International Trade, Pollution Accumulation and Sustainable Growth: A VAR Estimation from the Pearl River Delta Region

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Abstract. In order to investigate international trade influence in the regional environment. This paper constructs a vector auto-regression (VAR) model and estimates the equations with the environment and trade data of the Pearl River Delta Region. The major mechanisms to the lag are discussed and the fit simulation of the environmental change by the international impulse is given. The result shows that impulse of pollution-intensive export deteriorates the environment continuously and impulse of such import improves it. These effects on the environment are insignificantly correlated with contemporary regional income but significantly correlative to early-stage trade feature. To a typical trade-dependent economy, both export and import have hysteresis influence in the regional environment. The lagged impulse will change environmental development in the turning point, maximal pollution level and convergence.

1. Introduction
The Pearl River Delta, known as the "world factory", contributes about 30% of aggregate value international trade in China annually in the past ten years, which is considered as world-shaking for over 30 years for its amazing reform and opening. However, the Pearl River Delta’s international trade is based on the high input, high consumption, high pollution and developing mode of pollution first and treatment last. Pollution and resources shortage has become a double-edged sword to the sustainable development of economy in the Pearl River Delta region.

Environment Kuznets curve (EKC) reflect the interrelationship between economic growth and environment change. EKC is often shaped as inverted-U because environment deteriorates as economic growth at early stage and improves later. Most of researchers regard that inverted-U is the result of sequential development of three effects, i.e. scale effect, technology effect and structure effect (Grossman G M and Krueger A B, 1993) [1]. In the very beginning of industrialization, scale effect is overwhelming and dominates the change of environment. The other two effect is so weak that the environment changes mainly by the economic scale. It is the deterioration stage in the inverted-U EKC. In this stage economic growth exploit environment and resources at little residential consciousness and very low cost. Afterwards, structure effect and technology effect comes to stronger and replace the leading position of scale effect, which will guide the interrelationship between economic growth and environment to virtuous circle (Lu Y and Guo L, 2008) [2]. Usually, they play effectiveness simultaneously, because technology effect is interrelated to structure effect. The former one will help the latter one to perform better and advance faster. As to the reasons of the replacing, much research work has been done from different perspectives including market mechanism (Thampapillai et al., 2003) [3], consumer preference (Lopez R and Mitra S, 2000; Lopez R et al., 2007) [4], [5],
environmental policy (Torras M J, 1998) [6] and international impacts (Copeland B R and Taylor M S, 1995, 2004) [7], [8]. The explanation varies greatly but the replace order and consequence is quite similar in most of empirical research.

A great deal of empirical study testified the mechanism of inverted-U EKC. They have selected different kinds of data in cross-section, time series and panel structure from different countries and territories in different periods. However, there are many differences among not only methods but also results. The discrepancies include shape, slope and turning point. As to the shape of EKC, some research work disagrees that all of EKC is shaped as inverted Egli H and Steger T M (2007) [9] regarded that EKC is probably multi-shaped. That is environment may deteriorate continuously, or, in some circumstance, improve after the first turning point and deteriorate at the turning point. Therefore, EKC may also be a line with positive slope or N shape (Fu M, 2008) [10]. In the first case, there is no turning point and in the second case, there are two turning points. Some panel data regression results show that the second turning point does exist in some developing countries and that whether or not turning point will appear depend on the detailed circumstances of selected countries and periods as well as the pollution measurement (He J and Wang H, 2012) [11].

As to the position of the EKC turning point, there is no convincing result because the analysis from different paper shows that different regime or geographic location may result in different turning point (Zhu P H et al., 2010) [12]. Indicator variety or different econometric method also influence the turning point estimated, which makes the comparison of the turning point among different countries difficult. If take the stochastic factor into consideration, EKC will be more complex among countries (Prieur F, 2009) [13]. Suppose that pollution accumulation is some kind of Brownian motion, up to three threshold value may arise in environment changing process, which will lead to M or more complex shaped EKC.

