Research on the relationship between environmental contamination level and economic development standard—Based on the perspective of law and economics

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Abstract. Carbon emissions and fossil fuel are two causes of environmental pollution. Based on China’s carbon emissions according to the Ministry of Ecology and Environment of the People’s Republic of China from 1990 to 2014 and GDP data analysis using multiple linear regression methods in economics. Excessive emissions of carbon can be an obstacle to impede the economic development. Therefore, the countries should protect the environment to sustain long-term economic growth.

1. Introduction
With the improvement of the level of productivity development, the means to achieve rapid economic growth through the high consumption and high pollution generating mode and the concept of post-pollution treatment have become unsuitable for the present and future development requirements. Seeking a path to sustainable development cannot be delayed.

Environmental pollution is caused by many factors, which can cause great damage to the atmosphere, land and water resources. In the "Belt and Road" economic belt, due to the construction of railway routes and new factories, it brings about even more pollution and destruction [1]. The following will introduce two specific factors that cause environmental pollution.

Carbon emissions, or greenhouse gas emissions, have received much public attention in recent years. The so-called carbon emissions, mainly refers to the carbonaceous material pollution caused by the atmosphere, its main component is carbon dioxide. In addition, there are other hydrocarbons such as natural gas, methane ethane and so on [2]. Exhaust fumes from factories, exhaust fuels from aircraft, trains and ships, and pesticides and fertilizers for agricultural irrigation are the major sources of carbon emissions in the Belt and Road economic zone [3]. In the Vision and Action for Promoting the Building of the Silk Road Economic Belt and the 21st Century Maritime Silk Road issued by the National Development and Reform Commission, the Ministry of Foreign Affairs and the Ministry of Commerce in 2015, we specifically mentioned how to reduce carbon emissions in the countries along the Belt and Road problem. This shows that the pollution caused by carbon emissions has great influence on the construction and development of the economic belt.

Fossil fuel is also one of the causes of pollution. It is a mixture of hydrocarbons or hydrocarbon derivatives consisting of the substances mentioned above that cause carbon emissions and some toxic substances such as sulfides. Because fossil fuels are a world class energy source, the damage it causes is worldwide. The first destruction of land during the exploitation of fuels resulted in a global warming
of the dioxide released during combustion and the subsequent discharge into the oceanic rivers after combustion, resulting in increased pollution. Its impact on environmental pollution is even worse than carbon emissions [4].

2. Methods and analysis
Environmental problems do have some impact on economic development, but the extent of their impact is hard to measure. In order to understand the economic impact of the above factors, the following will be China's 35-year carbon emissions and gross domestic product (GDP) and nearly 25 years of fossil fuel use as the data and using multiple linear regression to measure Impact of Environmental Pollution on China's Economic Development [5,6].

First introduce the current very popular carbon emissions as a variable as an explanatory variable, the model is set to:

\[ Y_t = \beta_1 + \beta_2 X_t + u_t \]

Where, \( X_t \) is gross domestic product (GDP); \( Y_t \) is carbon emissions; \( u_t \) is a random error term.

