Study on the dynamic relationship between environmental pollution control and tourism economic growth -- a case study of China

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Abstract. Environmental pollution control is closely related to the growth of tourism economy. Based on relevant data of China from 2000 to 2017, a vector error correction model was established to test the dynamic relationship between investment in environmental pollution control and tourism economic growth in China. The results show that there is a co-integration relationship between investment in environmental pollution control and tourism economic growth. Through impulse response and variance decomposition analysis, it is found that the fluctuation of tourism economic growth is mainly affected by investment in environmental pollution control. According to the result of causality test, investment in environmental pollution control is the gran cause of tourism economic growth. Therefore, in order to play a role of environmental pollution control investment in promoting the growth of tourism economy, on the one hand, we should attach importance to the improvement of laws and regulations related to tourism environmental protection, on the other hand, we should improve the investment mechanism of environmental protection, and finally, we should strengthen the supervision system of environmental protection and the construction of environmental protection agencies.

1. Research review
Since Genegrossman and Kruemeger proposed the environmental kuznets curve (EKC) hypothesis in 1995 [1], Lucas verified the "inverted u-shaped" curve relationship between SO2, BOD5, NO2, lead, CFCs, solid waste and economic development in 1996 [2]. Therefore, environmental pollution and tourism economic growth have attracted the attention of many scholars. Weng Gangming and Han Zhen (2012) [3], Cheng Ke (2014) [4] et al studied the relationship between tourism economic development and ecological environment based on environmental kuznets curve. Wang mingkang, liu yanping and li tao (2019) [5], Zhou Jiewen, Jiang Zhengyun and Zhao Yue (2019) [6] et al studied the impact of tourism industry agglomeration on environmental pollution. Liu Changsheng and Jian Yufeng (2010) [7] and Zhang Xinfang (2018) [8] studied the coordinated development of environmental protection and tourism economy with econometric methods. Zheng Shuwang and Bian Xiaohan (2016) [9] studied the collaborative development mechanism of tourism and environmental pollution control based on kenha model.

In conclusion, there are few studies on the dynamic relationship between environmental pollution control and tourism economic growth from the perspective of environmental pollution control. This study aims to study the impact of environmental pollution control investment on tourism economic growth in China, and provide reference for China to formulate relevant policies and implement investment.
2. Data collection and processing

2.1. Variable selection
The index used for the growth of tourism economy is China's total tourism income, including domestic tourism income and international tourism income. According to the exchange rate between 2000 and 2017, the us dollar and RMB are in units of 100 million yuan, expressed by INC. Environmental pollution control refers to the capital used to form fixed assets in the capital input of industrial pollution control and urban environmental infrastructure construction, which is the total amount of investment in environmental pollution control, the unit is 100 million yuan, expressed by INV.

2.2. Data processing
The data in this paper are from the World Bank, the National Bureau of Statistics of the People's Republic of China, China tourism statistics yearbook 2018, China environment statistics yearbook 2018, etc. In order to fit the regression model with the linear model, the above two series should be logarithmic, and the variables after treatment should be denoted as LNINC and LNINV respectively.

3. Empirical test

3.1. Stationarity test of sequence
Before analyzing the dynamic relationship of time series, the stationarity of the series should be analyzed by ADF unit root test first, so as to avoid possible "pseudo-regression". The results of unit root test are shown in table 1.

| Variable  | \((c,t,m)\) | ADF test value | 1% critical value | probability P value |
|-----------|-------------|----------------|-------------------|---------------------|
| LNINC     | \((c,t,0)\) | -2.861940      | -4.616209         | 0.1971              |
| LNINV     | \((c,t,0)\) | -0.216259      | -4.616209         | 0.9861              |
| D(LNINC)  | \((c,t,1)\) | -4.534952      | -4.667883         | 0.0075              |
| D(LNINV)  | \((c,t,1)\) | -5.311695      | -4.667883         | 0.0033              |

Note: \((c,t,m)\) indicates whether the unit root test equation contains a constant term, a trend term and a lag period Eviews8.0 is automatically determined by SIC criteria.

As can be seen from the results of unit root test in table 1, the original number is listed as a non-stationary series. The ADF value of the first-order difference sequence of the two variables is less than 1% critical value, and the probability P value is less than 0.01. There is no unit root in the first-order difference sequence, LNINC and LNINV are both I (1), satisfying the conditions for further co-integration analysis.

