Influence of Environmental Regulation and Energy Price on Energy Efficiency

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Abstract. In recent years, the Chinese government has attached great importance to the improvement of energy efficiency, and has formulated many corresponding policies for this purpose. Based on the theoretical analysis, this paper selects the relevant provincial data from 2009 to 2015, establishes a panel model and adds a dynamic panel model of lagging energy efficiency, and studies the effect of the combination of environmental policy and energy price on energy efficiency. The results show that environmental regulation has a negative effect on energy efficiency after eliminating endogenous models, and energy prices have a significant positive effect on energy efficiency. According to the above empirical results, the following policy recommendations are proposed: (1) to improve environmental legislation and supervision, continue to accelerate the study of economic regulation and environmental regulation policies; (2) continue to give full play to the significant role of energy prices in energy efficiency, continue to accelerate the market-oriented reform of factors, and gradually establish market-based policy tools.

Keywords: Environmental Regulation, Energy Price, Energy Efficiency, System GMM

1. Questions and Literature Review
At present, the economic loss caused by ecological pollution caused by China's highly energy-dependent mode of production accounts for 2% to 3% of the total GDP, and the energy problem has become one of the bottlenecks in the development of China's economic competitiveness. Today, when the economy has changed from high-speed growth to high-quality growth, energy efficiency has become an important indicator of high-quality growth. The purpose of energy conservation is not simply to reduce energy consumption, but to achieve economic growth with low input and high output. For China, the fundamental way to achieve the goal of energy conservation and emission reduction is to improve energy efficiency [1]. At the 2015 Paris Climate Conference, General Secretary Xi Jinping solemnly promised the world that carbon dioxide emissions would peak around 2030 and strive to achieve them as soon as possible. In 2016, 14.38% of China's global economy consumed 22.9% of the world's energy and "contributed" 30.0% of greenhouse gas emissions [11]. In the 2018 Environmental performance Index report released by Yale University, China's air quality ranks fourth from the bottom. As the issue of energy use has attracted more and more attention around
the world, China, as the largest carbon emitter in the world, has been pushed to the forefront of public opinion, and there have been voices condemning China's "contribution" to global carbon emissions. Excessive energy consumption and carbon emissions are still huge obstacles that China must overcome, and if not handled properly, it may even cause great damage to China's accumulated economic development achievements in recent years.

Zhang Zongyi et al. (2010) according to the assumption that all factors have the same marginal productivity in economics, the rise of energy prices can improve energy efficiency by affecting the substitution effect of factors [3]. Wang Junjie et al. (2014) analyzed the data from 1995 to 2012 and concluded that when the energy price is low, enterprises will use more energy elements instead of other elements, and only when the energy price is high enough will have a significant impact on energy efficiency [4]. Tang Jianrong et al. (2015) analyzed the adjustment effect model of energy prices to find that energy prices have a regulating effect on energy efficiency through consumption structure, industrial structure, and technological progress [5]. Zhou Wuqi (2016) clarified that prices have different effects on energy intensity in different industries [6]. Yang Jin et al. (2017) put total factor productivity, energy price, and energy intensity in a system, and studied the impact of the interaction terms of energy price and total factor productivity subvariables on energy intensity [13].

Not only market-based policy tools are concerned by scholars at home and abroad, environmental regulation, as a command-based policy tool, has always been the key object of scholars' research. For example, Chang et al. (2018) conducted an empirical test using panel data from 31 OECD countries and found that higher government efficiency can significantly reduce local energy intensity by improving energy efficiency [7]. Wan Lunlai et al. (2010) found that environmental regulation and economic development are conducive to the improvement of energy efficiency [8]. You Jihong et al. (2013) analyzed the data of Xinjiang from 1990 to 2010 and concluded that whether from the perspective of single-factor energy efficiency or total factor energy efficiency, environmental regulations will have a negative impact on energy efficiency [9]. Li Bin et al. (2016) found that the negative impact of imperative environmental regulation on energy efficiency is not significant, but it will have a significant negative impact on energy total factor productivity by restraining green technology innovation [10]. Wang Teng and Yan Liang (2017) subdivide the intensity of environmental regulation [2]. When the intensity of regulation is low, environmental regulation has a positive impact on energy efficiency, while when the intensity of regulation is high, environmental regulation has a negative impact on energy efficiency.

On the basis of previous research, some domestic scholars have begun to combine the two aspects of research to explore the relationship between environmental regulation, energy prices and energy efficiency. Hu Bentian and Huang Huihui (2017) used the method of factor analysis to measure the intensity of government environmental regulation from 2000 to 2015, and introduced energy prices to establish an econometric model [1]. The results show that environmental regulation has a lagging effect on the improvement of energy efficiency. Energy prices are not conducive to the improvement of energy efficiency.