### Table 1. China's carbon emissions and GDP data (1980–2014).

| years | Carbon emissions \( Y_t \) (million tons) | GDP \( X_t \) (100 million) |
|-------|-------------------------------------------|-----------------------------|
| 1980  | 1440.0                                    | 4545.6                      |
| 1981  | 1424.8                                    | 4889.5                      |
| 1982  | 1483.5                                    | 5330.5                      |
| 1983  | 1559.8                                    | 5958.6                      |
| 1984  | 1689.8                                    | 7243.8                      |
| 1985  | 1746.5                                    | 9040.7                      |
| 1986  | 1852.3                                    | 10274.4                     |
| 1987  | 1992.8                                    | 12050.6                     |
| 1988  | 2142.9                                    | 15036.8                     |
| 1989  | 2223.6                                    | 17000.9                     |
| 1990  | 2277.7                                    | 18718.3                     |
| 1991  | 2389.4                                    | 21826.2                     |
| 1992  | 2502.2                                    | 26937.3                     |
| 1993  | 2703.5                                    | 35260.0                     |
| 1994  | 2811.0                                    | 48108.5                     |
| 1995  | 3057.6                                    | 59810.5                     |
| 1996  | 3125.4                                    | 70142.5                     |
| 1997  | 3095.1                                    | 78060.9                     |
| 1998  | 3180.1                                    | 83024.3                     |
| 1999  | 3084.3                                    | 88479.2                     |
| 2000  | 3350.3                                    | 98000.5                     |
| 2001  | 3437.4                                    | 108068.2                    |
| 2002  | 3654.4                                    | 119095.7                    |
| 2003  | 4219.1                                    | 134977.0                    |
| 2004  | 4878.1                                    | 159453.6                    |
| 2005  | 5444.3                                    | 183617.4                    |
| 2006  | 5955.7                                    | 215904.4                    |
| 2007  | 6360.4                                    | 266422.0                    |
| 2008  | 6532.7                                    | 316030.2                    |
| 2009  | 6839.1                                    | 340320.0                    |
| 2010  | 7294.9                                    | 399769.5                    |
| 2011  | 8000.4                                    | 468562.4                    |
| 2012  | 8250.8                                    | 518214.7                    |
| 2013  | 8872.5                                    | 588018.8                    |
| 2014  | 8880.0                                    | 635910.0                    |
Based on the data in Table 1, using the general least-squares method to estimate the model yields the following data and regression equation (1):

\[ Y_t = 2073.788 + 0.0126X_t \]

\[ t = (17.9452)(25.2576) \]

\[ R^2 = 0.9508 \quad F = 637.9551 \quad DW = 0.1569 \]

\[ (1) \]

The regression equation (1) higher coefficient of determination, the regression coefficients were significant. For the model with 35 samples and only one explanatory variable, a significant level of 5% is obtained. Table 2 shows that dL = 1.402 and dU = 1.519, and DW < dL in the model. Obviously there is autocorrelation in this model [7].

In order to solve the problem of carbon emissions - the autocorrelation in the GDP model, we use the generalized difference method. The residual sequence et is obtained from the regression of \( Y_t = 2073.788 + 0.0126X_t \). Let the autocorrelation coefficient be \( \rho \), the lag of et autoregressive regression is available regression equation (2):

\[ e_t = 0.9698e_{t-1} \quad \rho = 0.9698 \]

\[ (2) \]

Generalized differential regression on regression equation (1), where vt is a new random error term, yields:

\[ Y_{t-1} - 0.9698Y_{t-1} = \beta_1(1-0.9698) + \beta_2(X_{t-1} - 0.9698X_{t-1}) + v_t \]

Get the following generalized differential regression output and regression equation (3), see Table 3.

Table 2. Carbon emissions-GDP regression equation (1).

| Variable          | Coefficient | Std. Error | t-Statistic | Prob. |
|-------------------|-------------|------------|-------------|-------|
| C                 | 2073.788    | 115.5622   | 17.94521    | 0.0000|
| X                 | 0.012595    | 0.000499   | 25.25777    | 0.0000|
| R-squared         | 0.950816    | Mean dependent var | 3935.783 |
| Adjusted R-squared| 0.949326    | S.D. dependent var | 2338.862 |
| S.E. of regression| 526.4988    | Akaike info criterion | 15.42582 |
| Sum squared resid | 9147633.    | Schwarz criterion | 15.51470 |
| Log likelihood    | -267.9519   | Hannan-Quinn criter | 15.45650 |
| F-statistic       | 637.9551    | Durbin-Watson stat | 0.156927 |
| Prob(F-statistic) | 0.000000    |             |             |       |

Table 3. Generalized differential regression equation.