Regarding interrelation between trade and environment, there are three kinds of viewpoints. The first one is that trade liberalization is beneficiary to the environment. Lucas R et al. (1992) [14] made the regression analysis on the relationship between the intensity of pollutants in measured in emission per unit of output and economic growth by multiple countries data from 1960 till 1988. The result shows that pollutants agglomeration declines in some countries after reaching a certain income level after rapid growth of pollution emissions and pollution intensive industry scale in the developing world. The second viewpoint regards that international trade accelerate the pollution of the environment. Chilchilniky G (1994) [15] argued that free trade to developing countries is more destructive than to developed countries. Trade liberalization will accelerate the deterioration of environment as well as resources exhaustion in developing countries, which threatens global environment and ecosystem if private property rights are not clearly defined, in another word, the polluter thinks emission as public and will surly average the cost and damage to every country. The third viewpoint is that the impact of international trade on the environment is uncertain. Copeland B R and Taylor M S (1995) [7] introduced a South-North model and disintegrate the influence to environment into three effects, which are scale effect, structure effect and technology effect respectively, so as to analyse the impact of international trade on the environment. The result suggests that free trade makes the South environment destructed and the North, improved.

Some domestic study of the relation between trade liberalization and environment is more precise in analytical regional-concerned result. Some scholars think that the interrelation between international trade and environment can be explained by some kind of game theory and apply to the law of the unity of oppositeness. Wu G M and Wu G S (2011) [16] introduced a game theory model of the prisoner's dilemma to study the environmental game process and trade game process among the partners of the international trade. He found that the relationship of environment and trade is a stable Nash equilibrium rather than an irreconcilable contradiction. Expanding the mechanism of trade liberalization influencing pollution, some domestic scholars regarded that four effects should be taken into consideration: scale effect, structure effect, technique effect and law effect. Li B et al. (2006) [17] constructed a general equilibrium model of international trade and environment so as to decompose the environmental effect by trade into scale effect, structure effect, technology effect and law effect. He found that scale effect aggravates the deterioration of environment in China, and the structure effect and technology effect improves environment.
The discrepancies in empirical study are partly due to ignorance of endogenous interrelationship between economic growth and environment. Most of research work put emphasis on one-way impact on environment by economic growth rather than reaction of environment (Andreoni J and Levinson A, 2001; Dinda S, 2005) [18], [19]. If economic growth results in scale effect, structure effect and technology effect, which have effects on environment, will environment change have feedback and influence economic growth? In fact, when regarded as factor of production, environment will affect economic growth by all of these effects. In our early research, it was found that economic growth is affected by the environment. Environment quality is also featured as a flow factor for output, which implies that more rapidly the economy does grow, more costly the environment is. Considering that high environment quality can provide abundant factor endowment for production, a country before turning point obviously has different structure effect from one after turning point. Such kind of upturn will happen to one country in different economic stage and change all of effects on environment by economic growth.

This paper will focus on the inner mechanism and its effects on relationship between the international trade and the regional environmental pollution by empirical analysis. Quite different from other research work, we introduce lagged factor so to provide more powerful explanation to auto-correlation in environment change in the Pearl River Delta. In the next section, we will introduce variables and data. Section three introduces the VAR model, test the stability and cointegration and estimate the coefficients. In the fourth section, we discuss the international trade hysteresis influence in environment and impulse to environment inverted U process. The last section is our conclusions.

2. Materials and methodology
To introduce endogenesis, we suppose that environment and economic growth will impact each, so each of them should be taken as endogenous variable decided by another endogenous variable and exogenous variables. We set the model structure in Figure 1.

