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Empirical Analysis on China's Environmental Investment and Economic Growth

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Abstract

Granger causality test is used in this paper to test the causality relationship between economy growth and environmental investment in China; cointegration test is used to investigate the long-term stable equilibrium relationship of Chinese GDP and environmental investment; vector error model is used to test effect short-term fluctuation of environmental investment has on GDP. According to the empirical result, environmental investment would promote economic growth in China in both short and long term. This paper explains the internal relations of environmental investment and GDP, finally puts forward some advice for the construction of environmental protection in China.

Key words: Environmental investment; Environmental protection investment; Cointegration test; Granger causality test; Vector error correction model

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INTRODUCTION

In the past few decades the world has experienced rapid economic growth, using ecological resources unrestrainedly, promoting economic progress at the expense of the environment, thus causes serious environmental problems. Frequent environmental devastating disaster makes people more and more aware of the importance of protecting the environment, such as photochemical smog in Los Angeles, smoke in London, minamata disease in kumamoto and fog in China. Economic development or environmental protection may be the one of the hardest problems for most countries these days. Some argue that there's only one can be chosen in economic growth and environmental protection, the development of economy brings environmental pollution, and environmental protection must be carried at the cost of development speed. What's the relationship between environmental protection and economic growth? How can the Chinese government make policy decision?

W· Leontief (1970) is the first economist studies the relation between economic growth and environmental protection based on the macroscopic quantitative analysis. He thinks that cost of pollution control should be included product cost, coupled with raw material and labor consumption as the full cost, and analyzes the role environmental policy plays on economy and the relationship between economic development and environment control (Nordhaus & Tobin, 1972). Grossman (1995) puts forward the view that along with the increase of per capita income, environmental quality would get worse at first and then get better, and in turn promotes economic growth, through the study of the north American free trade area. Lopez (1994) adds the feedback mechanism of pollutants on long-term economic growth and the depletion of natural resources into economic growth model, points out that the strict environmental policies or environmental awareness improvement will increase the pollution control investment, thus has blocking effects on capital accumulation, and hinder economic growth.

There're abundant achievements in domestic researches. In order to investigate the effects of environmental investment on economic growth, Sun (2002) establishes preferred growth model for environmental investment. Yin (2005), Yang (2009) and Puo (2010), make further study on Sun's model, but the results show that the model does not suit to Chinese actual situation. Ma (2002), Li (2006), Wang (2008), and Su (2009) add environmental elements into a variety of economic growth model, theoretically explain the influence of the environmental investment on economic growth, the results show that the environmental protection investment does promote economic growth. Zhou (2011) makes empirical test by the data of east, mid and west China, proves the long-term equilibrium relationship between economic growth and environmental investment does exist in three major regions, there are also regional differences. Ye (2011) uses panel data from 31 provinces in 2003-2008, the results differ in provinces, whether environmental investment would promote the economic growth is not sure. According to the above studies at home and abroad, there is a big controversy about the relationship between the environmental investment and economic growth, which needs further study.

1. THEORY AND STATUS QUO ANALYSIS

1.1 The Interaction Analysis Between the Environmental Investment and Economic Growth

Environmental investment is originally part of the economic construction, the blind increase of environmental investment in the short term may reduce the accumulation of productive investment and weaken the productive investment, which will increase the production cost, reduce social demand, making negative effect on economic growth. As a special kind of investment, environmental investment does promote economic growth with effects of both supply and demand.

In the side of supply effect, the increase of the environmental investment promotes the development of environmental protection industry, which has an active impact on economic growth. The development of environmental protection industry gradually changes the mechanism of economic growth, improve the quality of economic growth, such as effective use of environmental resources and the improvement of the living environment for residents.

