Environment, Resource and Ecology Journal (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/erej.2025.090205
ISSN 2616-3756 Vol. 9 Num. 2

Analysis for Eco- Innovation Performance under Environmental Regulation Pressure in China—Based on "Porter Hypothesis"

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Keywords: Environmental Regulation Pressure, Eco-Innovation Performance, "Porter Hypothesis"

Abstract: This paper provides an analysis of the relationship between the environmental regulation pressure and eco-innovation performance in Chinese industry. This allows us to have a comprehensive study about the Porter Hypothesis which insists the properly designed regulation pressure can be captured through the turning point of a non-liner "U" relationship.

1. Research Background

At the stage of industrialization in China, economic growth relies heavily on energy consumption, which brings more pollution to our environment. Even though China has riveted attention on improvement, there is also an increasing amount of energy used every year. According to the statistics, emission discharge from energy consumption increases dramatically and brings us more pollution. Economy needs to develop at the expense of energy consumption, in which case, eco-innovation targeting on increasing energy efficiency is crucial in the world as well as in China. Many patents have been granted to each country for environment protection in recent years, such as the technology for water discharge reduction or for waste recycling. It is important, because it not only reduces the cost of complying with the environmental regulations, but also brings an absolute advantage over industries (Porter, 1995) [1].

The relationship between environmental regulation pressure and eco-innovation performance has drawn more attention than ever before, as environmental regulation is an important factor influencing eco-innovations either for its positive or negative effect (Rennings,2012) [2]. At present, about 50 environmental policies have been put into practice in China, and by regulating production behavior, government tries to improve environmental quality and increase energy efficiency. Environmental Discharge Standards, for example, is one of them and has been widely used especially in high-pollution industry. However, there is a "dilemma" between environmental regulation stringency and economic development for the industry. That is, we have to obtain one target at the expense of giving up another one. China is still at the stage of industrialization and industry is looking for the way for profit- maximization. Taking the manufacture industry as an example, it is so important that it cannot be downsized even though it suffers more under the stringent environmental regulation. Through this, we can understand why policy makers are much confused about a properly designed regulation.

From a static point of view, “Traditional Hypothesis” argues that under the optimal condition, the technology, resource and consumption demand in the industry are all fixed. At this point, stringent regulation will only increase industry’s cost and weak its innovative ability (Brann Lund, 1999; Barara & Mconnell, 1990) [3]. While from a dynamic point of view, Porter argues that the environmental regulation can serve industrial eco-innovation as time goes by, even though there may exist a negative effect from regulation at first. However, a properly crafted regulation pressure shows contemporaneous positive effect on eco-innovation once set up, because increasing environmental regulation stringency will incent the industry to find a less cost way to reduce pollution. The view is called the “Porter Hypothesis”. Additionally, Porter believes that due to the heterogeneity, the sector with high load of pollution would be more powerful for innovation under the stringent regulation, so scholars chose some specific high-polluting industries to process their test. Based on the literature, this paper is extended to study further about the turning point of this “U” relationship between the environmental regulation stringency and eco-innovation performance. This can be used to identify the reasonable environmental regulation pressure suitable for China to promote eco-innovation.

2. Overview of Chinese Environmental Regulation Pressure and Eco-Innovation Performance

2.1 Environmental Pollution Situation in China

In China, with the rapid economic growth, environmental pressure is much heavier than before, especially pressure from industry production. According to the statistics (CDIAC), in 2010, industrial waste gas emission has reached 51 million, waste water emission was 617.3 billion, and solid waste stood at 24 billion tons. Furthermore, the annual sulfur dioxide emission has increased a lot, more than 19.4 million tons during the decades. The same with industrial nitrogen oxides, it has increased from 11.36 million tons to 14.65 million tons from 2006 to 2010. It can be concluded that industry has become the main polluter that restricts economic development.

