RECESSIVE ENVIRONMENTAL REGULATION AND ENERGY CONSERVATION AND EMISSION REDUCTION

by

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ABSTRACT

This study examines the direct and indirect effects of recessive environmental regulations, namely public supervision on energy conservation and emission reduction. Based on provincial data in eastern China for years 2008-2016 and panel data analysis, it is shown that direct supervision has no impact on improving energy efficiency. However, recessive environmental regulation can decrease per capita energy consumption indirectly through optimizing the structure of foreign investment and stimulating foreign green investments. Moreover, such regulation has the potential to decrease energy consumption per unit of GDP indirectly by accelerating industrial restructuring and promoting technological innovation. Given these results, it is suggested that the public and Non-Governmental Environmental Protection Organization in eastern China should be used more intensively to promote energy saving and emission reduction.

Keywords: recessive environmental regulation; energy conservation and emission reduction;

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Extreme weather such as cold and heat waves, storms, heavy precipitation, and droughts occur frequently. To cope with global warming, nearly 200 country parties in the United Nations Framework Convention on Climate Change issued the Paris Agreement at the Paris Climate Change Conference in December 2015. Global warming resulting from the widespread use of fossil energy is regarded as a major threat to the environment. As a result, energy conservation and emission reduction have become a common problem faced by all countries in the world. The energy-saving targets proposed by the Chinese government are key environmental policies. Reducing energy intensity and per capita energy consumption are also essential to maintain national energy security and sustainable development.

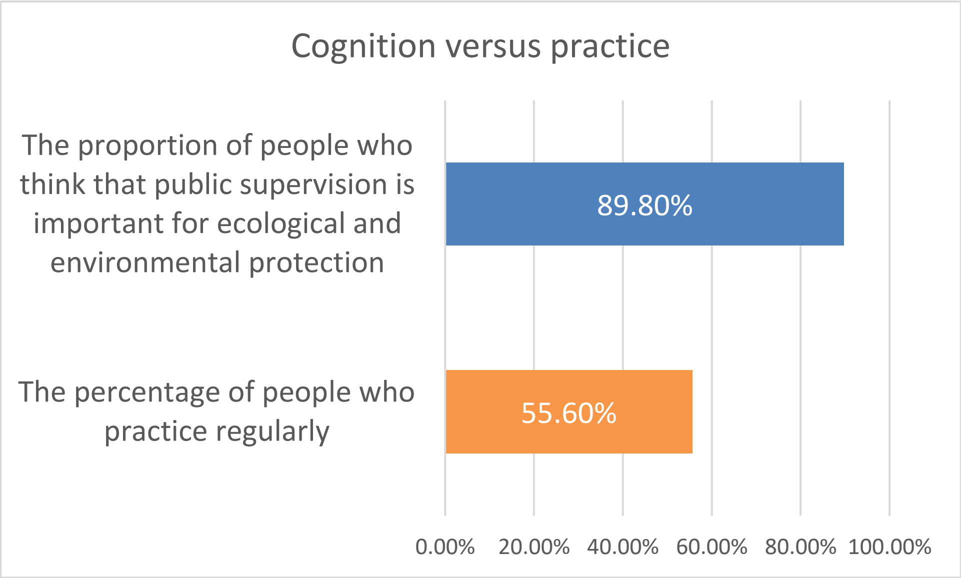
Energy conservation means saving energy or reducing energy consumption. Emission reduction means reducing pollutant emissions. Energy conservation and emission reduction (ECER) occur usually as a phrase in the existing literature. Energy conservation means energy efficiency, which means enterprises can get more output with the same level of input (or an equal amount of output from less input). Emission reduction means enterprises emit fewer pollutants for the same level of output.

Energy conservation and emission reduction is an important way to improve the quality of economic operation and the quantity of economic growth. The implementation of energy conservation and emission reduction has high economic, environmental, and social values. In recent years, with the rapid development of China's economy, the depletion of natural resources has become increasingly acute. This is mainly due to China's economic structure and extensive economic growth mode. Chinese average GDP growth rate in the past seven years is 6.16%, while G7’s is only 0.90% according to IMF database. Energy conservation and emission reduction can not only effectively coordinate the relationship between China's energy consumption, carbon dioxide emissions and the quantity of economic growth, but also can transform the economic growth mode and improve China's competitiveness in the world. Jun-Ki (2018) analyzes the cascading economic and environmental effects of an electric utility company's industrial energy-efficiency rebate programs and finds that all three rebate programs provided a modest economic boost not only to directly involved equipment manufacturers and marketing service providers, but also to other upstream industries responding to the direct impact and the final demand augmented by the associated increase in value added in the regional economy. Therefore, the research on energy conservation and emission reduction is particularly important.

At present, the goal of improving environmental quality through energy conservation and emission reduction in China mainly depends on the regulation and intervention of macro-industrial policies. On December 20, 2016 the 13th Five-Year Plan for energy conservation and emissions reduction points that we should adhere to the work pattern of government leading, enterprises as the main body, market driven, and social participation. We need to give full play to the leading role of the government, make a comprehensive use of economic, legal, technical and necessary administrative means, and strive to improve the incentive and restraint mechanisms. Environmental regulation is an important policy tool for governance and improvement of the environment. It plays an important role in promoting energy conservation as well as emission reduction and higher environmental quality.