In the side of demand effect, the environmental investment has industry relevance, playing a leading role for other industries and making a multiplier effect. Environmental investment would improve the urban infrastructure construction, promote technological progress, stimulate employment, drive economic growth directly and indirectly. On the other hand, the use of environmental investment would guide utilizing of other fund, gradually optimize the industrial structure, achieve the optimal allocation of environmental resources and industry upgrading, so as to promote economic growth.

Economic development and environmental protection are complementary to each other. The environmental issues arise from economic growth stage, at the same time, economic growth provides a solid capital source for environmental investment, providing powerful guarantee for the environmental protection. With the rapid development of economy, people's living standard has been improved, so as the consciousness of environmental protection, making it urgent to improve the environmental quality and to enhance the life quality. Recently, environmental protection investment has increased significantly in China, the proportion of GDP has risen year by year, which has always been more than 1% in recent years. This paper speculates that China's rapid economic development has a certain role in promoting environmental investment.

1.2 The Status Quo of Environmental Investment in China

Environmental investment is of important significance to promote coordinated development of economic growth and environmental governance. Along with the rapid development of economy, resources, energy consumption and pollutant discharge synchronization is also increasing, the environmental protection is facing huge pressure. Therefore, the Chinese government has made certain achievements in environmental governance by flexible financial means: keeping the economy growing at the same time also gradually increasing environmental investment. During the period of "ninth Five-year Guideline",environmental protection investment is RMB 344.752 billion yuan, accounting for 0.87% of GDP; and during the "tenth Five-year Guideline" period the amount of environmental protection investment is 839.94 billion yuan, accounting for about 1.18% of GDP; finally during the last Five-year Guideline period, the total environmental protection turns out to be 2.376091 trillion yuan, accounting for about 1.54% of GDP. From the above data, it's clear that China's environmental protection investment is rising so as to improve the environmental situation. The protection investment situation in China since 2000 is as follows:

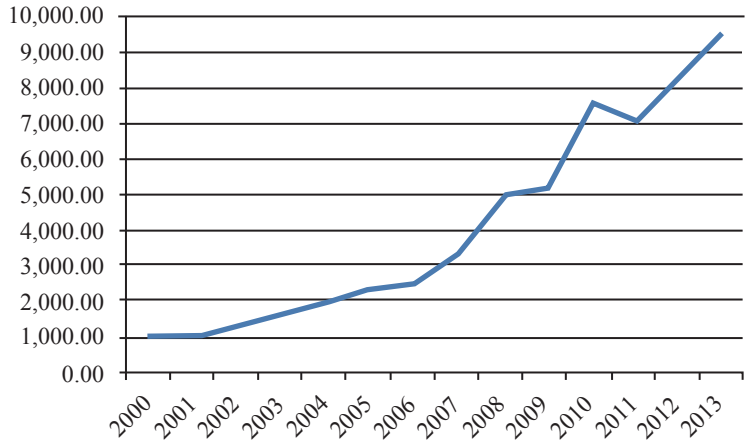

Figure 1
Environmental Investment Situation in China Since 2000

Based on the above figure, it's obvious that environmental investment in China is getting more and higher since 2000. 2006-2008 and 2011-2013, respectively, are two rapid growth period, apparent decline only shows in 2011. Under the pressure of environmental problems like fog haze, at present, there's a stronger voice for environmental protection in China. Without doubt, there would be increased investment in believe in environmental protection in the following years.

2. THE EMPIRICAL ANALYSIS AND INSPECTION

2.1 Variable Selection

Sample used in this paper is 2000-2013 annual data taken from the China statistical yearbook and Chinese environmental statistics yearbook. By summing up preliminary academic research and results, as well as availability of indicators, environmental pollution control investment is selected to reflect the status of China's environmental protection investment, and GDP is selected to reflect the situation of economic growth in China.

