Environmental Regulation, Technological Innovation and Sustainable Growth

Hongqiao Zhang[1], Xuedong Li [2], Ziguo Feng [3]

[1,3] Lingyun Limited liability company, Baoding, 072761, China

[2] Baoding Branch of Agricultural development Bank of China., Baoding, 072761, China

Keywords: environmental regulation; Porter Hypothesis; mediating effect; sustainable growth

Abstract: This paper selects different types of environmental regulation tools, and mainly includes the type of and capital investing, pollution releasing and energy using. The type of capital investing covers investment in environmental pollution control and industrial pollution control. The type of pollution releasing covers industrial sulfur dioxide emissions and industrial wastewater discharge. The type of energy using covers energy consumption. Among them, capital investing index and the intensity of environmental regulation change the same way. In other words, the larger the index is, the greater the intensity of environmental regulation is. The type of pollution releasing and energy using index are reverse changing with the intensity of environmental regulation. In this paper, the stepwise regression method is used to analyse the various environmental regulation tools. From these indicators, an environmental regulation tool can be drawn that can promote the sustainable development of regional economy with mediating effect of technological innovation.

1. Introduction and Literature Review

The "Potter hypothesis" which Links environmental regulation, technological innovation and sustainable growth formally proposed that environmental regulation can promote technological innovation and then influence enterprise performance. This conclusion has not reached a consensus in the theoretical circle. However, with the environmental problems becoming more and more serious, improving the intensities of environmental regulation have been widely recognized. Because of the diversity of environmental regulation tools, the evaluation of environmental regulation intensity index becomes complicated. Different environmental regulation tools have different effects on technological innovation and economic development. Different environmental regulation tools have different effects on technological innovation and economic development. At present, our country is in the dilemma of the deterioration of the environment and the unsustainable economic growth. How to strengthen technological innovation by the guidance of the government to achieve sustainable economic growth is the key problem.

First of all, using the panel data of China's 30 provinces and autonomous regions year 2003 to 2015 sustainable growth and the explanatory variables of environmental regulation tools of the regression analysis, the results show that all of the explanatory variables are significant, can effectively explain the sustainable growth. Then, construct the intermediary variable of technological innovation, and verify the relationship between technological innovation and environmental regulation tools. But in this process, Industrial pollution controlling investment did not pass the significance test, which indicate that the variables on the effect of technological innovation is not obvious. The hypothesis is different from the truth, which energy consumption has inhibitory effect on technological innovation. Environmental pollution control investment, industrial sulfur dioxide emissions, industrial wastewater emissions significantly on the role of technology innovation. These three environmental regulation tools in accordance with the "Potter hypothesis" on the role of technological innovation. Finally, the explanatory variables of sustainable growth test and intermediary variable technique the innovation of environmental regulation and the remaining variables, the result is obvious, that the environment pollution of environmental regulation tools The hypothesis of governance investment, industrial sulfur dioxide emissions and industrial wastewater discharge is established through technological innovation, which mediate

variables affecting regional sustainable growth. Local governments can formulate environmental regulation policies accordingly, and strengthen environmental regulation tools that construct positive effects that can promote technological innovation through regional mediation and sustainable growth. We should increase investment in environmental pollution control, formulate reasonable industrial SO2 emissions and industrial wastewater emissions for enterprises, so that we can enhance the compensation effect of environmental regulation on technological innovation and promote sustainable economic growth.

Environmental Performance Index is used to measure a country's Environmental Performance, taking into account air pollution, water pollution and climate change. In 2008, China's EPI scored 65.1 points, and China ranked 105th out of 149 countries and regions. By 2015, China's EPI score had dropped to 49 points, with only 121 out of 164 countries and regions. EPI score and ranking reflect the comprehensive status of environmental problems in China. Environmental problems is the result of environmental resources is in the nature of public goods and environmental problems have negative externalities, and seek to maximize the interests of the microeconomic subject, environmental problems by market mechanism itself is difficult to solve, therefore, must be carried out by the government in the hands of environmental regulation to protect the environment. The 18th national congress of the communist party of China (CPC) proposed to add the construction of ecological civilization to the "five elements", but the restoration of environmental problems is not a one-day work. To solve the environmental problem, we should not only change the existing economic development model, but also adjust the industrial structure.

2. Research Methods

New classical economic growth theory, technological progress is a factor in economic growth, that is, the national economic output is labor, capital and technology of the function, but the model that technological progress is an exogenous variable, and use the total factor productivity (also known as the solow residual value) as a measure of the role of technological progress in the production. The basic model of the idea can be expressed as follows.