| Variable          | Coefficient | Std. Error | t-Statistic | Prob. |
|-------------------|-------------|------------|-------------|-------|
| C                 | 159.9251    | 37.92967   | 4.216359    | 0.0002|
| X-0.9698*X(-1)    | 0.007671    | 0.001110   | 6.910124    | 0.0000|
| R-squared         | 0.598745    | Mean dependent var | 333.2925 |
| Adjusted R-squared| 0.586206    | S.D. dependent var | 257.8559 |
| S.E. of regression| 165.8705    | Akaike info criterion | 13.11731 |
| Sum squared resid | 880416.9    | Schwarz criterion | 13.20710 |
| Log likelihood    | -220.9943   | Hannan-Quinn criter | 13.14793 |
| F-statistic       | 47.74981    | Durbin-Watson stat | 1.149087 |
| Prob(F-statistic) | 0.000000    |             |             |       |
Yt = 159.9251 + 0.0077Xt

Se = (37.9297) (0.0011)
t = (4.2163) (6.9101)

R^2 = 0.5987  F = 47.7498  DW = 1.1491

When the sample size becomes 34, at a significant level of 5%, dL = 1.393, dU = 1.514 and DW is still less than dL, indicating autocorrelation still exists. This shows that no matter what circumstances, the interference of other environmental pollution factors always exist. Therefore, from the carbon-emission-GDP generalized difference model, we know that for every unit GDP increase, it will increase 0.0077 million tons of carbon emissions, that is, there is a positive correlation between GDP and carbon emissions.

In order to be able to influence the impact of total environmental pollution factors on gross domestic product (GDP), we introduce another explanatory variable below: chemical fuel use. Create a new model:

Yt = β1 + β2 X2 + β3 X3

Where, Y is the gross domestic product (100 million); X2 is the carbon emissions (million tons); X3 is the fossil fuel consumption (10,000 tons of standard coal). X2, X3 as explanatory variables, Y as explained variables [8,9], see Table 4.

Table 4. China’s carbon emissions, fossil fuel use and GDP data (1990~2014).

| years | Carbon emissions X2 (million tons) | Fossil fuels X3 (Tons) | GDP Y (100 million) |
|-------|-----------------------------------|------------------------|---------------------|
| 1990  | 2277.7                            | 103922.0               | 18718.3             |
| 1991  | 2389.4                            | 104844.0               | 21826.2             |
| 1992  | 2502.2                            | 107256.0               | 26937.3             |
| 1993  | 2703.5                            | 111059.0               | 35260.0             |
| 1994  | 2811.0                            | 118729.0               | 48108.5             |
| 1995  | 3057.6                            | 129034.0               | 59810.5             |
| 1996  | 3125.4                            | 133032.0               | 70142.5             |
| 1997  | 3095.1                            | 133460.0               | 78060.9             |
| 1998  | 3180.1                            | 129834.0               | 83024.3             |
| 1999  | 3084.3                            | 131935.0               | 88479.2             |
| 2000  | 3350.3                            | 138570.0               | 98000.5             |
| 2001  | 3437.4                            | 147425.0               | 108068.2            |
| 2002  | 3654.4                            | 156277.0               | 119095.7            |
| 2003  | 4219.1                            | 178299.0               | 134977.0            |
| 2004  | 4878.1                            | 206108.0               | 159453.6            |
| 2005  | 5444.3                            | 229037.0               | 183617.4            |
| 2006  | 5955.7                            | 244763.0               | 215904.4            |
| 2007  | 6360.4                            | 264173.0               | 266422.0            |
| 2008  | 6532.7                            | 277419.0               | 316030.2            |
| 2009  | 6839.1                            | 286092.0               | 340320.0            |
| 2010  | 7294.9                            | 312125.0               | 399769.5            |
| 2011  | 8000.4                            | 340178.0               | 468562.4            |
| 2012  | 8250.8                            | 351041.0               | 518214.7            |
| 2013  | 8872.5                            | 358784.0               | 588018.8            |
| 2014  | 8880.0                            | 360000.0               | 635910.0            |