In order to eliminate the variance influence in the time series of environmental protection investment and GDP increment, this paper makes logarithm transformation on the time series of these two variables. Logarithm transformation would not affect the configuration relationship between the two variables, which help linearization and also model establishment. Data transformed is recorded for lnEI and lnGDP, all the data used in this paper is shown in Table 1:

Table 1
Original and Logarithmic Data (Unit: billion yuan)

	GDP	EI	lnGDP	lnEI
2000	99,214.55	1,014.90	11.505044	6.9225454
2001	109,655.17	1,106.70	11.605096	7.0091379
2002	120,332.69	1,367.20	11.698016	7.2205201
2003	135,822.76	1,627.70	11.819106	7.3949233
2004	159,878.34	1,909.80	11.982168	7.5547538
2005	184,937.37	2,388.00	12.127773	7.7782115
2006	216,314.43	2,566.00	12.284488	7.8501035
2007	265,810.31	3,387.30	12.490538	8.1277884
2008	314,045.43	4,937.03	12.657293	8.5045192
2009	340,902.81	5,258.39	12.739353	8.5675802
2010	401,512.80	7,612.19	12.902995	8.9375062
2011	473,104.05	7,114.03	13.067071	8.8698242
2012	519,470.10	8,253.46	13.160565	9.0183878
2013	568,845.21	9,516.50	13.251364	9.1607824

2.2 Unit Root Test

Non-stationary data of time series often shows common trend, direct data regression is of little significance despite the higher of determination coefficient R^2. To avoid such spurious regression, unit root test is made so as to find out whether the data is stationary; the result is shown as follows.

Table 2
ADF Test and Its Result

Time series	*T*	Critical value	Conclusion
lnEI	-0.776626	-3.144920	Non-stationary
lnGDP	-0.108698	-3.119910	Non-stationary
dlnEI	-0.619551	-1.982344	Non-stationary
dlnGDP	-1.278458	-4.008157	Non-stationary
ddlnEI	-4.370440	-3.212696	Stationary
ddlnGDP	-4.885407	-3.212696	Stationary

Note. The significant level is 5%

Under the 5% significant level, lnEI, lnGDP and their first-order difference sequence dlnEI, dlnGDP have unit root and the sequence is not smooth. While their second-order difference sequence ddlnEI and ddlnGDP don't have unit root, turning out to be stationary series. Thus time sequence of lnEI, lnGDP is second-order single integer sequence, the linear combination is of smooth, and there's a cointegration relationship these two time series.

2.3 Granger Causality Test

It's considered that the environmental protection investment and economic growth promote each other, would such judgment be suitable for China? Granger causality test is made upon the above variables; that is to find out which variable is the cause of another variable. The result shows as bellows.

Table 3
Granger Causality Test and Its Result

H_0	*F*	*P*	Result
lnEI is not the granger cause of lnGDP	6.36490	0.0035	Refuse
lnGDP is not the granger cause of lnEI	1.30990	0.3287	Accept

According to the table above, for the first original hypothesis "lnEI is not the granger cause of lnGDP", *F* statistics is 6.36490, the probability is 0.0035, which is less than 5%, therefore the hypothesis is refused, so environmental protection investment is the cause of economic growth. For the second hypothesis "lnGDP is not the granger cause of lnEI", *F* statistics is 1.30990, the corresponding probability is 0.3287, which is far more than 10%, hypothesis accepted, then economic growth is not the cause of environmental protection investment increase. As a result, unidirectional causality is found between the time sequence EI and GDP, which is from EI to GDP.

2.4 Cointegration Test

Time sequence of lnEI, lnGDP is both second-order single integer sequence, cointegration test is made to keep the time sequence stationary, and the following function is made.

$$\ln \mathrm{GDP}_t = \alpha_0 + \alpha_1 \ln \mathrm{EI}_t + \mu.$$

Based on the EG inspection, firstly the function $\ln \mathrm{GDP}_t = \alpha_0 + \alpha_1 \ln \mathrm{EI}_t + \mu$ is estimated, then calculating the unbalanced error, the following function can be get:

$$\ln \hat{\mathrm{GDP}}_t = \hat{\alpha}_0 + \hat{\alpha}_1 \ln \mathrm{EI}_t \ ,$$

$$e_t = \ln \hat{\mathrm{GDP}} - \ln \mathrm{GDP}_t \ .$$

The result of initial regression shows as follows:

