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The impact of China's investment increase in fixed assets on ecological environment: an empirical analysis

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Abstract

In this paper, sequential data for 1990-2009 in China is used to conduct empirical analysis of impact of China's fixed assets investment increase on ecological environment. The results show that China's fixed asset investment has long-term stable correlation with economic growth, energy consumption, industrial wastewater and solid waste emissions. China's rapid growth in fixed asset investment, particularly irrational investment structure is important reason for severely damaged ecological environment; Economic growth and high energy consumption cause the same impact on deterioration of the ecological environment. Therefore, control of investment in fixed asset and development of energy saving and green economy is the key in the further reform.

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1. Introduction

Since "The Limits to Growth" was published in 1971, an increasing number of people attach great importance to the issue of environmental pollution. In December 2009, The Copenhagen summit was held, since then, people in all countries began to consider the issue of ecological environment. It is the most serious and urgent issue in the world. Many economies, such as developed countries, achieved economic development in expense of the ecological environment and realized the modernization of their economies, but the costs were enormous. China is in the initial stage of industrialization, should draw lessons from developed countries to avoid possible problems. After thirty years of reform and opening up, China's economy has made progress to a large degree, its GDP has been ranked at the top. With rapid economic growth, amount of investment in fixed asset also increases rapidly. For example, since 1990, China's investment in fixed asset remain double-digit growth ratio for most of times, and the growth ration reached 25.9% in 2008, and even reached 30% in 2009. However, flow of investment in fixed assets is an important indicator of a country's industrial structure, if investment in fixed asset is mainly in energy-

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efficient industries, this means the country's industrial structure is rational, and sustainable development can be realized. In contrast, if investment in fixed assets is mainly in industries of high energy consumption and high pollution, this indicates that the industrial structure is unreasonable, and its economic development model is unsustainable.

With rapid increase of investment in fixed asset in China, China's energy consumption growth rate increase year by year, between 2003 and 2006, growth rate of energy consumption were all in double-digits. During the financial crisis, growth rate of energy consumption in 2009 rose by 5.26%； In this period, China's environmental degradation was serious, emissions of industrial wastewater were always in a high level, especially in 2009, and the growth rate was 143.77%. Then whether the change of ecological environment is related to rapid growth of investment in fixed assets? Currently, relevant research is not enough, more of study focus on economic growth, ecological environment and low carbon economy. This paper is mainly concerned about correlation between China's investment in fixed asset and the ecological quality, as well as flow of investment in fixed assets in China, to provide policy recommendations.

2. Econometric model and data processing

In this study, industrial wastewater and solid waste emissions are the main indicators for the environmental impact, in addition, because the rapid economic growth has great impact on the ecological environment, but China's industrial development features "high input, high consumption and high pollution", GDP and energy consumption will also be considered as the dependent variable within the model.

In this paper, simplified dynamic and linear regression model is used for analysis on each variable, thus we can find the impact of rapid growth of investment in fixed assets on the ecological environment by analysis of the mode. Specific model are as follows:

$$FS_t = \alpha_0+\alpha_1 K_t +\alpha_2 Y_t +\alpha_3 E_t+\varepsilon_t \qquad (1)$$

$$FW_t = \beta_0+\beta_1 K_t -\beta_2 Y_t +\beta_3 E_t+\omega_t \qquad (2)$$

Where, FS_t represents amount of industrial waste water in China every year, a unit is a million tons; FW_t represents amount of solid waste, a unit is million tons; K_t represents amount of investment in fixed assets in China every year, a unit is tens of billions of RMB; Y_t represents China's gross domestic income, it is used to replace variable of economic growth, a unit is ten billion yuan; E_t means amount of energy consumption in China each year, a unit is million tons. α_i and β_i are all parameters to be estimated; ε_t and ω_t are and are stochastic errors. According to common belief of economic scholars, we can predict regression results in expression (1) and (2): Increase in energy consumption will increase industrial waste water and solid waste emissions, therefore, α_3 and β_3 are positive.