3.2. VAR model establishment and model stability test

3.2.1. Selection of optimal lag period. Considering the limitation of sample size, Johansen co-integration test is selected in this paper. Before the co-integration test, the VAR model should be estimated. Firstly, the lag period of the VAR model should be determined, and the lag period should be selected as period 1 according to the minimum criteria of AIC, SC and HQ, as shown in table 2.

| Lag | LogL   | LR    | FPE   | AIC   | SC    | HQ    |
|-----|--------|-------|-------|-------|-------|-------|
| 0   | -15.04946 | NA    | 0.03303 | 2.273261 | 2.367686 | 2.272256 |
| 1   | 26.13550 | 65.89594* | 0.000237* | -2.684734* | -2.401514* | -2.687751* |
| 2   | 29.82599 | 4.920645 | 0.000257 | -2.643465 | -2.171431 | -2.648493 |
| 3   | 31.83345 | 2.141298 | 0.000372 | -2.377794 | -1.716947 | -2.384833 |

* indicates lag order selected by the criterion.
3.2.2. **VAR (1) model estimation.** The estimated result of unconstrained VAR (1) model is.

\[
LNY_t = \begin{bmatrix} 0.81 & 0.21 \\ -0.07 & 1.00 \end{bmatrix} LNY_{t-1} + C
\]

Among them: \( C = \begin{bmatrix} 0.19 \\ 0.85 \end{bmatrix} \), \( LNY = \begin{bmatrix} LNINC \\ LNINV \end{bmatrix} \)

As can be seen from the matrix form of the estimation results of the above VAR (1) model, the influence coefficient of LNINV (\(-1\)) on LNGDP is 0.210854, respectively. Investment in environmental pollution control plays a certain role in promoting the growth of tourism economy. From the perspective of lag effect, the investment of environmental pollution control has a lag effect on tourism economic growth. According to the overall test results of VAR (1) model, the overall fitting effect is good.

3.2.3. **VAR (1) model stability test.** Although the goodness of fit of VAR (1) model is high, its stability still needs to be further verified. In this paper, AR characteristic root chart was used to analyze and test the stability of VAR (1) model, and relevant results were shown in table 3 and figure 1 respectively.

### Table 3 results of VAR (1) model stability

| Root                      | Modulus  |
|---------------------------|----------|
| 0.948824 - 0.133927i      | 0.958229 |
| 0.948824 + 0.133927i      | 0.958229 |
| -0.421867 - 0.203080i     | 0.468202 |
| -0.421867 + 0.203080i     | 0.468202 |

In table 3, the established VAR models of LNINC and LNINV, two variables with a lag of 1 period, have 4 characteristic roots. The reciprocal modulus of all unit roots is less than 1, indicating that the established VAR (1) model is stable.

![Inverse Roots of AR Characteristic Polynomial](image)

**Figure 1 AR test results**

In the coordinate system of figure 1, the points in the unit circle represent the reciprocal modulus of AR characteristic root, and the corresponding points of the reciprocal modulus of each characteristic root fall within the unit circle. It can be further confirmed that the established VAR (1) model is a stable VAR model.

3.3. **Johansen co-integration test**

Although LNINC and LNINV are non-stationary, the variables formed by the linear combination of these two non-stationary time series may have a long-term stable relationship. On the basis of the VAR (1) model, trace statistics and maximum characteristic root statistics were used to test the co-integration
relationship between LNINC and LNINV. The test model was set as the period with a linear
deterministic trend lag, and the co-integration test results were shown in table 4.

Table 4 trace test and maximum characteristic root test results

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---------------------------|------------|-----------------|---------------------|---------|
| None *                    | 0.459652   | 16.83287        | 15.49471            | 0.0313  |
| At most 1 *               | 0.353713   | 6.984184        | 3.841466            | 0.0082  |

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

As can be seen from table 4, there are two co-integration relationships at the 5% significance level. Therefore, there is a long-term co-integration relationship between LNINC and LNINV.

3.4. VECM estimation and test
Vector error correction model (VECM) was established based on the VAR (1) model to further analyze the long-term equilibrium and short-term fluctuation relationship between investment in environmental pollution control and tourism economic growth in China. The form of VECM matrix is

$$D(LNY) = \begin{bmatrix} -0.20 & -0.24 \\ 0.12 & -0.51 \end{bmatrix} D(LNY_{t-1}) + \begin{bmatrix} -0.16 \\ -0.33 \end{bmatrix} vecm + \begin{bmatrix} 0.21 \\ 0.19 \end{bmatrix}$$

Among them, $LNY = \begin{bmatrix} LNINC \\ LNINV \end{bmatrix}$, $vecm = [1.00 \ -0.77] \times LNY - 3.13$

According to the overall VECM test results, the overall interpretation ability of the model is strong. The corresponding equations of VECM matrix form are as follows:

Equation 1:
$$D(LNINC) = -0.16vecm - 0.20D[LNINC(-1)] - 0.24D[LNINV(-1)] + 0.21$$

Equation 2:
$$D(LNINV) = -0.33vecm + 0.12D[LNINC(-1)] - 0.51D[LNINV(-1)] + 0.19$$

The error correction coefficient of equation 1 is negative, which means that the unbalanced error of the last period will make a great negative correction to the tourism economic growth of this period with the adjustment strength of 15.64%, so that the total tourism income will return from the short-term unbalanced state to the long-term equilibrium state. The error correction coefficient of equation 2 is negative, which indicates that the unbalanced error of the last period can be corrected in the opposite direction, but the tourism revenue of this period is close to the long-term equilibrium state.