Table 4
Initial Regression and Its Result

Variable	Coefficient	Std. error	*t*-statistic	Prob.
C	6.198168	0.812175	34.02311	0.0000
LNEI	0.766198	0.022489	34.06955	0.0000
R-squared	0.989768	Mean dependent var		12.37792
Adjusted *R*-squared	0.988915	S.D. dependent var		0.601861
S.E. of regression	0.063368	Akaike info criterion		-2.548161
Sum squared resid	0.048186	Schwarz criterion		-2.456867
Log likelihood	19.83713	Hannan-Quinn criter		-2.556612
F-statistic	1160.734	Durbin-Watson stst		2.001892
Prob(*F*-statistic)	0.00000			

According to the table above, the function turns out to be lnGDP=6.198168+0.766198lnEI.

The model fitting of lnGDP and lnEI is very good: The value of determination coefficient R^2 is 0.989768, almost equal to 1; and the *T* statistic and *P* values of *F* statistic of the two variable is less than 0.0001, test passed.

Unit root test is made upon $\hat{e}_t$ to test whether it's stationary. If time series of $\hat{e}_t$ is stationary, it's considered sequence of lnGDP and lnEI is (1,1) co-integration; if first-order of $\hat{e}_t$ is stationary, it's considered sequence of lnGDP and lnEI is (2,1) co-integration. The unit root test of $\hat{e}_t$ shows as follows.

Table 5
Unit Root Test of Residual Sequence

T	1% significant level	5% significant level	10% significant level	*P*	Result
-3.292527	-4.200056	-3.175352	-2.728985	0.0416	Stationary

The above table shows, the *T* value is less than 5%, thus the residual error sequence doesn't have unit root, the sequence is Stationary. Based on the definition of cointegration relationship, it's considered that there is a cointegration relationship between lnGDP and lnEI, therefore there's stable relationship of the previous period between China's GDP and the environmental protection investment EI, and presents the change of same direction.

2.5 Error Correction Model

Error Correction Model (shorthand for ECM) is a specific form of econometric Model, which can be estimated by the classical regression method. On the basis of the empirical result of the residual error item, sequence of lnGDP and lnEI is considered as (1,1) co-integration. Based on the first-order autoregressive distribution, model is as follows:

$$\ln GDP_t=\beta_0+\beta_1 \ln EI_t+\beta_2 \ln EI_{t-1}+\mu \ln GDP_{t-1}+ecm_t .$$

After the final regression, the result is as follows:

Table 6
Final Regression and Its Result

Variable	Coefficient	Std. error	*t*-statistic	Prob.
C	-0.004442	0.012422	-0.357569	0.7329
D(LNEI)	0.457157	0.125756	2.840080	0.0296
D(LNEI(-1))	-0.129573	0.270157	-0.479623	0.6485
D(LNGDP(-1))	0.135073	0.088958	1.518211	0.1798
EMC(-1)	-0.844729	0.313520	-2.694333	0.0358
R-squared	0.612776	Mean dependent var		-0.000193
Adjusted *R*-squared	0.354627	S.D. dependent var		0.050773
S.E. of regression	0.040789	Akaike info criterion		-3.257865
Sum squared resid	0.009982	Schwarz criterion		-3.077005
Log likelihood	22.91826	Hannan-Quinn criter		-3.371874
F-statistic	2.373728	Durbin-Watson stst		2.158182
Prob (*F*-statistic)	0.164797			

The error correction model of environmental pollution control investment EI and GDP is built as follows.