![Figure 1. Model Framework](image)

The model includes two endogenous variables, one is environment and the other is economic growth. Economic growth has four channels to influence environment, i.e. scale effect, structure effect and technology effect and trade. Scale effect is deleterious to environment and structure effect and technology effect is advantageous. Trade effect is variable. These effects not only influence environment but also change environment reproduction, which may speed up or slow down environment improvement. Economic growth relies on several factors, including capital, labour,
human resources and especially, environment. Environment has effects on total factor productivity, which determines the output. Environment factor input quality and quantity is dependent to environment performance and the performance is influenced by economic growth through three effects. It is very important that environment has feedback to economic growth and trade. And, economic growth and trade influence the environment in turn. In our early research, we have construct a simultaneous equation group to simulate the interrelationship among them. We have estimated the coefficients in the equation group and transform the group to single equation. Considering the feedback will have hysteresis effect, we include the feedback in the lag item of economic growth. The model is set as

\[ y = f(y, e, L.y, L.e, tr, ot) \]  \tag{1} \\
\[ e = g(y, e, L.y, L.e, tr, ot) \]  \tag{2}

in which y, e, tr and ot is GDP, environment, trade and other exogenous factors respectively and L is lag operator. The effect of feedback is included in variables L.y and L.e. Other exogenous factors include foreign direct investment (FDI), energy and industry structure. Variables of trade include export ex and import im. Lag term is tested up to 4th order. Both y and square y are included in the equation group.

For the convenience of analysis and data availability, this paper selects exports and imports as indicators of international trade. In order to highlight the influence by trade structure, we use product of ratio and GDP. However, the ratio is not the simple proportion of aggregate import or export in GDP. Considering that technology progress will impact international trade, we weigh the ratio by industry and give technology intensive and less pollution intensive industry more weight. Pollution is measured by emission of wastewater, industrial waste gas and industrial waste solid. We collect the environment quality year report 2004 till 2014 from GIS in Guangdong Environmental Protection Department Data Centre. According to the emission in each city where monitor station lies in, we weigh environmental quality data to an index indicator from 0 to 1, smaller is better. The Pearl River Delta’s pollution and trade data, covering the period from 2002 to 2014, are collected from statistical yearbook and the economy development statistics report in the Guangdong and the Pearl River Delta. Some data before 2005 are calibrated by other statistic material.

We will pay more attention to the interrelationship between the growth rate of international trade and environment. Primary regression also suggests that logarithmic indicators perform better in our model considering goodness of fit and logarithm will not change the interrelationship but can reduce heteroscedasticity significantly and make the sequence into stationary series easily. Considering the dependent variables of pollution may have correlation with dependent variables of trade and in order to prevent estimation from multi-collinearity, we also calculate 1st class difference of each variable for test comparison and use differentiated logarithmic variables in our VAR and panel model.

3. Results

3.1. Time series test
First, we inspect the time series stationarity by ADF test for samples of time series using STATA. Table 1 shows the logarithmic results as well as the differentiated logarithmic results for comparison.

| Variable | Test | Statistics | Stationarity | Test ∆ | Statistics | Stationarity |
|----------|------|------------|--------------|--------|------------|--------------|
| Log(ex)  | c, t, 1 | -1.406 | No | c, t, 3 | -5.533 | Yes |
| Log(im)  | c, n, 0 | -1.196 | No | c, t, 0 | -3.676 | Yes |
| Log(water) | c, t, 0 | -3.092 | No | c, n, 3 | -4.028 | Yes |
| Log(gas) | c, t, 1 | -2.548 | No | c, n, 0 | -4.203 | Yes |
| Log(solid) | c, t, 0 | -2.61 | No | c, n, 0 | -4.409 | Yes |

*Test form c, t, k parameters denote constant term, time trend, and lag order number of unit root test. ∆ represents the first order difference. The optimal lag order number is determined by the AIC criterion, when the absolute value of ADF is greater than 5% critical level, the sequence is judged as stationary series.
According to the rule of AIC and SC, each group of variables are tested up to 3rd lags. Table 2 shows the results.

