Corporate performance under air pollution control: Evidence from "Atmosphere Ten Articles" Policy

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Abstract: Enterprises who are the most responsible for air pollution are also constrained by environmental protection policies the most. As the strictest environmental policy in China, Atmosphere Ten Articles carries the task to balance the relationship between the ecology and economic development. This paper analyzes the impact of this policy on enterprise performance from two perspectives: social performance and economic performance. The corporate life cycle theory is also integrated into the policy evaluation, and enterprise ownership heterogeneity is analyzed. Through decomposition, we found that the policy can promote the enterprises' economic performance through technological innovation and resource allocation effect. This paper extends the existing environmental policy evaluation framework and provides empirical reference for future research.

Keywords: Corporate Social Responsibility; Total Factor Productivity; Atmosphere Ten Articles; Corporate Life Cycle

1. Introduction

Due to the high externality associated with environmental pollution and treatment, it is difficult to solve complex environmental problems only by relying on the market mechanism. Governments across the world have introduced relevant policies to make up for the deficiencies of the market mechanism and promote the transformation of the economy to green and low-carbon (Tanaka, 2015). The environmental problems China is facing are becoming more serious with the rapid development of the economy according to the statistics of *Environmental Year Book of China*. At present, China is at a critical stage of economic transformation, where downward pressure on the economy coexists with pressure on the environment and resource usage. According to *the Bulletin on the State of China's Ecology and Environment* released in June 2020, of the 337 prefecture-level cities in China, only 157 met the city-wide air quality standard, accounting for 46.6 percent of the total. Faced with these dual pressures, China is constantly exploring new paths of harmonious development between the economy and the environment. China made an important contribution to the Paris Agreement at the 21st Conference of the Parties to the United Nations Convention on Climate Change (COP21) in 2015, stating explicitly that China's carbon dioxide emissions would peak in 2030 and gradually decline afterward. The general debate of the 75th session of the United Nations General Assembly on September 22 mentioned that global efforts should be made to be "carbon neutral" by 2060. During 2013 to 2017, with the implication of the strictest clean air policy in China -- "Action Plan of Air Pollution Prevention and Control" (commonly known as "Atmosphere Ten Articles"), the concentration of PM 2.5, a main indicator of air pollution, has dropped significantly

across the country.

Kneese and Schultze (1975) believe that in the long term, an important criterion for the effectiveness of environmental regulation policies is whether the regulation promotes the development of environmental protection technologies. Therefore, effective environmental regulation should not only control pollution emissions and protect the environment, it should also stimulate innovation as much as possible to complement environmental regulation. It should promote the profitability of regulated enterprises, and enhance optimization of industrial structure and economic growth of the regions affected by the regulation. Countries pay great attention to the impact of environmental regulations on technological innovation when they formulate policies, hoping that environmental regulations can stimulate enterprises' productivity (Iraldo et al., 2011).

For different enterprises, the impact of environmental regulation on their performance may also be different. From the perspective of enterprise heterogeneity, this paper discusses the impact of the environmental policy -- the Atmosphere Ten Articles on the enterprise performance. In this research, the corporate performance is measured by corporate social responsibility (CSR) and total factor productivity (TFP), which can be indicators of the enterprise performance from the perspective of social performance and economic performance respectively. Most of the research of the policy effect on enterprises have not focused on the development stages heterogeneity, so we also divide the full samples into several subsamples according to the corporate life cycle and ownership attributes of the enterprise. Different enterprises can formulate different trade-off strategies in the face of regulations, so the effects of those policies on different enterprises may not be the same (Adizes, 1988). It is of certain practical significance for the government to formulate environmental policies according to the development tasks of different stages and the nature of different enterprises in the future, so as to achieve the social and economic goals effectively.

This paper is organized as follows. In the next two sections, the Atmosphere Ten Articles policy and existing research on related topics are summarized and discussed. Section 4 is the description on sample and experimental design. Empirical analysis and results are shown in section 5. Section 6 presents robustness tests. Section 7 discusses the mechanism how environmental policies may function, and section 8 offer further thoughts and conclusion.