The coefficients α_1 (β_1) and α_2 (β_2) may be positive or negative, depending on a country's economic development level and whether it attaches great importance to the ecological environment. In general, industrial structure of developed countries gradually optimize, and more investment funds are in some high value-added industries, while energy-intensive industries are declining, and investment in fixed assets help to reduce the pollution on the environment, then α_1 (β_1) is negative; In contrast, in economically less developed countries, investments are mainly used in high-pollution sectors, and rapid increase of investment in fixed assets will increase the industrial waste water and solid waste emissions, in other words, rapid growth of investment in fixed assets will deteriorate the ecological environment, then α_1 (β_1) is positive. Although China has attached great importance to economic restructuring and adjustment of industrial structure in recent years, the extensive economic growth mode is still widely used in practice. Therefore, it is estimated that α_1 (β_1) is positive. Moreover, as Grossman and Kruger

(1991,1994) has pointed out, when a country's economic development reaches a high level, economic growth is conductive to improvement of the environment, namely α_2（β_2）is negative; And if the country is in the stage of development, the economy growth will further deteriorate the environment, α_2（β_2）is positive. In the paper, it is concluded that China's economy is in low level, so the two coefficients are all positive. It should be noted that all variables are for time series of 1990 – 2009, because we intend to find impact of China's investment increase of fixed assets on the ecological environment, the investment increase of fixed assets was not significant in the eighties of last century, and that even decreased in 1989. Since the eighties of last century, in order to expand domestic market and meet demands of production growth, the State Council decided to increase investment in fixed assets, and the investment began to grow quickly. To facilitate calculation, all variables have been transferred into atural logarithm, and the data sources are "China Statistical Bulletin" from the Bureau of Statistics of China and "China Environment Bulletin" from the Ministry of Environmental Protection of China. EVIEWS5.0 software is used for model analysis.

3. Model analysis

Through the model analysis, we can determine the correlation between variables, and accurately estimate the relationship and impact on others. First, we make tendency chart for time series according to natural logarithm of each variable, the results show that there is trend among variables, which indicates co-integration relationship among variables. Therefore, we mainly conduct co-integration analysis. To put it simple, we analyze on estimation results from the two equations at the same time.

3. 1 ADF stationarity test

In analysis of time series, there may be multicollinearity among the variables, then, if we conduct regression analysis directly, the spurious regression may incur, and estimation results may not correctly explain the relationship between variables. Therefore, we should firstly conduct stationarity test on the time series. We adopt ADF（Augmented Dickey-Fuller）test method. First of all, carry out stationarity test on original sequence, first-order and second-order difference sequence of four variables in model (1). ADF lag order is automatically determined based on the principle of minimum AIC and SC values, meanwhile, it is better to choose a DW value which is close to 2, to avoid autocorrelation. Test results are shown in Table 1. To put it simple, stationarity test results of first-order difference sequence for each variable are neglected; Δ represents second-order difference sequence. Test results showed that, t-statistics of four original sequences are all larger than that at 1% level.

It can be concluded that all original sequences are not stable; similarly, all first-order difference sequence are below 1% level. Based on stationarity test on second-order difference sequence, we find that all variables are above 1% level; then, we carry out stationarity test on FW_t variable in the equation (2), it is found that the second-order difference sequence of the original sequence is stable. Therefore the four variables in equation (1) and the four variables in and equation (2) are all same-order stationary sequences; there is cointegration relationship between the variables. Therefore, we will conduct cointegration analysis on all variables in both of equations.

3.2 Co-integration test

There are usually two ways to test cointegration relationship, namely, two-step Engle-Granger and Johansen test method. Two-step EG method is easy to use, but in general that it applies only to estimation and testing of single cointegration, it has substantial deviation in the ordinary least squares (OLS) estimates cointegration of small samples. As for the four cointegrations variables were studied in this paper, it is more appropriate to choose the Johansen maximum likelihood analysis of test method. The optimal lag phases of two Johansen test in the paper are 1, the test results of equation (1) was shown in Table 2.