**Table 2. Vector cointegration test**.

| VECTOR | H0: NONE | Trace | Max Eigenvalue | H0: 1 AT MOST | Trace | Max Eigenvalue | COINTEGRATION |
|--------|----------|-------|----------------|---------------|-------|----------------|---------------|
| ex, water | 15.9578  | 12.6442 | 3.3136         | 3.2274        |       |                | 1             |
| ex, gas | 19.1293  | 16.0673 | 3.0620         | 3.0010        |       |                | 1             |
| ex, solid | 12.6220  | 8.8423  | 3.7797         | 3.8525        |       |                | 0             |
| im, water | 15.9933  | 12.3866 | 3.6067         | 3.5503        |       |                | 1             |
| im, gas | 21.9442  | 18.4832 | 3.4610         | 3.1217        |       |                | 1             |
| im, solid | 12.0990  | 7.6466  | 4.4525         | 4.2564        |       |                | 0             |

*a Null hypothesis is none cointegration and 1st order cointegration at most respectively. The 5% critical value for trace is 15.41 and for maximum eigenvalue is 3.76. The last column is the judgement order. Ex and im is export and import respectively. All tests are applied in 1st order differentiated logarithmic variables.

Table 2 suggests that both export and import are 1st order cointegrated with water and air pollution while there is no significant cointegration relationship between solid pollution and any trade, either export or import. Therefore, international trade has long run influence on the environment of the Pearl River Delta, despite that the environmental change may has intrinsic random features and some emission are not significantly observed tightly related to trade, e.g. solid. For comparison, we also test the logarithmic variables without 1st order difference. The result shows that no cointegration relationship exist among any groups of vectors.

### 3.2. VAR model and impulse response

According to the result of time series test, we focus on relations of international trade and pollution of water and air, so we construct two groups of VAR model as follows:

\[
\text{VAR 1: } Z_t = (d \log \text{water}, d \log \text{ex}, d \log \text{im})
\]

\[
\text{VAR 2: } Z_t = (d \log \text{gas}, d \log \text{ex}, d \log \text{im})
\]

Considering that increasing lag order will lower the freedom degree of estimation and in order to eliminate autocorrelation of residual to provider stronger explanatory capability, we set the maximum lag order to two. All variable are 1st order differentiated and logarithmic. VAR model test result for order is given in table 3.

**Table 3. Lag order to VAR**.

| lag | LL  | LR   | FPE  | AIC  | SC   | HQ   |
|-----|-----|------|------|------|------|------|
| VAR1 | 0  | 28.9099 | --   | 1.5e-07 | -7.1744 | -7.1446 | -5.89963 |
|      | 2  | 133.566 | 56.43 | 1.2e-07 | -7.7544 | -7.6353 | -8.55817 |
| VAR2 | 0  | 27.1214 | -    | 4.8e-07 | -7.03036 | -6.0005 | -6.23128 |
|      | 2  | 117.856 | 35.34 | 1.8e-07 | -7.33322 | -7.2140 | -8.13692 |

*a LL gives the likelihood function value of VAR model. LR is likelihood ratio. FPE represents the final prediction error, AIC refers to Akaike information criterion. SC means Schwarz’s information criterion, HQ denotes Hannan-Quinn information criterion. Taking all criterions into consideration, we regard that 2nd lags for VAR1 and VAR2 are the optimal result. Estimation result of the model is listed in Table 4.

**Table 4. VAR estimation**.

|     | Con | L.Water | L2.Water | L.Export | L2.Export | L.Import | L2.Import |
|-----|-----|---------|----------|----------|-----------|----------|-----------|
| VAR1 | Water | 0.001   | 0.464    | 0.301    | 0.487     | 0.355    | -0.501    | -0.361    |
|      | Export | 0.055   | 0.243*   | -0.124   | 0.748     | -0.002*  | 0.011     | 0.008     |
|      | Import | 0.045   | 0.177    | -0.093*  | 0.098     | -0.012   | 0.726**   | -0.001    |
The table below presents the estimated coefficients for the VAR model:

|        | Con | L.Air | L2.Air | L.Export | L2.Export | L.Import | L2.Import |
|--------|-----|-------|--------|----------|-----------|----------|-----------|
| Air    | 0.013 | 0.811 | -0.028 | 0.425    | 0.218     | -0.536   | -0.009    |
| Export | 0.036 | 0.235 | -0.115*| 0.806    | -0.089    | 0.088    | -0.011    |
| Import | 0.043 | 0.215 | -0.111*| 0.154    | -0.083**  | 0.808    | -0.023*   |

*L is the 1st order lag operator and L2 is the 2nd order lag operator. Con is constant term. Critical level is 5%. *" and **" is significant at 10% critical level only and not significant at 10% respectively.