3.5. Impulse response analysis and variance decomposition

3.5.1. Impulse response analysis. In order to further analyze the dynamic relationship between LNINC and LNINV, one standard deviation impact was given to LNINC and LNINV respectively, and then the impulse response function graph of these two variables was obtained, as shown in figure 2 and figure 3.
Figure 2 and figure 3 show that LNINC gradually and slowly declines after being impacted by itself. LNINC's response to the impact of LNINV is not particularly obvious. Investment in environmental pollution control has a certain lag effect on tourism economic growth, which may be closely related to its lag.

3.5.2. Variance decomposition. According to the variance decomposition results of LNINV (table 5), the total tourism revenue INC, affected by its own fluctuations, showed an overall upward trend, from 6.87% in the first phase to about 16.82% in the 10th phase. The influence of environmental pollution treatment investment on the fluctuation of tourism revenue decreased from 93.13% in the first phase to 83.18% in the 10th phase.

| Period | S.E.  | LNINC       | LNINV       |
|--------|-------|-------------|-------------|
| 1      | 0.097850 | 6.871789 | 93.12821 |
| 2      | 0.124415 | 8.384398 | 91.61560 |
| 3      | 0.141916 | 9.811066 | 90.18893 |
| 4      | 0.158108 | 11.13233 | 88.86767 |
| 5      | 0.175468 | 12.34193 | 87.65807 |
| 6      | 0.194340 | 13.44044 | 86.55956 |
| 7      | 0.214204 | 14.43176 | 85.56824 |
| 8      | 0.234316 | 15.32132 | 84.67868 |
| 9      | 0.253998 | 16.11515 | 83.88485 |
| 10     | 0.272727 | 16.81943 | 83.18057 |
3.6. Granger causality test
According to the Granger causality test results (table 6), LNINV is the Granger cause of LNINC at the 10% significance level in the first lag period, indicating that the investment in environmental pollution control plays a positive role in the total income of tourism to a certain extent. LNINC was not the granger cause of LNINV at 10% significance level in the lag period 1.

| Table 6 Granger causality test |
|-------------------------------|
| **VAR Granger Causality/Block Exogeneity Wald Tests** |
| Dependent variable: LNINC |
| Excluded | Chi-sq | df | Prob. |
| LNINV | 4.600969 | 1 | 0.0320 |
| All | 4.600969 | 1 | 0.0320 |
| Dependent variable: LNINV |
| Excluded | Chi-sq | df | Prob. |
| LNINC | 0.313370 | 1 | 0.5756 |
| All | 0.313370 | 1 | 0.5756 |

4. Conclusions and recommendations

4.1. The conclusion
The conclusion is as follows: based on VAR and VECM, it can be seen that there is a long-term equilibrium relationship between environmental pollution control and tourism economic growth in China, and there is a significant lag effect between environmental pollution control and tourism economic growth promotion. The results of impulse response analysis showed that LNINC had a gradual and slow decline trend after being impacted by itself, and LNINC’s response to LNINV impact was not particularly obvious, which might be closely related to its hysteresis. Through variance decomposition, it is found that the fluctuation of tourism economic growth is mainly affected by investment in environmental pollution control, followed by its own influence. According to the Granger causality test results, LNINV is the Granger cause of LNINC at the 10% significance level in the 1st lag period, which indicates that the investment in environmental pollution control plays a positive role in the total income of tourism to a certain extent.

4.2. Suggest
In order to realize the sustainable development of China's tourism industry, from the perspective of investment in environmental pollution control, first of all, we should continue to strengthen and improve the laws and regulations on environmental protection in tourism areas, and the government and relevant departments should formulate and improve relevant measures to improve the environmental quality of tourist cities and increase the investment in environmental pollution control. Secondly, the construction of environmental protection infrastructure in various regions should be strengthened, the investment mechanism of environmental protection should be improved, the investment in environmental pollution control should be increased, the publicity of environmental pollution control should be strengthened, and tourists' awareness of environmental protection should be enhanced. Finally, it is necessary to strengthen the supervision system of environmental protection and the construction of environmental protection agencies, improve the management system of local environmental protection, and implement effective supervision and management of tourism environmental protection.

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