2.1 Model Establishment

Draw lessons from the existing literature, this article USES the law of the mediation effect analysis of environmental regulation, the relationship between the technology innovation and sustainable growth, mainly adopts the mediation effect of Baron and Kenny three-stage method for empirical research. The specific model is as follows:

$$\lambda(t) = \mu + k\sum_{t_k<t} we^{-w(t-t_k)}$$

2.2 Parameter Estimation Method in the Self-exciting Process

On the basis of the neoclassical school, a model of sustainable growth is used in conjunction with the kapoor function. Ke sermon glass function variable substitution effect conjunction between the selection of variables in this paper is more adapt to the economic status quo, capital, labor, and there is some degree of substitution relationship between technological innovation. The model can be expressed as:

$$\log L(\mu, k, w \mid t_1, ., t_n) = \sum_{t_i:2\le i\le n} \log\left(\lambda(t_i)\right) - \int_0^T \lambda(t)\,dt$$

The maximum likelihood function used to estimate is:

$$\log L(\mu, k, w \mid t_1, ., t_n) = \sum_{t_i:2\le i\le n} \log\left(\mu + k\sum_{t_k<t} we^{-w(t-t_k)}\right) - \mu T - k\sum_{t_k<t}\left(e^{wt_k} - e^{w(t_k-T)}\right)$$

3. Empirical Analysis

3.1 Unit root test

First of all, the stability test of LNGDP, lnlabor, LNK, lneci, lnefi, lneco, lnwem and lnwem was conducted respectively. Since the original sequence was not stable, all the data were obtained by first order difference and stable sequence was obtained. Looking at the results of the LLC and ADF tests, you can see that the sequence is stable after the first difference in both tests.

Table 1 Variable stationarity test.

variable	Terms of inspection	T statistic	P values	Sample size
Lngdp	Levin, Lin & Chu t*	-19.5203	0.0000	300
	ADF-Fisher Chi-square	235.261	0.0000	300
lnk	Levin, Lin & Chu t*	-8.63779	0.0000	300
	ADF-Fisher Chi-square	102.709	0.0005	300
lnlabor	Levin, Lin & Chu t*	-8.81839	0.0000	300
	ADF-Fisher Chi-square	140.211	0.0000	300
lneci	Levin, Lin & Chu t*	-6.44062	0.0000	300
	ADF-Fisher Chi-square	128.901	0.0000	300
lnefi	Levin, Lin & Chu t*	-7.58376	0.0000	300
	ADF-Fisher Chi-square	144.305	0.0000	300
lneco	Levin, Lin & Chu t*	-8.88168	0.0000	300
	ADF-Fisher Chi-square	100.907	0.0007	300
lnsem	Levin, Lin & Chu t*	-19.4231	0.0000	300
	ADF-Fisher Chi-square	197.795	0.0000	300
lnwem	Levin, Lin & Chu t*	-12.49537	0.0000	300
	ADF-Fisher Chi-square	150.878	0.0000	300

3.2 Cointegration test

By using kao test, it can be concluded that the first-order difference sequence of each variable has co-integration relationship, as shown in the figure below:

The p values are all 0, so the original hypothesis is rejected, and the original hypothesis is that there is no co-integration relationship between the sequences. It can be said that, at the significant level of 1%, the sequence of each variable is cointegration. You can do the next step.

Table2 Cointegration test

ADF	T - statistic	P values
	-6.683642	0．0000
Residual variance	0.004637	
HAC variance	0.004828	

Table3 Correlation analysis

Variable	Correlation coefficient	Standard error	T-statistic	P values
RESID(-1)	-0.419696	0.052537	-7.988612	0.0000
R-squared	0.219046	Mean dependent var		-0.001635
Adjusted R-squared	0.216665	S.D. dependent var		0.093535
S.E. of regression	0.082784	Akaike info criterion		-2.139113
Sum squared resid	2.247867	Schwarz criterion		-2.116088
Log likelihood	354.9536	Hannan-Quinn criter.		-2.129928
Durbin-Watson stat	2.072741			

3.3 Hausman test

After the co-integration test, the model is judged, and the random effect model or fixed effect model is determined.

Table 4 Hausman test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	106.462534	7	0.0000

According to the hausman test results, the p value is 0, i.e., the original hypothesis of the random effect model is rejected, and the fixed effect model should be used.

3.4 Regression analysis

After confirming the use of the fixed effect model, the regression analysis of the variables results in the following results.