In general, environmental regulation by the government includes explicit and recessive environmental regulation. Explicit environmental regulation includes command-and-control, market-based incentives, and voluntary environmental regulation. As to recessive environmental regulation, it refers to the internal and intangible environmental protection idea, consciousness, attitude and cognition, etc. (Yumin Zhang 2009). However, China's implicit environmental regulation is at a low level. The public still has high cognition but low practice in the field of green consumption, waste classification, environmental protection and social supervision. Less than 60 percent of respondents (55.6%) have monitored environmental pollution by enterprises. The government's monitoring channels are their first choice, followed by the media and environmental protection organizations. In addition, the number of environmental protection organizations is small. They are difficult to register in China because of bad specialty and a lack of funds and influence according to the 2019 and 2020 Citizen Ecological and Environmental Behavior Survey Report.

Figure 1 Cognition versus practice



Therefore, the goal of this report is to estimate the direct and indirect effects of recessive environmental regulations on energy conservation and emission reduction in eastern China and explore more effective way to achieve the goal of energy conservation and emission reduction using panel data of 14 Chinese provinces from 2008 to 2016. The empirical result shows that recessive environmental regulations can improve energy efficiency indirectly.

The paper is structured as follows: Section 2 presents literature review. Section 3 develops the methodological approach adopted in this study. Section 4 presents a description of the relevant variables, functional forms for statistical estimation, obtained results and their discussion. Section 5 concludes the study and provides policy implications.

2.0 LITERATURE REVIEW

2.1. Theoretical Background

Environmental pollution in economics is viewed as a negative externality. It can be both a negative production and/or negative consumption externality. According to economic theory, in the presence of a negative externality, private economic agents cannot correctly incorporate them into decision-making which leads to economic inefficiency. In such a case, the intervention is a welcome option to correct for such market failure. In terms of a government response, intervention may include increased regulation and/or improved incentive mechanisms. This paper is interested in how such intervention are applied in China.

Since this paper is primarily interested in recessive environmental regulation in China, I analyzed the existing literature in this field. Recessive environmental regulation embodies the power of public participation in supervision. There are many literature sources about the effects of the oversight of the news media and the general public. For example, Yongjun Tang (2020) explored data on 200 listed enterprises in China and studied factors that affect voluntary carbon disclosure, finding that social pressure has a greater impact on non-state-owned enterprises. O'Faircheallaigh (2010) stated that benefits of public participation are often taken for granted, and partly for this reason the underlying rationale for greater public participation was sometimes poorly articulated, making it more difficult to determine how to pursue it effectively. Cohen & Blankshtain (2013) made a distinction between two ways in which a participation process initiated by a non-governmental organization (NGO) can empower the community: (i) through transfer of decision-making power from formal institutions to local forums; and (ii) by building the capacity of participants to make decisions together as a community.

The link between energy conservation and emission reduction has just emerged in recent years. Most studies focus on the efficiency of energy conservation and emission reduction, policies and other aspects. Most of the broader studies focus on the low carbon economy, greenhouse gas emission reduction, global climate change estimates and energy efficiency. Aaheim et al. (1999) made a comprehensive investigation on the implementation effect of energy saving projects for CO2 emission reduction in Hungary, and found that when CO2 emission was controlled, the regional pollution morbidity rate would also be reduced, and the corrosion degree of building facilities would also be reduced, and the energy saving and emission reduction projects had a good comprehensive benefit per unit cost. Worrell Ernst et al. (2001) introduced energy conservation policies and experiences of developed countries, and emphasized the role of government in energy conservation under market economy conditions. From the theoretical background, we can see the oversight of the news media and the general public may have a great impact on energy conservation and emission reduction.

2.2. Empirical Background.

Various researchers have tried to estimate the link between energy conservation and policies aimed at pollution reduction. Zhang (2013) found that four factors - tax policies, government subsidies, credit policies and media supervision - had a significant positive impact on corporate energy conservation and emissions reduction. Zhang (2019) found that recessive regulation can decrease electricity consumption through foreign investment, technology, industrial structure and economics of scale. Hu (2020) constructed an econometric model of the nexus between city size and energy use, finding that expansion of China's city size tends to positively affect energy conservation: as city size continues to expand, energy consumption exceeds some critical value and changes from increasing to decreasing. In this process, it is easier to achieve a decline in energy intensity than a decline in per capita energy consumption. The critical value of the impact of urban population agglomeration on energy intensity is smaller than that on per capita energy consumption; that is, the energy-saving effect generated from the expansion of the urban population causes the urban energy intensity to decline first, followed by the decline of per capita energy consumption. Eirini Stergiou (2021) evaluates the industrial total factor energy efficiency (TFEE) at a national and European level, finding that path dependence phenomena have a strong presence on energy efficiency, irrespectively of the methodology approach adopted, indicating the role of past accumulated knowledge, technical capabilities, climatic characteristics and technological “lock-in”. Technological “lock-in” refers to a technology whose market share is large enough that it becomes a de facto standard product, which can be used most easily with other products and thus lock users into that product.

Since my primary interest is in recessive environmental regulation on energy conservation and emission reduction, I have analyzed some literature sources directly associated with this policy. Heyes (2018) develops a model in which social pressure on a firm to behave well is jointly produced by a state regulator (EPA) and an NGO. Tu (2019) finds that the Pollution Information Transparency Index (PITI)[1] has a positive influence on pollution emissions reduction. These all reflect recessive environmental regulation’s direct effect.