Additionally, during the period of industrialization in China, economic growth relies heavily on energy consumption, which brings more pollution to our environment. Taking CO2 as an example, its annual average emission rate in energy use has reached 11.7% in 2009 (EIA World Energy outlook 2013), as Figure1 shows:

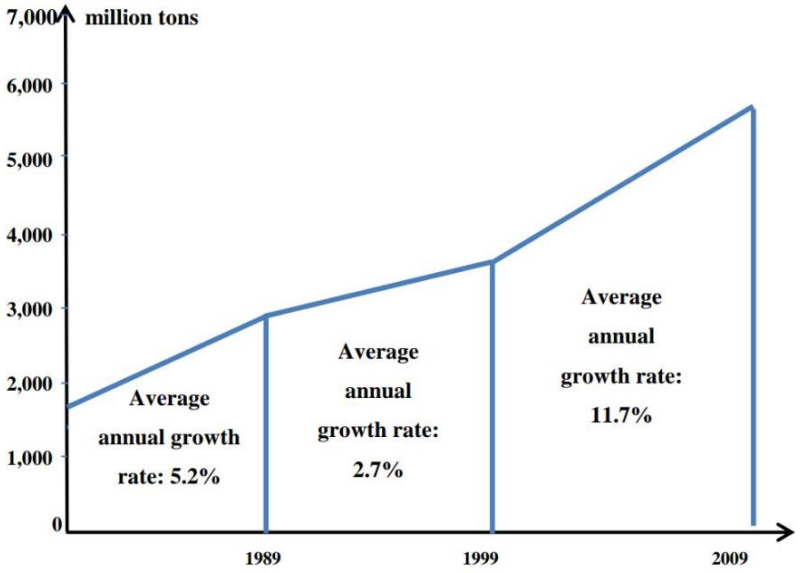

Figure 1: CO2 Annual Growth Rate from Energy Use in China.

Source: EIA World Energy Outlook 2013

It is not realistic to reduce energy consumption, as it is an important resource for economic development. Even in the following considerable period of time, China will continue to be at the stage of industrialization when more energy will be used than before. On the one hand, China is short of energy in many areas. On the other hand, energy efficiency is far below the average level of the world, even lower than some developing countries, like Brazil and India. The Figure 2 is the current situation of energy consumption in China, United State and India. Among these three countries, China has a sharply increasing trend for energy consumption. What's more, it is estimated that energy consumption in China will be twice as many as the amount of the United State in two decades (EIA International Energy Outlook 2013).

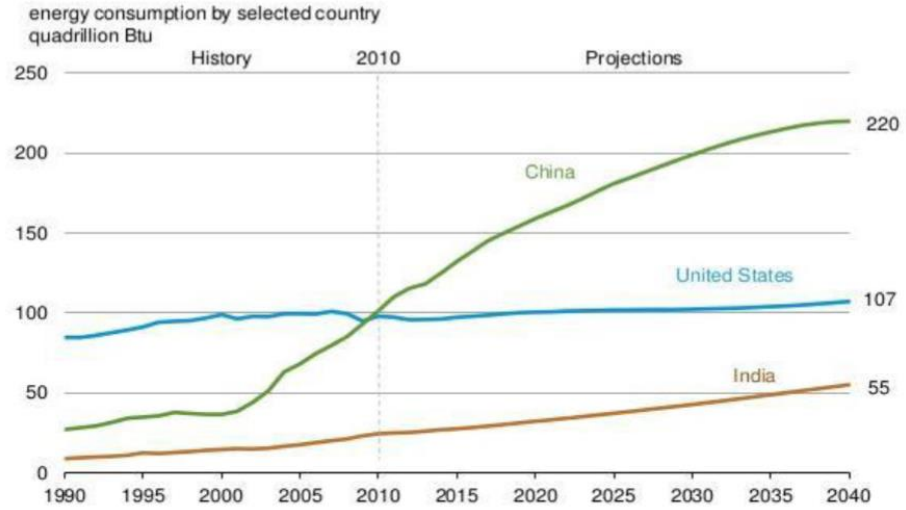

Figure 2: Total Energy Consumption from Selected Countries.

Source: EIA International Energy Outlook 2013

Additionally, it can be figured out in Figure3 that in China, energy consumption from industry accounts for the largest part compared to other sectors, indicating an urgent requirement for increasing energy efficiency in Chinese industries. In that situation, adopting an economic mode in conformity with improving energy efficiency is urgent and how to enhancing energy consumption efficiency is crucial.

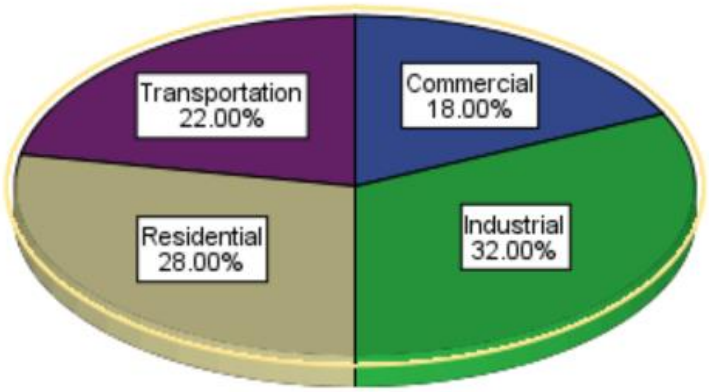

Figure 3: Energy Consumption by End-Use Sector in China.