Table 5 OLS analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNK	0.359656	0.022669	15.86538	0.0000
LNLABOR	0.084707	0.026642	3.179439	0.0016
LNECI	0.031685	0.009552	3.317178	0.0010
LNEFI	0.030662	0.011561	2.652213	0.0084
LNECO	0.597551	0.057588	10.37637	0.0000
LNSEM	-0.138236	0.032274	-4.283202	0.0000
LNWEM	0.083363	0.026023	3.203409	0.0015
C	-1.982914	0.442816	-4.477962	0.0000

It can be seen that the variable is significant, explain the variables to be explained is explained, investment of pollution control, industrial pollution control investment, industrial SO2 emissions, industrial wastewater emissions, energy consumption of the p value is less than 0.05, which means under the 5% significant level, the explanatory variables are to be explained variables per capita GDP has explanatory power.

4. Conclusion and implications

According to the empirical results, some tools of environmental regulation can influence the economic growth of the region through mediation effect.

Model (1) in eci, efi, eco, sem, wem coefficients were 0.031685, 0.030662, 0.597551, 0.138236, 0.597551, shows that environment pollution control investment and industrial pollution control, energy and industrial wastewater emissions the comprehensive function of regional economic growth is positive, that is these variables for compensation effect than the extrusion effect of economic growth, and industrial SO2 emissions of the comprehensive function of regional economic growth is negative, indicating that it extrusion effect on economic growth than on the compensation effect.

In conclusion, environmental regulation tools of investment, industrial SO2 emissions of pollution control, industrial waste water emissions can verify professor porter hypothesis, and proved that the role of environmental regulation on regional sustainable growth is completed through the mediating role of technological innovation. The industrial pollution control and environmental regulation tools complete investment and energy consumption can't prove that professor porter hypothesis, but to a certain impact on regional economy, industrial pollution control to complete the investment multiplier to accelerate effect produce positive effect on economic growth.

It can be seen from the foregoing that some environmental regulation tools influence the development of regional economy through mediation effect, and some tools are directly related to regional economy. Investment, industrial SO2 emissions of pollution control, industrial waste water emissions through mediation effect produce positive effect on technology innovation and have positive effect on regional economic growth, and industrial pollution control investment, energy consumption of the intermediary effect of technology innovation is not obvious, there is a little difference, the former to the latter, no intermediary role, while the latter assumption of the intermediary role of technology innovation and 5 instead, but the intermediary effect was established.

Environmental regulation tools are diversified. Investment can not only through the intermediary effect of pollution control have positive effects on technological innovation, also can have a multiplier effect on economic growth, the government in formulating the budget, should strengthen the investment in environmental pollution control, combining with the stage of economic development, the environmental pollution problems and to balance regional development issues.

Local governments have more incentive policies than punishment. The government should also encourage enterprises to invest in the environment. On the one hand, the government should grasp the structure of investment in pollution control and the annual budget amount. On the other hand, by establishing the model effect, the environmental protection fund should be introduced to attract the idle funds in the region to the public welfare undertakings. In this way, the benign interaction between economic development and environmental protection can be ensured. Only in a comfortable environment, can residents, enterprises and government continue to exist.

References

[1] Brunnermeier S B, Cohen M A. Determinants of Environmental Innovation in US Manufacturing Industries[J]. Journal of Environmental Economics and Management, 2003, 45 (2): 278 -293.

[2] Minghua L, Yongzhong Y. Environmental Regulation and Technology Innovation: Evidence from China[J]. Energy Procedia, 2011, (5): 572 -576.

[3] Borghesi S, Cainelli G, Mazzanti M. Linking Emission Tradingto Environmental Innovation: Evidence from the Italian Manufacturing Industry[R]. Research Policy (2014), http://dx.doiorg /10.1016 / j. respol, 2014-10-014.

[4] Baron R M, Kenny D A. The moderator-mediator variable distinction in social psychological

research[J]. Journal of Personality and Social Psychology, 1986, 51(6): 1173-1182.

[5] Cao G, Han Y, Cui W, et al, Multifractal detrended cross-correlations between the CSI 300 index futures and the spot markets based on high-frequency data, Physica A: Statistical Mechanics and its Applications, (414), pp. 308-320, 2014.

[6] Hou Y, Li S, the impact of the CSI 300 stock index futures: Positive feedback trading and autocorrelation of stock returns, International Review of Economics & Finance, (33), pp. 319-337, 2014.

[7] Zhou Z, Dong H, Wang S, Intraday Volatility Spillovers between Index Futures and Spot Market: Evidence from China, Procedia Computer Science, (31), pp. 721-730, 2014.

[8] Hawkes A G, Spectra of some self-exciting and mutually exciting point processes, Biometrika, 58(1), pp. 83-90, 1971.

[9] Zhuang J, Ogata Y, Vere-Jones D, Stochastic declustering of space-time earthquake occurrences, Journal of the American Statistical Association, 97(458), pp. 369-380, 2002.