2. Policy Review

The high growth and high consumption mode of the economy have brought heavy environmental pressure, and environmental pollution also hinders the healthy development of the economy, with industrial emissions leading the chart (Vennemo et al., 2009). In 2010, the State Council of China adopted the *"Guiding Opinions on Promoting Joint Prevention and Control of Air Pollution to Improve Regional Air Quality"*. In 2012, the *"Twelfth Five-Year Plan for the Prevention and Control of Air Pollution in Key Areas"* systematically and specifically proposed the coordinated control of air pollution. In 2013, the State Council issued the “Action Plan of Air Pollution Prevention and Control” with ten terms, requiring that by 2017, the

concentration of PM10 in cities at and above the prefectural level should be reduced by more than 10% from the 2012 level, and that the number of days deemed at least fair in air quality should increase over the years. The concentration of PM2.5 in the Beijing-Tianjin-Hebei region, the Yangtze River Delta, and the Pearl River Delta should fall by about 25%, 20%, and 15%, respectively. In Beijing, the average annual concentration of fine particulate matter should be kept at about 60 micrograms per cubic meter. This was considered an almost impossible task when the project came out. The assessment of local governments is particularly harsh. The multiple rounds of intensified supervision on air pollution control during the implementation were called "the largest action directly organized at the national level in the history of environmental protection" by the Ministry of Environmental Protection of China.

After the implementation of the policy, between 2013 and 2017, the national average exposure to PM2.5 dropped by 32% from 61.8 micrograms per cubic meter to 42.0 micrograms per cubic meter. Emission reductions have been the leading factor in China's air quality improvement in recent years, contributing 91% to the reduction in PM2.5 exposure levels nationwide, while meteorological conditions contributed only 9% (Zhang et al. 2019).

3. Literature Review

The research on the impact of environmental regulation on enterprise performance has been controversial since the Porter hypothesis was put forward. One view is that environmental regulation improved environmental quality at the expense of enterprise benefits. Researchers believe that environmental regulations cause companies to lose their market share (Jenkins, 1998), and the overall impact on productivity was negative, as the additional costs of environmental regulation in the short term exceeded the positive impact in the long run (Lanoie et al., 2008). In particular, for integrated plants, environmental regulation tended to shift investment from production to emissions reductions, resulting in more significant emission reduction costs and low productivity (Gray and Shadbegian, 2003). In addition, enterprises upstream of the production chain generate relatively higher environmental externality and social costs than the value of their production activities (Clift and Wright, 2000). This is also evidenced by empirical research that the Acid Rain Program (ARP) of the United States in 1990 reduced total factor productivity of coal-fired boilers by 1 to 2.5 percent but reduced industrial output by between 1 and 6 percent (Hancevic, 2016). Tighter environmental regulations have led to a 2.6 percentage point decline in total factor productivity in U.S., particularly with ozone control particularly negatively affecting productivity (Greenstone et al., 2012). In developing countries such as India, environmental regulation has improved environmental quality, but has had little impact on productivity (Harrison et al., 2015).

In contrast, Porter hypothesis holds that technological innovation in enterprises brought about by environmental regulation can offset additional costs and thus enhance the competitiveness of enterprises (Lanjouw and Mody, 1996; Porter, 1991; Popp, 2011). Most of the research on China holds a positive view of the Porter hypothesis. Research shows that energy conservation and emission reduction mainly promote the improvement of total factor productivity through technological progress (Wang and Liu,

2015). Similarly, Emission trading as a market-based environmental regulation improves total factor productivity through two ways: promoting technological innovation and optimizing the efficiency of resource allocation (Ren et al. 2019).

There have also been studies that intend to improve and refine the Porter Hypothesis. Some researchers found that environmental regulation has insignificant effect on improving green production among enterprises in heavy polluting industries, and the effect does not lag over time (Wang and Zhang, 2019). However, there is an inverted U-shaped relationship between the intensity of environmental regulation and the total factor productivity of carbon-intensive enterprises, that is, it does not meet the long-term Porter hypothesis. Different carbon-intensive industries are in different phases of the inverted U-shaped curve, with some industries already exceeding the inflection points (Zhao, Liu and Yang, 2018), which means environmental regulation may promote these enterprises' total factor productivity. However, when the intensity of environmental regulation is too stringent for companies to bear, total factor productivity may decline (Wang and Liu, 2014). Others found that there may be a two-way dynamic relationship between environmental regulation and firm productivity. The impact of emission reduction policies on green total factor productivity can be time-sensitive. The recent environmental policies may indeed promote the growth of green total factor productivity, but in the long run, the environmental policies may become outdated and fail to promote the growth of green total factor productivity (Huang, Hu and Chen, 2018).

At present, scholars have closely investigated the improvement in environmental conditions as a result of environmental policy. The implementation of the Atmosphere Ten Articles has significantly reduced PM2.5 concentration and related health issues of residents in China (Zhang et al., 2019). However, there are few studies on the economic benefits of the Atmosphere Ten Articles. Peng et al. (2020) reached the conclusion through quasi-natural experiments that the Atmosphere Ten Articles are beneficial to the improvement of total factor productivity in energy development, but the promotion may become difficult to realize due to the industrial division of labor and the energy market price mechanism.