Table 1 ADF stationarity test results for all variables

Variables	T value	1% critical level	Conclustions	Variables	T value	1% critical level	Conclustions
FS	-0.942688	-2.692358	Not stable	Δ FS	-3.327327	-2.708094	Stable
FW	-1.040734	-2.692358	Not stable	Δ FW	-3.256947	-2.740613	Stable
E	-1.885402	-2.728252	Not stable	Δ E	-3.677001	-2.717511	Stable
K	-1.306130	-2.699769	Not stable	Δ K	-2.902797	-2.740613	Stable
Y	-4.666409	-2.728252	Not stable	Δ Y	-2.893220	-2.754993	Stable

Table 2 The cointegration test results of equation (1)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
None *	0.998945	182.7589	54.07904	0.0000
At most 1 *	0.903774	66.23689	35.19275	0.0000
At most 2 *	0.606704	26.43891	20.26184	0.0062
At most 3 *	0.463150	10.57462	9.164546	0.0268

As can be seen from Table 2, if the null hypothesis of one cointegration relationships of the four variables do not exist, the trace statistic is much larger than the critical value of 5%, the P value almost zero means the probability of original assumption is almost zero, meaning that the null hypothesis is rejected, there is at least one variables cointegration; if the null hypothesis has one , two or three cointegration relations, track statistics is also over the critical value of 5%, the original hypothesis is rejected, indicating that there are long-term stable cointegration relationship among the four variables, that is strong correlation. Further estimated cointegration equation is as equation (3):

$$FS_t = 0.152K_t + 0.164Y_t + 0.957E_t - 4.81 \tag{3}$$

$$(0.01040)\ (0.00590)\ (0.01144)\ (0.03254)$$

Log likelihood: 192.9294

Note: The standard deviation of coefficient is within in the () next to Cointegration equation (3).

It can be seen from variable cointegration regression coefficients equation (3) that waste water emissions of industrial, fixed asset investment and GDP were positively correlated with energy consumption. Specifically, investment in fixed assets increase (decrease) 1% will lead to increase (decrease) in amount of 0.152% of industrial wastewater discharge; increase of 1% of gross domestic product will lead to 0.164% increase of the wastewater discharge; energy consumption impact the wastewater discharge large heavily. See from the above cointegration test results, it confirmed the early estimation, rapid growth of fixed assets is indeed greatly increased the discharge of industrial wastewater and deteriorated the ecological environment.

The test results of equation (2) is shown in Table 3：

Table 3: The test results of equation (2)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
None *	0.997707	160.4676	54.07904	0.0000
At most 1 *	0.797802	57.14069	35.19275	0.0001
At most 2 *	0.753306	29.96603	20.26184	0.0017
At most 3	0.304483	6.172695	9.164546	0.1778

As can be seen from Table 3, the cointegration test null hypothesis of equation (2) has at most two cointegration, trace statistic is greater than the critical value of 5%, it reject the null hypothesis, indicating that there are more than two cointegration relationships; on the assumption that a maximum of three cointegration, the trace statistic is less than the critical value, if passed, finally proved that there are three long-term cointegration relationship in the four variables of equation (2), further estimation of cointegration is as the following equation (4):

$$FW_t = 2.34K_t - 1.06Y_t + 2.85E_t - 3.47 \tag{4}$$
$$(0.00261)\ (0.00185)\ (0.01407)\ (0.00178)$$

Log likelihood: 157.5403

Note: The standard deviation of coefficient is within in the () next to cointegration equation (4).

It can be seen from the regression coefficients of cointegration equation (4) that, solid waste has a positive correlation with the fixed asset investment and energy consumption, the increase of fixed asset investment will greatly impact the discharge of solid waste, investment in fixed assets increased (decreased) 1% will increase (decrease) 2.34% of solid waste emissions; energy consumption will also increase the emissions of solid waste; However, emissions of solid waste were negatively correlated with the GDP, meaning that the national economy growth helps to reduce solid waste emissions, which shows that the efficiency of our energy use in recent years was raising as the economy level increased, and the solid waste recycling ratio was also increased gradually.