Zhang (2014) decomposes energy intensity change into five factors: changes in energy efficiency, share of value added, input structure, consumption structure, and consumption volume. Then he found that recessive environmental regulation may improve energy efficiency through stimulating green investments,

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[1] the Pollution Information Transparency Index (PITI) mainly evaluates the urban pollution source supervision, pollution treatment, information disclosure to the public, etc. The full score is 100 points. The more transparent and comprehensive the information disclosure, the higher the score.

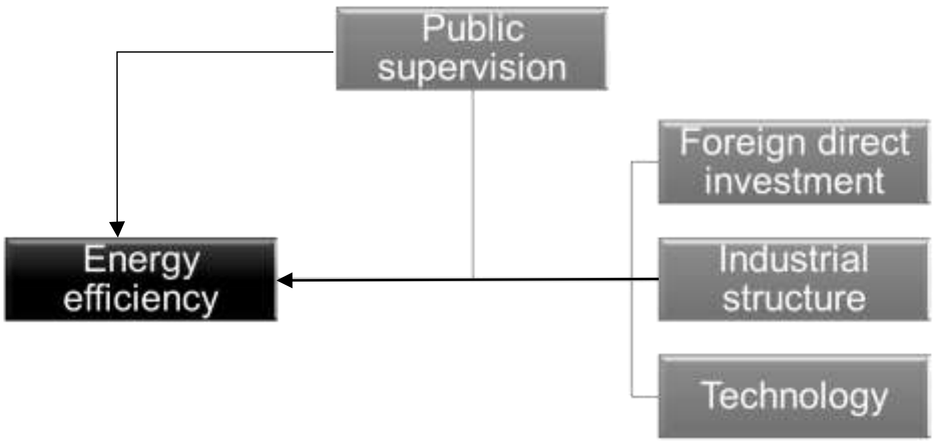
accelerating industrial restructuring, and promoting technological innovation. Huang (2021) conducts a difference-in-differences approach to analyze the impact of explicit environmental regulation on R&D investment and finds that environmental regulation has a positive effect on R&D expenditures. Fang (2021) finds that government explicit environmental regulation can significantly increase the number of green patents of heavily polluting industries. Kim (2019) finds that stringent environmental regulations attract FDI, leading to a “race to the top” or “green haven.” It is possible that a host country’s environmental regulations could enhance domestic productivity, which, in turn, attracts foreign multinational firms. Li (2020) finds that industrial structure, energy structure, government regulations, level of technological innovation, and the degree of openness have a significant impact on China's energy carbon emissions efficiency. Singh (2021) uses data from fieldwork in the Kanpur industry of India and estimates efficiency using the directional distance function approach under three directional vectors, finding that explicit regulation improves the environmental efficiency of leather firms. However, regulation imposes an opportunity cost on firms of an average 3% loss in expanding leather output and reducing inputs. The study recommends mandating the use of cleaner technology and market-based instruments to improve environmental efficiency. Peng (2021) uses large panel data of Chinese industrial enterprises for 1998-2007, to identify the productivity effects of this market-based environmental regulation by employing a difference-in-difference-in-differences design, finding that the market-based environmental regulation has exerted significant productivity-enhancing effects across all types of industrial enterprises, with stronger effects associated with privately owned, more productive, and less pollution-intensive enterprises. Li (2020) recommends improving the mechanism of the long-term implementation and dynamic evaluation of the River Chief System (RCS), highlighting the independence of evaluation authorities, and introducing third-party evaluation and public supervision systems when investigating the policy impact of RCS. The Chinese Central Government incorporated environmental responsibility into the assessment and promotion system of local officials by referring to the competent economic responsibility system, thereby forming the environmental responsibility system (e.g. RCS).

Based on my literature review, the main aspects influencing energy conservation and emission reduction are policies, technology, industrial structure, economics of scale and social pressure. In this study, I will follow the approach presented in Zhang (2019).

3.0 METHODOLOGY

The direct effects of recessive environmental regulation on energy conservation and emission reduction are embodied in guidance, adjustment and standardized management for environmental behavior of an individual or organization. The indirect effects are reflected in administrative, economic, legal, educational, scientific and illegal means of violence and other forms, affecting technology, economic structure, foreign investment which in turn affecting energy efficiency.

Figure 2 Direct and indirect effects



The goal of this study is to estimate the direct and indirect effects of recessive environmental regulations on energy conservation and emission reduction in eastern China. Zhang (2019) estimates the indirect effect of recessive environmental regulation on energy conservation and emission reduction using the interaction terms: recessive regulation interacting with foreign-investment, technical level, industrial structure and economic scale. Thus, to estimate the effects of recessive environmental regulation on energy conservation and emission reduction, the interaction terms are important to show how one variable mediates the other variables that influence on the dependent variable.

This study will estimate indirect effects of recessive environmental regulations on energy conservation and emission reduction in eastern China in regard to three factors: foreign direct investment, industrial structure and regional technical level. The possible transmission mechanisms are discussed below. Other variables like economic scale, population density and explicit environmental regulation will be control variables.