Source: IEA World Energy Balance 2008

2.2 The Need for Environmental Regulatory System in China

Environmental regulation is needed urgently facing the situation of the severer pollution and higher energy consumption. With industrialization and economic system reform, environmental regulation system in China experienced a long way from scratch. Only by complying with the economic reform can it make sense in economic society, given the reasons that 1.Economic reform incents economic development which is featured by rapid growth, optimal structure and high production efficiency. 2. Population growth will continually bring pressure on environment. On one hand, more energy is consumed and high demand needs for environment protection on the other hand. 3. Under the situation of social stratification, income disparity and urbanization, many social groups turn up and their interest clash with each other. In this case, resource allocation fairness has become the main issue of development. 4. Environmental polluters have changed from state owned industrial enterprises to various private enterprises as well as agricultural activities. Facing with such change, regulation needs improvement. 5. Globalization has a profound impact on industries. Market has more power to rearrange the resources and the industry is much more sensitive in front of market signal. In that case, environmental regulation is crucial for our society.

2.3 Situation of Innovation Performance in China

Under the strain of pollution, more technologies are invented, such as those for acid rain control, eutrophic lakes protection, cleaning production, and so on. These technologies have been put into widely application in different areas. With these technologies, the environment is intended to be protected and energy efficiency to be increased.

However, even though China has riveted attention on innovation for energy efficiency, it is not enough. It is acknowledged that China is the largest “manufacturing power” in the world. “Made in China” is ubiquitous, from products to the producing capital. Manufacture industry has played an important role in China’s development during the past two decades as its total amounts ranked the fourth in the world. Low innovation ability makes Chinese manufacturing industry short of intellectual property rights. Intellectual property right protection still stay at the initial stage and the invention patents belonging to them are few, however. All these require technology progress in manufacturing industry—the pillar industry in China.

2.4 Development of Industrial Environmental Regulation

Over 50 years, industrial environmental regulation has experienced a dramatic change. During the different stages of development, there shows various implementing measures environmental protection. The typical industrial environmental regulation is presented as the follows.

In the 1970s, as industrial economic accelerated, “High Input, High Consumption” policy was set out in heavy industry, which played an important role in economic development. They have not realized the damage of industrial pollution and there were short of the pollution abatement technologies, so they focused only on large scale production at the expense of higher environmental pollution. Environmental regulation was few except for some control-and-command measures like *“Three Simultaneousness”* Deposit and Pollution Discharge Standard. Usual regulation was to remove non-abatement equipment compulsively and charge emission fee, especially in high-pollution industries.

Since the 1980s, industrial environmental regulation focused on *“Prevention and* Responsibility”. Government forced industries to be responsible for what they have done during the producing process. Industries started to apply end-of-pipeline solutions to dispose wastes in production. The so called “end-of-pipeline” technology was incorporated into existing producing process at the final stage but

not the specific procedure during the process. They seemed to be incremental innovative when facing regulation pressure while leaving the production almost unchanged. Since the 1990s, industrial environmental regulation focused on "Sustainable Development". Market- based measures were put into use and these regulations emphasized on reducing industries' cost and maximizing profits. Emission trading was a good example. A limit on pollutant emission was set up and sold as emissions permits. Industries are required to hold a number of permits which is equivalent to their emissions and the total amount of emission cannot exceed the al l owed discharge permit. Industries with high load of pollution need buy permits from those whose practical demand is fewer than they are permitted so as to be allowed emitting more pollutants. Market-based measure makes industry adopt a more proactive measure for environmental abatement and cut down their costs.

In 21st century, industrial environmental regulation focused on "The Scientific Development", which calls for more industrial environmental-friendly zones. They diversified their measurements and made efforts to establish environmental-friendly systems of price, trade and tax.

