rigid and unchanged.

3.3.4. Variance decomposition

Variance decomposition is to decompose the fluctuation of every endogenous variable according to its cause and to decompose it into *n* components associated with each equation to analyze the relative importance of endogenous variables in the model (Zhang Chun, 2014 [19] and Zhang, L. 2015 [20]).

Table 4. Variance decomposition of sulfur dioxide

Forecast prriod	Standard error	LNSO2	LNPCGDP	LNK_L	LNINVE	LNEXP
1	0.1041	100.0000	0.0000	0.0000	0.0000	0.0000
2	0.1490	92.0296	0.63956	7.0204	0.0074	0.3087
3	0.1838	87.8197	4.15640	7.1485	0.1952	0.6801
4	0.2202	83.9283	8.66729	5.4087	0.7679	1.2278

Guang dong	5	0.2452	81.8148	11.0691	4.5771	0.7075	1.8315
	6	0.2571	80.8652	11.9723	4.3347	0.6786	2.1492
	7	0.2634	80.5258	12.3420	4.1761	0.6537	2.3024
	8	0.2669	80.4326	12.4625	4.0778	0.6487	2.3784
	9	0.2687	80.4446	12.4741	4.0223	0.6420	2.4170
	10	0.2696	80.4635	12.4530	4.0081	0.6432	2.4322
Guangxi	1	0.1560	100.0000	0.0000	0.0000	0.0000	0.0000
	2	0.1722	98.2479	5.2653	1.3842	0.1670	0.1989
	3	0.2045	92.6947	0.3825	5.1472	0.1247	1.6509
	4	0.2302	82.7121	0.9384	5.9146	4.7730	5.6619
	5	0.2328	81.0428	1.5445	6.2236	4.6718	6.5173
	6	0.2354	79.4843	2.4182	6.2133	5.3705	6.5136
	7	0.2407	79.7836	2.3145	6.1851	5.2090	6.5078
	8	0.2422	78.9519	2.4851	6.3214	5.5639	6.6777
	9	0.2440	78.6065	2.9013	6.2317	5.5479	6.7126
	10	0.2451	78.0826	3.1684	6.1787	5.9134	6.6569

The results of sulfur dioxide variance decomposition (see Table 4) in Guangdong shows that per capita GDP contributes the most majority, which increases steadily after the third period and reached 12.45% in the tenth period. It represents that 12.45% of the variance of sulfur dioxide emissions could be explained by the development of PCGDP. The contribution rate of the government by the means of the industrial pollution control investment to the emission of sulfur dioxide emissions is very low with the second period of 0.007% and the tenth period of 0.64%. Capital-labor ratio is up to 7.02% in the second period, but gradually decreases after the third period until 4% in the tenth. The export scale increases slowly throughout the whole period and reached 2.43% in the tenth period.

The export volume has a greater impact on the variance decomposition of sulfur dioxide in Guangxi although the third period is still at 1.65%. It increases rapidly to 5.66% in the fourth period, then increases moderately to 6.65% in the tenth period. The export scale explained that there was a 6.65% variance in the prediction of sulfur dioxide emissions. The export commodity structure and government investment closely follows it by 6.17% and 5.91% respectively in the twelfth phase. Per capita GDP is relatively lower than the other three variables but also reaches 3.16% in the twelfth period. It rises to 5.26% at the second stage and then fluctuates to the last period. The per capita GDP contribute lower impact to environment in Guangxi compared with that of 12.45% in Guangdong.

3.4. Result Analysis

Based on the empirical analysis of the time series of Guangdong and Guangxi, the following conclusions are drawn: in the level state, sulfur dioxide and four variables in two regions are not stable and are stable after second order difference. The cointegration test results show that there is a stable cointegration relationship between sulfur dioxide and the four variables. The impulse response analysis of sulfur dioxide to four variables in Guangdong province proves significant because of the lagged impact. So the significant response appears to the middle phase and it tends to converge over time. The response of sulfur dioxide in Guangxi to the shock of the four variables performs very volatile, but it also tends to converge at the end. The Guangdong variance decomposition shows that the PCGDP and the government harnessing industrial pollution by investment on sulfur dioxide emissions sees two pillars of the highest and the lowest. The Guangxi variance decomposition shows that the two extremes are the export scale and the PCGDP. The environmental effect of two province's trade manifest quite heterogeneous and also different from the work of Chou Haifeng (2014) based on intra-product trade.

There is a cointegration relationship between the four variables and sulfur dioxide means economically that the environmental deterioration is caused by four variables in which the scale effect and the export structure will aggravate the pollutant emissions, technical effect is the opposite, the government of Guangdong pollution control investment does not play a desirable role to improve the environment. This shows that the increase in the total export of Guangdong and the structure of export commodities will reduce the quality of the environment.

Export expansion of Guangdong will aggravate the pollution of the environment mainly because exports are almost all industrial manufactured goods which are more environmental unfriendly compared to other products. The total export value in Guangdong accounts for large part of economy and environmental pollution much heavier than that in Guangxi. With the increase of per capita GDP, pollutants will reduce. But it's uncertain for "the slope effect" (He Jie, 2010) in government governance on industrial pollution control. As we haven't analyzed the supply-demand method from the point of market conditions, we cannot determine whether the government relaxed environmental regulation in pursuing to improve the competitiveness which leaves further study. The effects of technology contribution in Guangdong and Guangxi show two polar of the highest and the lowest, which on the one hand, is on the line with hetero applicability of "Pollution Haven Hypothesis" in China Cai Fang (2008) due to the uneven regional development. The more developed provinces, the higher pollution is. The western region has not reached EKC's turning point; on the other hand is also in accordance with reality: Guangdong's higher per capita GDP and the

technical level is relatively higher, while Guangxi is just the opposite.

4. Main Conclusion and Suggestions

From the above analysis, we can see that the environmental structure effects of Guangdong and Guangxi provinces are all negative (the symbol is positive in the model). Both regions should adjust the export trade structure, promote the transformation of the foreign trade, and ensure that the trade can not only increase the welfare, but also contribute the environment. However, because of the different development level and the heterogeneity of the effect of trade on the environment, the government should adopt different environmental policy. Guangdong should reduce the export of high pollution products and promote the development quality of export. It is necessary to reduce the processing of more pollution and emissions based on the fact of large proportion of processing trade. To promote processing trade expands toward both ends on GVC. They should take full advantages of the technology spillover effect and develop sustainably by learning-by-doing first and further by self-innovation. The province should promote the export of high tier of processing trade and upgrade the processing chain so as to reduce pollution emissions. Guangdong also should increase investment in environmental protection technology R&D and enhance the technical level of pollution control. In order to reduce pollutant emissions and improve environmental quality, Guangdong may levy e-tax on the pollution-intensive products and carry out the policy of "third party governance" in Guangdong province and implement the policy of "who pollutes who is responsible for". In addition, other effective measures include to put stricter environment regulation on foreign investment enterprises, to reform the mode of investment from all absorption to optimal capital selection, to encourage clean industries or services to invest in Guangdong, to shut out heavily polluting industries. The established investment enterprises should be banned and monitored the exhaustive gas and waste refining observation points. Only in this way can governance efficiency improve. The negative impact of Guangxi's export trade on the environment is less than that of Guangdong. It can adjust the import, export and investment industrial structure while increasing the volume of exports, increase the support of environmental technology investment and green industry, and attach focus regulations and monitors on solid waste emission enterprises.

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