$$\Delta \ln GDP_t=-0.0044+0.357\,\Delta \ln EI_t+0.1351\,\Delta \ln EI_{t-1}$$
$$-0.1296\mu\,\Delta \ln GDP_{t-1}-0.84427ecm_{t-1} .$$

According to the table above, the model test has been passed, and the error correction term reflects the long-term equilibrium effect of two variables on short-term investment in environmental protection. Error correction coefficient is 0.84427, which indicates two variables have dynamic mechanism of self-correcting from short-term changes in the long-term equilibrium. GDP and environmental protection investment EI in China have stable relations with convergence trend. If previous GDP deviates from the long-term equilibrium relationship ($ecm_{t-1}\neq 0$), in order to maintain the long-term equilibrium relationship between GDP and EI, the previous value will be adjusted at a speed of 0.88427 (namely the coefficient estimate value of error correction) so as to return to long-term equilibrium path.

CONCLUSION

(a) In the both long and short run, growth of environmental protection investment does promote the growth of GDP. GDP and EI in China would change in the same direction, and if the environmental protection investment grows 1%, 0.3571% would GDP growth. The reason why environmental protection investment promotes economic growth can be conclude as: (a) Environmental protection investment is part of the national economy, which can promote the development of the production materials and other related industries through demand effect, therefore, create the gross domestic product (GDP). (b) Environmental protection investment provides employment opportunities, then increases people's income, stimulates the consumption, drives the economic growth. (c) Environmental protection measures are not isolated, but associated with technological progress, finally stimulate economic development. (d) Environmental protection investment improves the environmental quality and provide a good production environment, which are the prerequisite to improve labor productivity and economic benefits.

(b) In the long run, China's GDP has no effect on environmental protection investment, that is GDP can't promote environmental protection investment, which is mainly caused by the special approaches of investment management. There's government monopoly

in environmental protection investment in China, lacking a set of strict and operational management mode, and social capital at home and abroad cannot be effectively used. The environmental protection investment expenses aren't an independent subject in the subject setting of current government's budget, make it difficult to supervise and guarantee government's environmental protection investment.

SUGGESTIONS

(a) Building the marketization system for the environmental protection investment, which is the key point to keep the equilibrium effect between environmental investment and national economy growth. The market-oriented environmental protection investment system aims to break the government monopoly in the field of environmental protection investment pattern, to achieve the effective allocation of social resources, and to make the development more synchronicity of environmental protection investment and national economy through a series of market behavior.

(b) Accelerating the process of diversified sources for environmental protection investment, by establishing diversified investment subject system, which strengthens the awareness of environmental protection, so as to solve the problem of lacking for profit investors，and then sharing responsibility for environmental protection.

(c) Implementing green GDP accounting system, giving full consideration to the environmental change, covers system engineering of both resources accounting and environmental accounting. Other than the traditional GDP accounting method ignoring the environmental change in the process of national economic growth, under the green GDP accounting system, contribution can be scientifically measured in environmental protection investment makes for growth of national economy.

(d) Actively promoting the development of cleaner production technologies, so as the environmental protection industry, the technical effect environmental protection and economy growth. Enterprise, as the main body of production, is supposed to develop clean production technology to reduce resource consumption as well as environmental pollution and ease tensions of resources, environment and human beings. Thus the extensive industrialization pattern at the expense of the resource consumption and environmental pollution can be changed and finally improves the efficiency of China's economic growth.

(e) Setting clear environmental property rights to standardize enterprise behavior. Compared to the general investment, environmental protection investment has higher cost and lower income; under the target profit maximization, few enterprises are willing to invest in environmental protection beside of its great social benefit., environmental protection investment leads to as the goal of economic man is not willing to make environmental protection investment. Therefore, the government is supposed to play its regulatory role, to define the property rights of environment system, to determine the price of resources on the basis of market mechanism, and to promote enterprises to pay for the corresponding environmental consumption environment, to reduce or even avoid environmental resources waste, and to encourage the investment in environmental protection.

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