Figure 2 shows the scatter plot and average line of water and air pollution estimated by the VAR model in 50 periods. We can find that the shape of line is quite similar with each other, but the pollution level is not exactly the same and this is only a matter of measurement. It can be found that the maximal pollution change rate of water and gas is 4.6860% and 6.4169% respectively. However, it is not the traditional EKC tuning point because the pollution keep growing at this point at its highest marginal rate. In these curves, pollution of water or air increase at beginning and the change rate of the pollution deterioration speed rate keep increasing until the 6th (to water pollution) and the 5th (to air pollution) period. After these point, environmental quality keep degrading and the degrading speed is increasing until the 17th (to water pollution) and the 18th period (to air pollution). Then, the change rate of environmental degrading rate of both water and air turn to negative, i.e. environment is deteriorating but the deteriorate rate stops from increasing and begins to decrease.

![Figure 2. Rate of water and air pollution change percentage](image)

Figure 2. Rate of water and air pollution change percentage

Considering the initial point in the sample of this paper is in pollution deterioration stage, accumulated change of both water and air pollution change percentage needs to decline below zero, when environment improves. The accumulated change of water and air pollution change percentage is plotted in Figure 3. To water pollution, at the 39th period, the accumulated change is near zero and to air pollution, the 53rd period. About 4-7 periods after those points, environment begin to improve, i.e. 43-60 periods of deterioration need to be experienced according to our estimation results.

![Figure 3. Accumulated sum rate of water and air pollution change percentage](image)

Figure 3. Accumulated sum rate of water and air pollution change percentage

3.3. Robust test
We have carried on 2 groups of robust test to the model estimation. The control variable is FDI and industry structure. The former one is for opening test, i.e. if another variable indicating opening can replace the agent position of international trade and also influence environment, will the model estimation result keeps robust. If FDI of similar type of products can change the fitness of the model or weaken the significance of the trade, the original estimation result is lack of robustness, which may imply that change of environment is not the specific result of trade.

Another control variable is industry structure. The structure effect of economic growth has already included this effect in the endogenous mechanism. If the model is robust, an additional structure variable will produce some collinearity and weaken the significance of trade. We also take the combined test for two control variables. The robust test result for water and air is listed in Table 5 and Table 6.

### Table 5. Robust test for water

| variables | Water pollution equations | Trade | FDI | Structure | Combined |
|-----------|---------------------------|-------|-----|-----------|----------|
| constant  |                           | 0.001*** | 0.002** | 0.001** | 0.001* |
| L.water   |                           | 0.464*** | 0.426*** | 0.501** | 0.550*** |
| L2.water  |                           | 0.301*** | 0.315** | 0.228** | 0.013** |
| L.export  |                           | 0.487*** | 0.409*** | 0.444*** | 0.334*** |
| L2.export |                           | 0.355**  | 0.289** | 0.295○  | 0.283○  |
| L.import  |                           | -0.501*** | -0.435*** | -0.488** | -0.465*** |
| L2.import |                           | -0.361*** | -0.187*** | -0.273*  | -0.201○  |
| FDI       |                           | --      | -0.173*** | --       | -0.102*** |
| Structure |                           | --      | --       | 0.005**  | 0.004○  |

* *** and * indicates 1%, 5% and 10% of critical level respectively. ○ is not significant at 10% critical level.