2.5 Industrial Performance under Environmental Regulation Pressure

Environmental regulation focuses on high-pollution industry production behavior especially, due to their large amount of energy consumption and pollution discharge every year. Government makes efforts on strict supervision and entry requirements. Besides complying with the National Discharge Standards, sectors with high load of pollution would also be supervised by other channels. Taking leather industry as an example, some pollution substance like CODCr and BOD5 are controlled strictly by the supervision center. Hydrolyzed leather protein generated during the production process would be inverted into ammonia-nitrogen, nitrate nitrogen and nitrous acid, and is controlled directly by government. Industry has to take a comprehensive measure to deal with the pollution and advanced abatement technology should be applied to meet the regulation requirement such as the refrigeration system, the technology of cortex dictamnilotion extraction which is both needed in clean production and the separation of CrII and Sulfide should be used for pollution management. China, as the largest battery producing country in the world, suffered heavy metal pollution, therefore, government takes various measures to control the development of such heavy metal industries. Various substances discharged from battery like PB, Hg, Cd, Ni, Zn are regulated by government and feasibility of such standards has also been leveled to the international standards. In order to decrease pollution discharge, heavy metal industry has to take various measures from several aspects, such as using raw and auxiliary materials, upgrading products structure, deepen treatment for polluted water and putting forward a complete management system. All these indicate that, abatement requirement for high-pollution industry is stricter than before, so industry has to spend more to comply with environmental regulation.

In fact, there is a "dilemma" between environmental regulation pressure and economic growth of the industry. That is, we have to obtain one target at the expense of giving up another. Some scholars suggest that the problem in China is not the lack of regulations but that executors cannot implement the discharge standard well. Stringent regulation increases their costs and makes them suffer more. Abatement makes them lack of innovation funds, which lowers their technology efficiency. To make the things worse, it is not illegal to violate those requirements, so enterprises failing to abate are not published and some are even unwilling to reduce emit.

To improve industrial abatement performance, we need to regulate them by transferring this responsibility into internal costs and put more pressure on them. According to "Porter Hypothesis", a properly designed regulation would incent industry to innovate, especially for high-pollution industry, which would have more power to innovate compared with the low-pollution one, and would have higher efficiency under stringent regulation. In China, whether this argument can be applied needs a

comprehensive analysis.

3. Literature Test for "Porter Hypothesis"

3.1 "Porter Hypothesis": "Win-Win" Theory

From a dynamic point of view, Porter argues that the environmental regulation can serve industrial eco-innovation as time goes by, even though there may exist a negative effect from regulation at first. However, a properly crafted regulation pressure shows contemporaneous positive effect on eco-innovation once set up, because increasing environmental regulation stringency will incent the industry to find a less cost way to reduce pollution. The view is called the "Porter Hypothesis". Additionally, Porter believes that due to the heterogeneity, the sector with high load of pollution would be more powerful for innovation under the stringent regulation, so scholars chose some specific high-polluting industries to process their test.

There is a continuing controversy over the exact connotation of "Porter Hypothesis". Most papers disaggregated the "Porter Hypothesis" into its component parts which they think Porter focuses on. Innovation is often more than offsetting any additional regulatory costs, which makes industries more competitiveness. In a sense, regulation pressure will broaden their horizon for new process to compliance regulation as well as increase their competitiveness. This is called the "strong" version, by which Porter linked the regulation pressure to industries competitiveness.

In the "narrow" version, Porter noted that the industry coming from the country with more stringent regulation may be more competitive than that coming from the country with relaxed regulation. By this, Porter challenged regulation policy makers to explore the probable effects of their actions that will incent innovation and increase competitiveness. This version is often used when comparing between nations.

3.2 Opponents for "Porter Hypothesis"

There are some opponents against "Porter Hypothesis". They thought there is no positive effect of regulation on eco-innovation performance and most of the evidence supporting "Porter Hypothesis" is accidental. Since firms are rational enough to make a right decision for profit, it is not necessary for regulation to incent firms to innovate. Additionally, under the regulation pressure, abatement costs are so high that cannot be ignored in the first place, because the requirement for buying abatement capital brings more cost to the industry, causing total cost higher than before (Barbera & McConnell, 1990). In a similar manner, the amount or combination of conventional inputs necessary to produce the manufactured and innovation output are affected by the requirement for the abatement capital (Christensen & Haveman,1981) [4]. Kemp (2011) suggested that requirement for environmental protection will force industry to pay more for employees. [5] So there shows a negative effect of regulation pressure on productivity (technology efficiency contained). Christensen estimated the effect of environmental regulation on technical efficiency of U.S. states' manufacturing industry level (2- digit SIC codes). They estimated the trans log stochastic frontier model accommodating heterogeneity in the production function and the results showed that there is a negative effect of environmental stringency on technical efficiency.