Source: National Bureau of Statistics of the People’s Republic of China.
http://www.stats.gov.cn/tjsj/ndsj/2015/indexch.htm

Multiple linear regression on the above data yields the following regression equation:
Table 5. Multiple linear regression equation.

| Variable     | Coefficient | Std. Error | t-Statistic | Prob.  |
|--------------|-------------|------------|-------------|--------|
| C            | -184422.6   | 21280.06   | -8.666451   | 0.0000 |
| X2           | 156.3668    | 72.08286   | 2.169265    | 0.0411 |
| X3           | -1.801052   | 1.756091   | -1.025603   | 0.3162 |
| R-squared    | 0.958484    | Mean dependent var | 203309.3 |
| Adjusted R-squared | 0.954710 | S.D. dependent var | 187664.5 |
| S.E. of regression | 39937.86 | Akaike info criterion | 24.14020 |
| Sum squared resid | 3.51E+10 | Schwarz criterion | 24.28647 |
| Log likelihood | -298.7525 | Hannan-Quinn criter. | 24.18077 |
| F-statistic  | 253.9572    | Durbin-Watson stat | 0.359144 |
| Prob(F-statistic) | 0.000000 |                      |        |

\[
Y = -184422.6 + 156.3668X_2 - 1.8011X_3
\]

\[
\text{Se} = (21280.06) \quad (72.0829) \quad (1.7561)
\]

\[
t = (-8.6665) \quad (2.1693) \quad (-1.0256)
\]

\[
R^2 = 0.9585 \quad R_1^2 = 0.9547 \quad F = 253.9572 \quad n = 25
\]

Statistical test:
- Goodness of fit: As can be seen from table 5, \( R^2 = 0.9585 \), the correction coefficient is equal to 0.9547, indicating that the model fitting well to the sample.
- 2.F test: Suppose \( H_0: \beta_2 = \beta_3 = 0 \). At a significant level of \( \alpha = 0.05 \), a degree of freedom \( F(0.05, (2,22)) = 3.05 \) was found from the F distribution table. As can be seen from table 5 \( F = 253.9572 > F(0.05, (2,22)) = 3.05 \). The null hypothesis \( H_0: \beta_2 = \beta_3 = 0 \) should be rejected, indicating that the regression equation is significant. That is, carbon emissions and fossil fuel consumption do have a significant impact on China's GDP [10].
- 3.t test: respectively for the \( H_0: \beta_j = 0 \) \((j = 1,2,3)\), given a significant level of \( \alpha = 0.05 \), check t distribution table for the degree of freedom of 22 critical value \( t_{0.025}(22) = 2.074 \). As can be seen from table 6, the t statistic corresponding to \( \beta_2 \) is 2.1693, which is greater than \( t_{0.025}(22) = 2.074 \), rejecting the null hypothesis \( H_0: \beta_j = 0 \) \((j = 1,2,3)\). This shows that in the case of constant use of fossil fuels, the explanatory variable carbon emissions \( X2 \) have a significant impact on China's GDP. At the same time \( \beta_3 \) corresponding t statistic is -1.0256 less than \( t_{0.025}(22) = 2.074 \), that accept the null hypothesis. That is, fossil fuels have no significant effect on GDP.

The final result of this model is that GNP will increase by 156.3668 billion yuan for every one million tons of carbon emissions assuming that other variables will not change; for every 10,000 tons of fossil fuels, GNP will Reduce 1.8011 billion [11].

3. Conclusion
Based on the above data analysis, it shows that fossil fuels must have a great negative impact on economic development. In the short term, carbon emissions can boost GDP growth. However, in the long run, excessive emissions of carbon substances will certainly hinder the economic development [12]. It is just this long-term development that has been seen in various countries. Therefore, many environmental laws and international mechanisms have been promulgated, including the birth of Transactions of Carbon Emissions Rights and Interim Measures for the Management of Transactions of Carbon Emissions Rights in China.

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