3.1. FDI Technology Spillover

FDI technology spillover refers to the involuntary technology diffusion of human capital knowledge and skills embodied in FDI through various channels, which has an indirect impact on the host country, then changing the technology level of relevant industries in the host country. FDI technology spillover is one of the ways to upgrade technology for the host country, and it is not controlled by FDI enterprises. The positive externality of knowledge and skills is the root cause of involuntary technology spillover from FDI enterprises to host countries.

Kokko (1994) systematically summarized the technology spillover of FDI, which is mainly divided into four situations. First, when FDI enterprises enter the host country, they have multiple advantages in technology management and scale, which creates pressure on enterprises in the host country and forces them to make full use of existing technologies to improve work efficiency and product quality. Second, in the face of the increase in the number of domestic enterprises and the intensification of market competition, the host country enterprises increase the investment in technology research and development to carry out technological innovation and to improve the technical level; Third, skilled workers and managerial talents trained by FDI enterprises will flow into enterprises of the host country; Fourth, FDI enterprises provide advanced technologies to upstream or downstream enterprises in host countries. Thus, recessive environmental regulation is expected to impact energy conservation and emission reduction indirect through optimizing the structure of foreign investment and stimulating foreign green investments.

3.2. Industrial Structure

Many studies have shown that the imbalance of industrial structure is one of the reasons for the sharp rise in energy consumption. (Zhang 2014, Zhang 2019, and Li 2020) The total energy consumption is related to the industrial scale. In regions dominated by heavy energy consuming industries such as chemical, papermaking and metallurgy, the total energy consumption will be large. Environmental regulation will increase the non-productive investment cost of enterprises and then increase the cost burden of enterprises with high energy consumption. However, enterprises' environmental protection funds can not only be used to dismantle the outdated production equipment with high energy consumption, but also promote enterprises to introduce more technologically advanced, environmentally friendly and energy saving production equipment, and then improve the production process in order to develop into a green and clean enterprise gradually and drive the reform of enterprises in other types of industries.

3.3. Technological Progress

Generally speaking, the improvement of technological level is conducive to reducing resource utilization intensity of economic activities and reducing the adverse impact of unit economic activity on the environment. Moreover, technological progress is irreversible. From the perspective of dynamic analysis, technological progress and innovation will improve the level of productivity of factors and energy saving and emission reduction capacity directly or indirectly. This also applies to the technology innovation which is not to protect the environment for direct purpose, or to make the pollution intensive industry constantly expanding development. In the long run, even in the polluting industries, high level of technology can reduce the pollution intensity of economic activities more effectively than lower technical levels objectively. Therefore, technological progress can make more output from the same input and reduce waste generation. At the same time, these also mean the reduction of environmental pollution volume and intensity in the process of production.

4.0 EMPIRICAL WORK

4.1. Data Sources

Panel data were collected for 14 provinces[2] in eastern China from 2008 to 2016. The data were collected from China's National Bureau of Statistics at http://www.stats.gov.cn/. In order to eliminate the effect of outliers, continuous variables were changed by Winsorize in 1% and 99% quantiles following Zhang (2019).

4.2. Variables and Model Specification

Energy consumption and environmental pollution are closely related to green development. Improving energy efficiency plays positive roles in promoting energy conservation and emission reduction. Thus, the outcome variable in this study is energy efficiency. Based on data availability and existing literature, I selected per capita energy consumption and energy intensity (energy consumption per unit of GDP) as contrary indicators of energy efficiency. Low per capita energy consumption means the less energy consumption for a given individual thus, high energy efficiency. Low energy intensity means high energy efficiency and we need less energy than before to increase the same GDP. Past work

[2] Beijing, Tianjin, Hebei, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Henan, Guangdong, and Hainan.

examining this topic includes Li (2019) who uses the variable coal consumption per unit of electricity generated as a measure of the level of energy efficiency and uses SO2, NOx and PM emissions to measure the level of emission reduction. Kong (2021) analyzes annual reports and count the frequency of words related to ECER, then defines two dummy variables to proxy for firms' ECER behaviors. Hu and Fan (2020) use the energy intensity to express energy consumption to explore how the expansion of city size affects energy consumption in the process of urbanization for China to achieve its energy conservation goals. Energy intensity refers to the energy consumption per unit of GDP (converted to a constant price in 2000).

The core independent variable is recessive environmental regulation. This refers to the internal and intangible environmental protection idea, environmental consciousness, environmental protection attitude and environmental cognition, etc. China has 989 million Internet users, 85.4 million more than in March 2020. The Internet penetration rate reached 70.4%, 5.9% higher than that in March 2020 based on the 47th Statistical Report on Internet Development in China. The Internet is a primary way for the public to obtain information and to supervise environmental pollution. Thus, following Zhang (2019) we selected the number of internet users to represent the strength of recessive environmental regulation in a province.

To reduce possible omitted variable bias, I controlled for seven other factors (listed in Table 1) which may affect electricity consumption. Foreign direct investment is the actual amount of foreign capital utilized by the province that year. This paper evaluates the industrial structure by considering the ratio of added value of secondary industry to GDP, which is reflected in the impact of the regional industrial structure on energy consumption. The size of the economy represented by gross regional domestic product. This paper uses the quantity of domestic patent application as a proxy variable for the level of science and technology of each province. Urban population density is the proxy variable of pollution caused by human activities in daily life. The volume of road freight is the proxy variable of pollution caused by transportation industry, because through calculation, in recent five years road freight is the biggest part of transportation in China, the average is 72.9%, and the second is waterway transportation which is only 14.3%. Investment in reducing industrial pollution is used to represent the explicit environmental regulation level and pollutant treatment efficiency of each province.