### Table 6. Robust test for air

| variables | Air pollution equations | Trade | FDI | Structure | Combined |
|-----------|-------------------------|-------|-----|-----------|----------|
| constant  |                         | 0.013*** | 0.008*  | 0.010*** | 0.001*  |
| L.water   |                         | 0.811*** | 0.600**  | 0.655**  | 0.477**  |
| L2.water  |                         | -0.028*** | 0.012**  | -0.001**  | -0.023*** |
| L.export  |                         | 0.425*** | 0.384**  | 0.419**  | 0.390**  |
| L2.export |                         | 0.218**  | 0.180**  | 0.224○  | 0.190**  |
| L.import  |                         | -0.536**  | -0.334**  | -0.451**  | -0.440**  |
| L2.import |                         | -0.009*** | -0.240*  | -0.215*** | -0.207○  |
| FDI       |                         | --      | -0.094*  | --       | -0.056**  |
| Structure |                         | --      | --       | 0.010*  | 0.009○  |

* *** and * indicates 1%, 5% and 10% of critical level respectively. ○ is not significant at 10% critical level.

The robust test result shows that both FDI and industry structure has slight influence on the model because overall significance lower down slightly in the test. However, the significance of lag term of environment has little change and it suggests that the hysteresis effect in this EKC VAR model is still robust. FDI effect on environment is quite similar to trade, which suggest opening effect may partly be resulted from investment.

### 4. Discussion

In this paper, we will focus two key points. One is international trade hysteresis influence in environment and the other is how impulse will change environment inverted U process.

#### 4.1. International trade hysteresis influence in environment

Regression results in Table 4 show that both water and air pollution is highly related to international trade hysteresis effects. One of the important founding is that both the 1st order and the 2nd order
coefficients of pollution intensive export in either VAR1 or VAR2 are positive, which means the impulse of such export is deleterious to the environment continuously. To most export intensive developing countries or regions, resources exhaustion, extensive manufacturing and poor regulation in pollution will all accelerated the pace to worse environment. However, lots of research done can only find such relationship as between pollution and contemporaneous international trade rather than pollution and lagged international trade. EKC empirical research by us earlier also suggests that the correlation between international trade and water environment is so weak that contemporary economic growth and corresponding structure, technology and scale effects are much more decisive than international trade in environmental change and the turning point. This is true only when considering the synchronous effects. Export and import effect on environment need more time to be seen.

One of the key explanations to this point is comparative advantage and factor endowment. When a region finds some factor endowment can bring comparative advantage in their export department, e.g. Foshan city in the Pearl River Delta in our sample find they can produce and export many ceramic goods for its endowment in labour and kaolinite, it tends to build strong producing capacity and export in large scale. In the early stage, it can be found that rapid growth in export doesn’t bring much environment destruction because the exhaustion of resource and its environmental damage is covered by natural recovery of eco-system. Thus we can only find insignificant influence in environment by export industry. And, this is stimulation to absence of environmental regulation as well as faster expansion of such export. With the development of the industry, environmental deterioration accelerates and cannot be restored by natural renewable process any longer. Therefore, the pollution deterioration is highly correlated to the influence of earlier stage export.

Another reason to export lag lies in the industry cluster led by export. Like the Pearl River Delta, most export-led regions in China or Asia attract a lot of enterprises for preferential policies, mature infrastructure, brand effect and technology spill over. When export booms, such kind of region has more rapid growth rate and attractiveness than other regions. More and more enterprises will invest here, whether they do international trade or not. Therefore, export growth in early stage may bring continuous prosperity as well as increasing pollution for the region. In some cases, environmental pollution will not decline even though export dwindles in several years because a large part of output for exporting will be redirected to regional or domestic market, or kept as stock. So export fluctuation is not the decisive factor to contemporary environment, but the important factor to future environment. The pollution is correlative to production in earlier stage, and part of which would have been arranged as the export, but now as regional or domestic sale.