3.3 Support for "Porter Hypothesis"

Porter emphasized that competition advantage does not rely on the static state, instead, it relates more to the dynamic process of the improvement. Properly designed regulations will incent industry to innovate and progress in the future. At first, higher regulation pressure makes them suffer more,

they have to adjust their production mode and improve their competitiveness gradually. More innovations would arise under higher regulation pressure.

Many evidence was showed in China. Li Bin (2011) [6] processed his study at province- level in China, squared pollution abatement activity was added to measure regulation pressure and pollution emission amount was chosen to measure eco-innovation performance. He found the "U" relationship between regulation pressure and eco-innovation performance, because though industries are short of the ability to transfer abatement cost at first, as regulation pressure increases, more power would be provided for them to innovate and offset regulation compliance cost. So he suggested a properly designed regulation pressure should be increased to the level at least which the turning point shows. Zhang Cheng (2011) [7] compared southern, middle and western areas in China and intended to exam "innovation offset" under regulation pressure in China based on industry-level. Squared pollution investment was used to measure regulation stringency. Compared to the western area, "U" relationship existed in southern and middle areas, besides the economic reason, they thought when facing regulation pressure, industry would transfer part of funds from innovation for abatement, which gives a negative effect on eco-innovation performance firstly. But when given higher regulation pressure, industry has to invest more on innovation to increase their competitiveness later. In that case, a positive effect exists due to the increase of regulation pressure. So he argued that government should increase regulation pressure continually and give a different stringency level in each area.

3.4 "Porter Hypothesis" in High- Pollution Industry

Porter (1995) [1] also argued the high-pollution industry will have more opportunities to identify inefficiency and more power for innovation because properly designed regulation informs the industry of inefficiency, which means when facing stringent regulation, pollution-intensive industry would be more sensitive to innovate and have higher efficiency than others. Thus, many scholars explored such relationship in some specific industry especially in high- pollution industries.

Bi (2013) [8] examined the relationship between environmental regulation and technology innovation in thermal power industry of 30 provinces in China. Thermal power industry, with higher energy consumption every year, is an energy-intensive industry in China. Regulation such as energy prices increased continually, however. The relationship between environment regulation pressure and the efficiency of Chinese thermal power was studied in three situations, that is non-regulation, weak-regulation and strong-regulation. He showed us the result that as a whole, environmental regulation has the trend to improve efficiency in Chinese thermal power, however the tendency was only significant in strong-regulation situation currently.

4. Countermeasures and suggestions

Based on the research before, a dynamic situation of regulation pressure is advocate and government should level environmental regulation pressure continuously. Only if regulation pressure is increased to a reasonable level based on sector characteristic, would industry begin to save enough space to innovate at present time and a more stringent regulation is required to be set in the sector with high pollution. It does not mean such behavior is blind because regulatory cost is so high that it cannot be ignored. Taking the textile industry, which is the sector with high pollution, as an example, it already completes a total of US$170.7 billion output from January to July this year and the regulation pressure is advised to increase to the level that forces industry's abatement expense to be at least 10.2% of this amount (about US$17.4 billion) which can transfer the situation to be positive.

Secondly, effect from environmental regulation is not only based on its stringency level but also determines by its tools (Sartzetakis & Constantatos, 1995) [9]. Government should optimize regulation measures as Porter suggests, only a properly designed regulation can make industry more

innovated. Many papers suggested that such policies as environment standards, discharge limits and products prohibition are less effective for innovation, because they are mandated tools and industry suffers heavy financial burden under such regulations (Jaffe, 1997) [10]. For Chinese industries, command-and-control measures are widely used because of their largescale production, which makes them suffer heavily. Some activities such as the paper work, monitoring etc. make the cost of complying with regulations high, and also in some other cases, the cost of compliance may exceed cost of penalties for noncompliance as penalties often not high and firms may choose to violate laws. However, ensuring industry the freedom is important. Compared to command-and-control measure, market-based policy is a better tool for development. Carbon taxes in some countries for example, are arguably more efficient than market restrictions such as CAFE standards because higher prices would cause less consumption and al so results in fuel efficiency in cars (West, 2005) [11]. Therefore, government should combine the command-and-control tool with market-based one to provide industry with more power to innovate and obtain a "win-win" situation (Jaffe & Stavins, 1998) [12].

Thirdly, enhancing R&D input and optimizing technology structure are necessary, especially in high-pollution industry. Additionally, the level of opening-up should be expanded and industry competition advantage be increased by market mechanism to incent eco-innovation performance.

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