Main variables and the associated definitions are in Table 1:

Table 1

Main variables and the associated definitions

Variable type	Variable	Definition
Dependent variables	pcec	Taking the logarithm of per capita consumption of electric power (10 thousand

		kilowatt hours)
	ei	Consumption of electric power per unit of GDP (kilowatt hours per yuan)
Independent variable	lnniu	Taking the logarithm of the number of Internet users (10,000 people)
Control variables	lnfdi	Taking the logarithm of foreign direct investment (100 million yuan)
	inds	The value-added of secondary industry (100 million yuan) / gross regional domestic product (100 million yuan)
	lngrdp	Taking the logarithm of gross regional domestic product (100 million yuan)
	lndpa	Taking the logarithm of the quantity of domestic patent application
	lnpd	Taking the logarithm of urban population density (people per square kilometre)
	lnvrf	Taking the logarithm of volume of road freight (10,000 tons)
	lniipc	Taking the logarithm of investment in industrial pollution (10,000 yuan)

N=126

Following Zhang (2019), I estimate the direct and indirect effect of recessive environmental regulations on energy efficiency using the following regression models (i) and (ii):

$$pcec_{i,t} = \alpha_0 + \alpha_1 lnniu_{i,t-1} + \alpha_2 lnniu_{i,t-1} \times inds_{i,t} + \alpha_3 lnniu_{i,t-1} \times$$

$lndpa_{i,t} + \alpha_4 lnniu_{i,t-1} \times lnfdi_{i,t} + X'\alpha_{i,t} + u_{i,t}$ (i)

$$ei_{i,t} = \beta_0 + \beta_1 lnniu_{i,t-1} + \beta_2 lnniu_{i,t-1} \times inds_{i,t} + \beta_3 lnniu_{i,t-1} \times lndpa_{i,t}$$

$$+ \beta_4 lnniu_{i,t-1} \times lnfdi_{i,t} + X'\beta_{i,t} + \varepsilon_{i,t} \quad \text{(ii)}$$

where $X'\alpha_{i,t}$ and $X'\beta_{i,t}$ include all control variables, α and β are parameters to be estimated, and $u_{i,t}$ and $\varepsilon_{i,t}$ are stochastic disturbance terms. Because public supervision has the hysteresis quality, I use the 1 period lag of the logarithm of the number of Internet users in the model.

Given this model specification, $lnniu$ and other three variables ($inds$, $lndpa$ and $lnfdi$) have interaction effects when influencing $pcec$ and ei. The marginal effect of $lnniu$ on $pcec$ and ei also depends on the value of $inds$, $lndpa$ and $lnfdi$.

The marginal effect of $lnniu$ on $pcec$:

$ME_1(lnniu|inds, lndpa\ and\ lnfdi) = \alpha_1 + \alpha_2 inds + \alpha_3 lndpa + \alpha_4 lnfdi$ (iii)

The marginal effect of $lnniu$ on ei:

$ME_2(lnniu|inds, lndpa\ and\ lnfdi) = \beta_1 + \beta_2 inds + \beta_3 lndpa + \beta_4 lnfdi$ (iv)

4.3 Unit Root Test

To test if all variables are stationary, this paper uses Im-Pesaran-Shin (IPS) unit root test, whose null hypothesis is a variable has a unit root and non-stationary. The results are as follows.

Table 2 Unit Root Test

Variables	Statistic
pcec	-5.184***
ei	-2.578***
lnniu	-3.755***
lnfdi	-3.470***
inds	-2.776***
lngrdp	-6.035***
lndpa	-9.229***
lnpd	-1.616*
lnvrf	-8.267***
lniipc	-2.745**

* indicates p-values < 0.1, ** indicates p-values < 0.05, and *** indicates p-values < 0.01.

This table shows that all variables are stationary, so there is no spurious regression problem.

4.4. Descriptive Statistics

Descriptive statistics are shown in Table 3. In this table, the maximum number of internet users is 80.24 million and the minimum is 2.16 million. Their corresponding network penetration rate are 74% (Guangdong in 2016) and 35.1% (Hainan in 2008). It indicates the amount of the Internet proliferation is very big.

Table 3 Descriptive statistics

Variable	Unit	Mean	Std. Dev.	Min	Max

pcec	10 thousand kilowatt hours	2.871	0.996	1.198	5.374
ei	kilowatt hours per yuan	0.078	0.019	0.041	0.132
niu	10,000 people	2387.294	1651.628	216	8024
fdi	100 million yuan	2738.401	2925.486	164.63	11746.95
inds	%	0.452	0.103	0.193	0.573
grdp	100 million yuan	26280.74	18031.18	1503.06	80854.91
dpa	one	38860.52	43113.06	312	203609
pd	people/km²	2674.73	1185.177	1145	5967
vrf	10,000 tons	100442.2	78330.65	9489	296754
iipc	10,000 yuan	264605.6	251471.8	3563	1416464

N=126

To test if multicollinearity exists in the data, Table 4 shows the variance inflation factor values of the logarithm of gross regional domestic product is the biggest, when per capita electricity consumption is the dependent variable, indicating multicollinearity. When electricity consumption per unit of GDP is dependent variable, the results are similar. However, since the study focuses on the respective effect of different variables on energy efficiency, so omitting relevant variables may cause missing variable bias. Therefore, I choose to include all independent variables in the model while cautioning that some results may be impacted by a degree of multicollinearity.