Quite different from export, the influence of import in environment is advantageous rather than deleterious. But the lag does also exists. The negative coefficients of all lag terms of import suggest that environment will improve with the import growth although such improvement is partly offset by pollution in consumption process. Similar with export performance in environment, there is even inferior correlation between environment change and contemporary import growth. According to comparative advantage theory, if developed region imports a great amount of pollution intensive goods, which means the production process is already shifted abroad with regional industry upgrade, and environment improves with this process. Nevertheless, the improvement does not happen synchronously in significance due to the hysteresis effect. However, hysteresis in import is completely different from it in export. It is generated by industry shift lag and consumption lag.

Industry transfer lag is the time between pollution intensive transfer and environment improvement. When a region decides or is obliged to transfer its pollution intensive industry abroad, e.g. to some lower development region, the transfer will not recover the environment very soon. There are several reasons to this point. First, recovery of ecosystem needs a relative long period, so the water and air quality does not improve as soon as pollution emission decline. Second, the transfer of pollution intensive industry is always later than import increase. To some regions, loss of factor endowment as well as competitive power are the reasons of such industry transfer. The diminishing of export and growth of import happen along with the loss, surely ahead of transfer, and environmental improvement happens even later to it. Third, some regions will kept their damaged environment unrecovered even when they can restore environment after the pollution intensive industry transfer because of huge costs in restoration. The environment improvement will slow down with the inaction of government. Fourth,
some consideration in regional employment makes the pollution intensive industry transfer halfway, so the increase in import is limited effective to pollution control. Consumption lag is the lag of the environmental improvement due to consumption upgrade from more pollution intensive domestic products to more environmental domestic products. When a region needs to upgrade its growth mode to more technology intensive and environmental friendly type, contemporary environment improvement is not so significant. There are many reasons to this point and we discuss four of them.

First, the government always restricts the production with uncontrolled emission and these manufacturing must transfer to other less developing regions. However, such now imported goods are even less environmental than produced regionally earlier in consumption process, because the current producers in less developing regions usually has much less environmental regulation. That's also why many researchers thought that there are may be some Pollution Heaven in the industry transfer. In the relative early stage, a region has less control for such pollution intensive import in order to satisfying regional demand. So environment does not improve along with such import increase.

The second reason to that point is that the regional producers may cut their producing cost to compete with other region producers, and the cut parts may include emission clean and pollution control. The regional producer’s response aggravates environmental destruction until it pulls out of the regional market. Before that, they produce more such goods with lower costs in order to recoup investment. So the environment will not improve with the import increase.

The third reason is something like the reason discussed in export, i.e. the import increase does not definitely decrease the regional production for the reasons of regional employment and tax. The adjustment usually needs three to ten years or even longer. The improvement of ecosystem is influenced by this process.

The last reason lies in the time between import and consumption, and this lag is not too long. Imported goods production lies in other region and will not pollute native region, but the consumption and waste recycling may pollute regional ecosystem. Therefore, the offset effect does not happen before the final consumption. Some imported goods are intermediate goods and it will spend some time before it changes into final products and be sold to consumers.

4.2. International trade impulse to environment inverted U process
Pollution rate dynamic fitted line in Figure 1 suggests that Environmental Kuznets Curve as well as its stage and turning point alteration may be explained as autoregressive process rather than cubic polynomial fitting of income. A great deal of literature regard that the economic growth makes the pollution deteriorate in early stage and turns to improve environment when income reaches a certain level. As stated in many surveys, the technology effect, scale effect, structure effect and regulation effect are adjusting tools to interrelationship between income and pollution. International trade influence in environment relies on its impact on economic growth and structural change in it.