In short, Energy consumption has significant effect on industrial wastewater and solid waste emissions, which is directly related to low efficiency of energy using in China. According to other study, energy consumption amount for per one dollar in China is 11.5 times of that in Japan, 7.7 times of that in Germany, more than 4 times of that in the US. Economic growth also has the same direction of impact on industrial wastewater discharges, but it can improve the emission of solid waste, which is the result of China’s governance on emission of solid materials, generally speaking, China's economic growth has brought adverse effects to ecological environment. This conclusion is verified the "Kuznets curve (Environmental Kuznets Curve, EKC) hypothesis" between economic growth and ecological environment. EKC hypothesis shows that when the income exceeds a certain threshold, with the increasing per capita income, environment will be improved. That means the per capita income and environmental pollution was "inverted U" curve. It is empirically confirmed by Grossman and Kruger in 1991 and 1994. Also they made it clear that when per capita income reached 4000-5000 U.S. dollars (1985 U.S. dollars), increasing per capita income will improve environment. Now, China's economy is in a stage of development, the impact economic development on ecological environment is still in the first part of the "inverted U", that is economic growth would adversely affect the ecological environment. Investment in fixed assets has the same direction of effect on industrial wastewater and solid waste. In the last 20 years, china's rapid growth in fixed asset investment has increased industrial waste water and solid waste emissions to some extent and destruct the ecological environment. This shows that China's fixed asset investment still exist a phenomenon of irrational investment structure. Although has made continued implementation of the policies, adjusting the industrial structure, china's rapid increasing investment was mainly flows to high energy consumption and high emission industries, which caused pollution to the environment and determined the unreasonable industrial structure in the short period. Some data shows that the fixed assets investment in secondary industry always got a larger proportion, except for a few years, it remained at 40% or more, and, relatively fast growth rate. In 2008, the fixed asset investment of Chinese secondary industry reached 43.89% ratio, increased by 28% over the previous year; in 2009, this promotion was 42.38%, and the growth rate was 26.8%. This further confirms the structure of China's fixed asset investment unreasonable; it is also caused because of these unreasonable adverse effects on the ecological environment.

4 Conclusions

China's industrial wastewater discharge, solid waste, fixed asset investment, economic growth and energy consumption were the study objects in this paper; we use vector autoregressive dynamic system model and the Johansen method studied of the correlations and impact among variables, and major findings are as follows. Firstly, Energy consumption has positive correlation relationship with industrial waste water and solid waste; the massive use energy has remarkable influences on ecological environment. Secondly, Economic growth also has the same direction of impact on industrial wastewater discharges, but it can improve the emission of solid waste, which is the result of China's governance on emission of solid materials, generally speaking, China's economic growth has brought adverse effects to ecological environment. Finally, fixed asset investment changes with industrial wastewater and solid waste towards the same direction, for 20 years, to some extent, rapid growth of China's fixed asset investment increased industrial waste water and solid waste emissions, and deteriorated ecological environment.

Right now, to achieve a green economy, saving energy, reducing pollutant emissions and optimizing industrial structure, for China the most important and most urgent task is to control the flow of investment in fixed assets. An effective measure is to build green finance, financial sector and environmental protection departments together to establish a set of credit information system, reduce the efficiency losses caused by information asymmetry, while the financial sector effectively control the capital inflows into emission reduction projects through the financing o credit screening system. Let the limited capital give full play to the action of financial cycle and leverage, leveraging the whole energy saving market and creating green economy. At the same time, to improve the efficiency of energy use, the Chinese government needs to develop appropriate incentive mechanism to encourage enterprises to actively develop energy saving technologies. Finally, the Chinese government needs to further strengthen international cooperation, share and import technology through bilateral mechanisms and international frameworks.

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