Table 4 The multicollinearity test

Variable	VIF
lngrdp	47.50

l.lnniu	22.41
lndpa	15.27
lnvrf	11.48
lnfdi	3.96
lniipc	3.64
inds	3.06
lnpd	1.25
Mean VIF	13.57

4.5. Direct and Indirect Effect of Recessive Environmental Regulation

With panel data, I first run both the fixed effects and random effects regressions, which help account for time-constant unobserved heterogeneity at the provincial level; then conducted the Hausman test to choose between the two. Results show that the random effect estimators are better than fixed effect estimators when per capita energy consumption is the dependent variable. Through Modified Wald test and Serial Correlation test, I found the model has heteroscedasticity and sequence correlation problems, then I use cluster robust standard error to modify this model. Regression analysis results are shown in Table 5. Fixed effects and OLS results will be placed in Appendix A. I found the indirect effects about industrial structure and technology on per capita energy consumption are statistically insignificant, which is different with Zhang (2019). The reason may be that Zhang used energy consumption as dependent variable, while I use per capita energy consumption. The government incentives for technological innovation are not enough.

Table 5 Random effect estimations of per capita energy consumption(pcec)

variable	Coefficient
l.lnniu	3.363*** (1.066)
lni (interaction term)	-0.035 (1.783)
lnd (interaction term)	0.021 (0.140)
lnf (interaction term)	-0.476** (0.216)
lnfdi	3.432** (1.640)
inds	0.435 (12.769)
lngrdp	-0.367 (0.839)
lndpa	-0.091 (1.180)
lnpd	-0.639*** (0.210)
lnvrf	0.631 (0.697)
lniipc	-0.021 (0.069)
constant	-19.931** (8.185)
N	112
R-squared	0.256

* =10% significance, **=5% significance, ***=1% significance.

With respect to the 1 period lag of the number of Internet users, the coefficient is statistically significant at the 1% level and positive, which is 3.363, meaning that recessive environmental regulation has a direct positive impact on per capita energy consumption.

The coefficient of the interaction term between the 1 period lag of the logarithm of the number of Internet users and the logarithm of the foreign direct investment is statistically significant at the 5% level and negative, which is -0.476. This result indicates the recessive environmental regulation can decrease per capita energy consumption indirectly through optimizing the structure of foreign investment.

$$ME_1(lnniu|inds, lndpa\ and\ lnfdi) = 3.363 - 0.476lnfdi \qquad \text{(v)}$$

However, another two indirect effects are statistically insignificant. This result indicates the recessive environmental regulation cannot decrease per capita energy consumption indirectly through accelerating industrial restructuring or promoting technological innovation.

When energy intensity is the dependent variable, Hausman test shows that fixed effect estimators are better than random effect estimators. Through Modified Wald test and Serial Correlation test, I found the model has heteroscedasticity and sequence correlation problems, then I use cluster robust standard error to modify this model. Regression analysis results are shown in Table 6. Random effects and OLS results will be placed in Appendix B.

Table 6 Fixed effect estimations of energy intensity(ei)