As a market-oriented policy tool, raising energy prices can promote manufacturers to reduce production costs and improve energy efficiency. On the other hand, environmental regulation, as a command policy tool, can improve green technology innovation and energy efficiency within a certain range. The purpose of this article is to verify whether the simultaneous implementation of these two policies is conducive to promoting energy efficiency.

2. Model Setting and Variable Description

2.1 Variable Description and Variable Calculation

Energy efficiency (EE). This paper will use the method of DEA-SBM to study energy efficiency. The SBM model considering the unexpected output is constructed as follows:
In this paper, the standardized industry comprehensive energy cost is used to
study the impact of environmental regulation on energy efficiency. Internalizing external costs of companies in a "carbon pricing" way is a good idea to
improve energy efficiency. Economic openness plays a very good role in improving
energy efficiency. With reference to the practice of Ye Qin[12], etc., a comprehensive index method was adopted to construct a comprehensive measurement system.

Control variables. Other important factors affecting energy efficiency are introduced into the econometric model. ①The proportion of state-owned(OS) assets reflects the characteristics of the ownership structure of the region. ②Industrial structure (IS). The acquisition method is as follows: the output value of the secondary industry / GDP. ③Foreign Direct Investment(FDI) is expressed by the proportion of the output value of foreign-invested industrial enterprises to the total output value.

2.2 Setting of Econometric Model
This paper will use the panel model to study the impact of environmental regulation on energy efficiency and the impact of energy prices on energy efficiency. The fixed effect model was used to test the sample data according to Hausman. The model is set up as follows:

\[
EE = \alpha_0 + \alpha_1 ER + \alpha_2 EP + \alpha_3 OS + \alpha_4 IS + \alpha_5 FDI + \varepsilon_i + \eta_i + \varrho_i
\]

Because the technological innovation of energy efficiency may have path dependence [50 ~ 51] and the lagging effect of environmental regulation, this paper will establish a dynamic panel data model with a lag of one period. This paper will use the system GMM for analysis.

\[
EE = \beta_0 + \beta_1 EE_{it-1} + \beta_2 ER + \beta_3 EP + \beta_4 OS + \beta_5 IS + \beta_6 FDI + \varepsilon_i + \eta_i + \varrho_i
\]

3. Empirical Analysis and Result Discussion
Comparing the results of the static and dynamic panel data models, it can be found that the effects of environmental regulation in the static panel data model are overestimated due to endogenous reasons. Environmental regulations have a negative impact on energy efficiency, with an impact coefficient of -0.103. It indicates that the intensity of government environmental regulation is not reasonable at present, or it may be that the policy transmission of environmental regulation is not in place, so that it does not play its due role. Energy prices have a significant positive impact on energy efficiency, with the largest impact coefficient among all variables. Energy prices play a very good role in improving energy efficiency. Internalizing external costs of companies in a "carbon pricing" way is a good idea to improve energy efficiency. Economic opening has a positive effect, with an estimated coefficient of 0.2707. It shows that the "pollution paradise" hypothesis is not applicable in China, and the
introduction of foreign capital has exerted the pollution halo effect. Opening up to the outside world can bring about a positive impact on improving energy efficiency, but this impact is not very significant, which proves that China is more dependent on independent innovation and has more room for development.

Table 1. Results of model estimation

| Variable | Fixed effect model | System GMM model |
|----------|--------------------|------------------|
| ER       | 0.0659**           | −.1030*          |
|          | (0.0330)           | (0.6210)         |
| EP       | 0.7668***          | 0.6709**         |
|          | (0.2487)           | (0.3063)         |
| EE\(_{-1}\) | 0.9984***       |                 |
| FDI      | −0.1229            | 0.2707*          |
|          | (0.1193)           | (0.1658)         |
| IS       | −0.7782***         | -2.2118          |
|          | (0.2422)           | (0.4485)         |
| OS       | 0.2670**           | 0.1062           |
|          | (0.1208)           | (0.1454)         |
| Sargan test | 0.5976             |                 |
| AR(1)    | 0.0425             |                 |
| AR(2)    | 0.1317             |                 |

Note: *, ** and *** represent significant variables at the levels of 10%, 5% and 1%, respectively.

4. Conclusion
The policy implications of the above empirical results are: First, environmental regulations have a negative effect on promoting regional energy efficiency improvement. The core role of environmental protection and regulatory authorities in promoting energy conservation and emission reduction processes should be strengthened, environmental legislation and supervision efforts should be strengthened, and continued acceleration research on economic regulation and environmental regulation policies, such as steadily advancing environmental tax reform and improving emission trading mechanisms. Second, continue to give full play to the significant role of energy prices in energy efficiency, continue to accelerate the reform of factor marketization, and gradually establish market-based policy tools as the core content of China's energy efficiency working mechanism. Based on China's current energy price situation and its price-to-price relationship with production factors such as capital and labor, formulate an energy price formation mechanism that can fully reflect its market supply and demand relationship, resource scarcity, and environmental protection costs.

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