However, the conclusion in this paper implies that environmental change in highly opening region may be less correlative to economic growth but more to international trade. It is a process of endogenous auto-development, and most attention-getting point is that trade has direct effects on environment, regardless of regional income level. International trade can change the environmental curve considerably. That also means the turning point in different countries or regions may vary considerably with their international trade mode and structure. Many research work has questioned that why the turning point in EKC is so different among countries that the maximal turning-point corresponding income is twice or more of the minimal value. We regard the reason lies in this endogenous dynamic process. Estimation result suggests that either water or air pollution change rate (attention, change rate rather than absolute level) will rise in the early periods. After a certain amount of periods (depending on the initial point and actual situation, which is 17 to 18 in our research region), pollution rate comes to the turning point and then environment deterioration rate reach maximum. After about 25 periods, the rate alteration converges to a certain level (-0.0286 to water and -0.0182 to air in the Pearl River Delta region in our research). Therefore, the corresponding pollution growth rate has an accelerative rise in early stages and the rise rate will reach the maximal value after 17 or 18 periods. After that point, the pollution will not abate immediately, but keep increasing with decreasing
deterioration rate until this rate lowers to zero. That is 39 and 53 periods to both water and air in our sample of the Pearl River Delta. Then, environment begins to improve continuously and the improving rate will also rise until converge to the certain rate. This inverted U shape is completely an endogenous auto regressive progress, in which trade has great influences in environment directly. In this paper, we only discuss the change of the turning point, zero point and convergence of environment. In our estimation and fitting, it is found that an increase of the 1st or 2nd order lag positive impulse of export (or negative impulse of import) has little change on the turning point period of the environment change rate, but significantly increases the maximal pollution level. Such kind of impulse change of export will delay the period to zero pollution rate. It may decrease the final convergence environmental improvement rate, or even make environment converges to a steady deterioration rate and never improve. Regions as the Pearl River Delta is usually featured with scale pollution intensive export. Due to poor regulation, such export has tremendous and long-lasting damages to regional environment. That is why we find impulse to environment of export in the Pearl River Delta region is higher than data in other regions in China. Extensive scale development in such export department leads to higher maximal level of pollution growth rate. When the impulse is not so strong that offset influence of other factors, e.g. import and other endogenous various, it will only delay the coming of environment improvement and dwindle the final improving rate. However, if the impulse overwhelm other influences, (may it happened in some cities of this region in case that pollution emission is not controlled properly). The zero environmental deterioration rate cannot be reached and regional environment will keep deteriorating until environment cannot support the economic growth any longer. We also find the impulse of export will abate with lag period in both water and air pollution, which suggests that the export influence in environment abate as time goes go. The coefficient of the 2nd order lag export is smaller than the 1st order lag. We have tested the 4th order lag of the VAR for comparison, using same sample and find even weaker and less significant influence by 3rd and 4th order lag. Part of the influence of higher order lag export has been included in the lower lag order term, but more important, the region is motivated to change the industrial layout, stimulate export upgrade and impose tough sanction and regulation against illegal emission. So the marginal influence in environment by early export growth decreases. This also happens to import.

5. Conclusions
In this paper, we investigate the international trade influence in environmental change, using the data of the Pearl River Delta. We find that pollution is highly related to international trade hysteresis effects. Impulse of pollution intensive export deteriorates the environment continuously and such impulse of import improves environment. Such effects as well as their influences in environment are insignificantly correlated with regional income, which implies that environment can be improved with trade structure and mode advancement in highly opening or trade-dependent economy, even in relative low-developed stage. This also suggests that rapid economic growth is not definitely helpful to an economy to cross the EKC mountaintop because it may has much higher turning point than other economies. International trade hysteresis effects can move auto-regressive EKC turning point, make stages shift and change the maximal value of environment as well as convergence feature. Long-lasting effect of impulse of trade can decide the way of environmental sustainable development or a vicious circle to some extent.

One of the most interesting conclusions in this paper is that environmental effect lag are quite different between export and import. The export lag is caused by comparative advantage, factor endowment and industry cluster. While the import lag is cause by industry transfer lag and consumption lag. We offer some major mechanisms. However, whether or not they have effect equivalency is still questioned. We are not optimistic about the environment performance in the Pearl River Delta region and other such kind of export intensive economic. According to the estimation result in the paper, this region needs at least 30-40 years before its environment coming to virtuous circle. Currently, the government of this regions is planning to apply stringent specification and control to pollution. To this trade dependent economy, before structural change, these stringent rules are merely teeter-totter between environmental protection and economic growth.
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