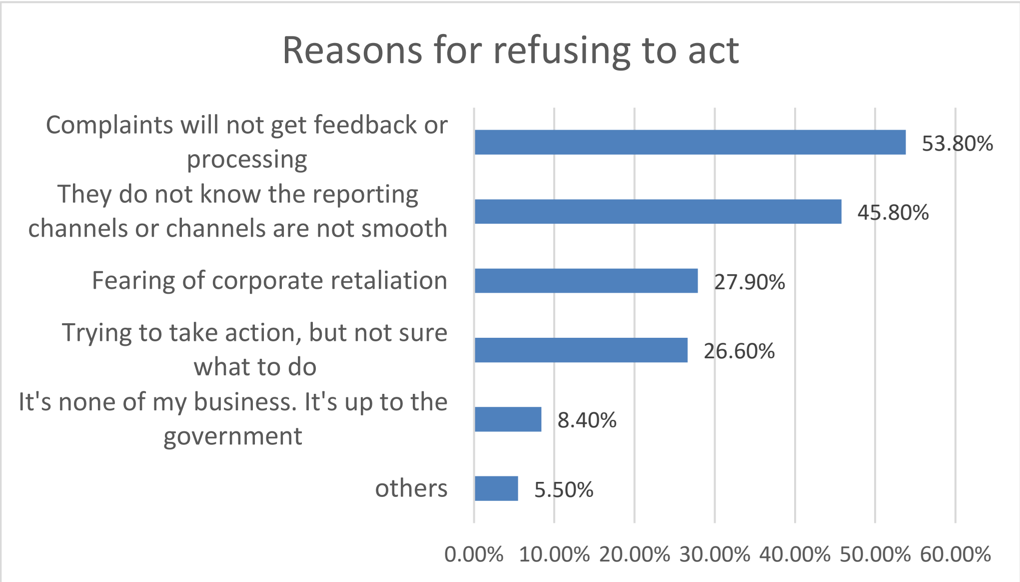
variable	coefficient
l.lnniu	0.031**

	(0.012)
lni (interaction term)	-0.054** (0.019)
lnd (interaction term)	-0.004** (0.002)
lnf (interaction term)	0.005* (0.002)
lnfdi	-0.036** (0.017)
inds	0.417** (0.143)
lngrdp	-0.037** (0.015)
lndpa	0.029** (0.014)
lnpd	-0.004 (0.003)
lnvrf	-0.002 (0.004)
lniipc	-0.001 (0.001)
constant	0.262*** (0.060)
N	112
R-squared	0.891
F (11,13)	111.05

* =10% significance, **=5% significance, ***=1% significance.

This table shows that overall R-sq is 0.891 and F (11, 13) is 111.05, so all the coefficients are jointly significant at the 1% level. With respect to the 1 period lag of the number of Internet users, the coefficient is statistically significant at the 5% level and positive, which is 0.031, meaning that recessive environmental regulation has a direct positive impact on per capita energy consumption. From these two tables, we can see there is no impact of recessive environmental regulation on improving energy efficiency. In other words, direct public supervision has not played a key role in saving energy and reducing emissions. According to the 2019 Citizen Ecological and Environmental Behavior Survey Report, the main reason for respondents who did nothing when facing environmental pollution of enterprises is “Complaints will not get feedback or processing” (53.8%) and “They do not know the reporting channels or channels are not smooth” (45.8%). Other reasons are in Figure 2. This result reflects that the public awareness in the field of green consumption, waste classification, environmental protection, and social supervision still needs to be increase.

Figure 3 Reasons for refusing to act



The coefficient of the interaction term between the 1 period lag of the logarithm of the number of Internet users and industrial structure is statistically significant at the 5% level and negative, which is -0.054. This result indicates the recessive environmental regulation can decrease electricity consumption per GDP indirectly through accelerating industrial restructuring. Recessive environmental regulation will cause the government to pay more attention to the serious pollution enterprises. Then the government can impose strict environmental measures accordingly to restrain the polluting enterprises. If those enterprises with high energy consumption and high pollution can't get profit under strict environmental regulation, they will exit the market. In addition, the demand for efficient and clean production will rise with the increasing awareness of environmental protection.

The coefficient of the interaction term between the 1 period lag of the logarithm of the number of Internet users and the logarithm of the quantity of domestic patent application is also negative at the 5% level, which is -0.004. This result indicates the recessive environmental regulation can decrease electricity consumption per unit of GDP indirectly through promoting technological innovation. However, this effect is very small. The reason may be that the government incentives for technological innovation are not enough. For some small enterprises, there is not enough money to invest in technology research and development under intense competitive pressure in eastern China.

The coefficient of the interaction term between the 1 period lag of the logarithm of the number of Internet users and the logarithm of foreign direct investment is statistically significant at the 10% level and positive, which is 0.005. This result indicates the recessive environmental regulation cannot decrease electricity consumption per GDP indirectly through optimizing the structure of foreign investment and stimulating foreign green investments. The reason may be that for developing countries to grow, they reduce their staff salary standard, set environmental regulations with low thresholds, and investigate the foreign capital enterprise loosely. In this case, pollution-intensive foreign industries will enter and increase energy consumption and environmental degradation. The Pollution Haven Hypothesis (PHH) states that as a result of increased regulation, multinationals shift their dirty production to countries with poor environmental standards. Fakhreldin and Elsawy (2018) using data for FDI inflows into China showed that there is a statistically significant negative relationship between Chinese environmental regulations and FDI, which supports the PHH.

$$ME_2(lnniu|inds, lndpa\ and\ lnfdi) = 0.031 - 0.054inds - 0.004lndpa + 0.005lnfdi \quad \text{(vi)}$$

4.6. Robustness Test

First, using the logarithm of the total industrial sulfur dioxide emissions (unit: ton) as the dependent variable, robustness test results are presented in Table 7.

Table 7 SO2 robustness test

Variable	Statistic

l.lnniu	0.901***
	(0.284)
l.ni	0.596***
	(0.117)
lnd	-0.055***
	(0.012)
lnf	-0.004
	(0.018)
CONTROLS	YES
CONS	10.785***
	(2.101)
R-Squared	0.594

* =10% significance, **=5% significance, ***=1% significance.

As previously found, Table 7 suggests that the direct effect coefficient is positive and statistically significant. The indirect effect coefficient regarding foreign direct investment is statistically insignificant. The indirect effect coefficient about the quantity of domestic patent application is negative and statistically significant. Notably, these are similar to the result when using the logarithm of consumption of electric power per unit of GDP as the dependent variable.

Second, using the logarithm of the number of mobile phone subscribers as the core independent variable, the robustness test results are presented in Table 8.

Table 8 Mobile robustness test

Variable	Statistic
l.lnmobile	0.022**
	(0.009)
lmi	-0.045***

	(0.013)
lmd	-0.004***
	(0.001)
lmf	0.004**
	(0.002)
CONTROLS	YES
CONS	0.223**
	(0.089)
R-Squire	0.892

* =10% significance, **=5% significance, ***=1% significance.

This table shows that the direct effect coefficient is positive and statistically significant, and the indirect effect coefficients about industrial structure and level of science and technology are negative and statistically significant. The indirect effect coefficient about foreign direct investment is positive and statistically significant. These are similar to the result when using the number of Internet users as the core independent variable.

In conclusion, through the robustness test above, it can be seen that the core independent variable and dependent variables are robust.

5.0 CONCLUSION AND POLICY IMPLICATIONS

This paper uses panel data concerning 14 provinces in eastern China from 2008 to 2016 to empirically test the direct and indirect effects of recessive environmental regulations on energy conservation and emission reduction. The conclusion are as follows. First, the direct supervision for energy consumption and emission reduction from the public has no impact on improving energy efficiency, and even increases per capita energy consumption in eastern China. Second, recessive environmental regulation can decrease per capita energy consumption indirectly through optimizing the structure of foreign investment and stimulating foreign green investments, and decrease energy consumption per unit of GDP indirectly by accelerating industrial restructuring, promoting technological innovation. However, the effect on optimizing the structure of foreign investment and promoting technological innovation is not obvious. This reflects the intensity of recessive environmental regulation is not big enough in eastern China. The government may set environmental regulation with low threshold and investigate the foreign capital enterprise loosely. In addition, the government incentives for technological innovation are not enough.

Based on the above research conclusions, I put forward to the following implications:

First, the government should lower the entry threshold like registration standards and institutional barriers for Non-Governmental Environmental Protection Organization in order to make full use of recessive environmental regulation as supervisor. These organizations should play a role in promoting environmental awareness and participating in contentious proceedings. Litigation is still the last and most powerful tool for environmental protection. Due to the gap in capital strength, ordinary people cannot compete with large enterprises, and they do not have enough economic strength to carry out environmental monitoring, technical appraisal and analysis. In addition, it is very important to increase public awareness of environmental protection. A sound supervisory system should be established. A smooth path should be established for the public supervising enterprises' pollution behaviour. The popularity of environmental protection hotlines, protection of informants, media exposure and local government supervision are all important.

Second, it would be better to investigate the foreign capital enterprise seriously. Foreign capital will flow in green industry under the influence of public opinion. This will promote green adjustment of the industrial structure.

Third, the government should encourage enterprises to increase their investment in research and development by increasing financial subsidies. Then under the effect of recessive environmental regulation including but not limited to the Non-Governmental Organizations, the media and the public, high energy consumption enterprises would be conducive to improving their production technology, improving industrial competitiveness, and developing clean recycling and high-tech production pattern.

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APPENDIX A

Empirical Results about Per Capita Energy Consumption(pcec)

variable	RE	FE	OLS
l.lnniu	3.363*** (1.066)	3.957*** (1.200)	-1.192 (0.844)
lni (interaction term)	-0.035 (1.783)	-0.446 (1.702)	5.364*** (1.562)
lnd (interaction term)	0.021 (0.140)	0.073 (0.120)	-0.082 (0.140)
lnf (interaction term)	-0.476** (0.216)	-0.623** (0.239)	-0.115 (0.183)
lnfdi	3.432** (1.640)	4.370** (1.715)	1.256 (1.379)
inds	0.435 (12.769)	3.223 (12.900)	-37.628*** (11.049)
lngrdp	-0.367 (0.839)	-0.170 (0.722)	0.370 (.603)
lndpa	-0.091 (1.180)	-0.458 (0.946)	0.214 (1.094)
lnpd	-0.639*** (0.210)	-0.640* (0.354)	-0.109 (0.174)
lnvrf	0.631 (0.697)	0.576* (0.295)	0.535** (.271)
lniipc	-0.021 (0.069)	-0.033 (0.082)	0.280** (0.115)
constant	-19.931** (8.185)	-24.380** (9.659)	-0.398 (4.876)
N	112	112	112
R-squared	0.256	0.264	0.596

* =10% significance, **=5% significance, ***=1% significance.

APPENDIX B

Empirical Results about Energy Intensity(ei)

variable	FE	RE	OLS
l.lnniu	0.031** (0.012)	0.036*** (0.011)	0.013 (0.016)
lni (interaction term)	-0.054** (0.019)	-0.061*** (0.016)	0.068** (0.029)
lnd (interaction term)	-0.004** (0.002)	-0.003*** (0.001)	-0.001 (0.003)
lnf (interaction term)	0.005* (0.002)	0.005** (0.002)	-0.004 (0.003)
lnfdi	-0.036** (0.017)	-0.032** (0.016)	0.038 (0.026)
inds	0.417** (0.143)	0.479*** (0.123)	-0.458** (0.206)
lngrdp	-0.037** (0.015)	-0.036*** (0.007)	-0.028** (0.011)
lndpa	0.029** (0.014)	0.028*** (0.009)	-0.003 (0.020)
lnpd	-0.004 (0.003)	-0.006* (0.003)	-0.002 (0.003)
lnvrf	-0.002 (0.004)	0.001 (0.003)	0.018*** (0.005)
lniipc	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)
constant	0.262*** (0.060)	0.188** (0.091)	0.023 (0.091)
N	112	112	112
R-squared	0.891	0.886	0.572

* =10% significance, **=5% significance, ***=1% significance.

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