4. Data and Methodology

The key empirical objective of this paper is to evaluate the causal effect of Atmosphere Ten Articles on firm performance. Based on the above background, we choose the policy as an exogenous shock to construct a quasi-natural experiment. This study is based on listed enterprises in Shanghai and Shenzhen stock market A-share from 2010 to 2019. Data come from information disclosure of listed companies in China Stock Market Accounting Research (CSMAR). The CSR index data is from Hexun[1]. The TFP data are calculated based on the estimation procedure of Olley & Pakes (1996) and Levinsohn & Petrin (2003).

[1] Firm level CSR data is collected from http://stock.hexun.com/, which collects data form the social responsibility reports and annual reports issued by enterprises listed under Shanghai Stock Exchange and Shenzhen Stock Exchange.

In our Difference in Difference (DID) model, we take the listed firms that lies in the 'Atmosphere Ten Articles' policy target area as the treatment group, which include cities in the Beijing-Tianjin-Hebei, Yangtze River Economic Delta, and the Pearl River Delta regions, as well as municipalities and provincial capital cities. Other cities form the control group. We adopt the following DID model specification:

$$Y_{it} = \beta_0 + \beta_1 AT_{it} + \delta \sum X_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is performance which include the measurement for CSR and TFP. CSR is an indicator measuring the firm's level of responsibility, which is a weighted variable of shareholders' responsibility, employees' responsibility, rights and interests of suppliers, consumers, environmental responsibility, as well as social responsibility.[2]

AT_{it} is a dummy variable that indicating if firm *i* is during the Atmosphere Ten Articles policy implementation period at year *t*. X_{it} present a set of control variables:

Firm Size (Asset) Larger companies are generally pay more attention to social responsibility performance and tend to have higher efficiency (Hall and Ziedonis, 2001). We use the logarithm of total assets to represent the size of the company (Chang et al., 2015).

Firm Age (FA) With the increase of the age of the firm, the organizational inertia will reflect on its social responsibility and productivity (Adizes, 1988).

Firm Growth (FG) The higher the growth of the firm, the lower the elasticity of daily expenditure. It is measured by: (current operating income - Operating income of last year)/Operating income of last year.

Return on Total Assets (ROA) Measured by net profit/total assets, it reflects the value creation ability of the enterprise.

Economic status (GDP). We use city annual GDP data to represent the economic status of the city, which come from *2010-2019 China City Statistical Yearbook*.

μ_i and ν_t are industry and year fixed effect, respectively. ε_{it} is the error term. Table 1 shows the basic descriptive statistics of the samples.

[2] CSR of Hexun is a weighted variable measures a firm's social responsibility. The weight of shareholders' responsibility accounts for 30%, the weight of employees' responsibility accounts for 15%, the weight of rights and interests of suppliers, customers and consumers accounts for 15%, the weight of environmental responsibility accounts for 20%, and the weight of social responsibility accounts for 20%. In different industries, the weights are adjusted accordingly. In consumer industry, the weight of employee responsibility accounts for 10%, the weight of rights and interests responsibility of suppliers, customers and consumers accounts for 20%, and the weight of other indicators remains unchanged; In manufacturing industry, the weight of environmental responsibility accounts for 30%, the weight of social responsibility accounts for 10%, and the weight of other indicators remains unchanged; In service industry, the weight of environmental responsibility accounts for 10%, the weight of social responsibility accounts for 30%, and the weight of other indicators remains unchanged.

Table 1. Basic variable descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CSR	12,959	25.392	18.714	-17.19	90.87
TFP_OP	12,014	3.731	.816	-1.642	7.893
TFP_LP	10,975	8.361	1.088	4.893	12.354
DD	12,990	.336	.472	0	1
asset	12,990	.019	.066	0	1.755
age	12,990	19.551	4.659	8	41
FG	12,855	0	.04	-2.176	2.447
ROA	12,989	.025	1.151	-48.316	108.366
lnGDP	11,163	8.597	1.151	4.204	10.549

5. Empirical results

5.1 Baseline DID

Tables 2 shows the results of estimation. From the basic results in column (1) and (2), we can see that all companies experienced improvement in CSR and TFP during the period from 2010 to 2019. After controlling the factors that may have impacts on firm performance, the results are still significant as shown in column (3) and (4).

Table 2. Impacts of 'Atmosphere Ten Articles' on CSR and TFP

	(1) CSR	(2) TFP_OP	(3) CSR	(4) TFP_OP
AT	0.5154*	0.0505***	0.5546**	0.0730***
	(0.2346)	(0.0129)	(0.2365)	(0.0195)
ln(asset+1)			-12.3371***	0.8316***
			(3.6096)	(0.2331)
Age			-1.2600***	-0.0096***
			(0.0793)	(0.0015)
FG			1.9862	0.0110
			(3.0141)	(0.0311)
ROA			0.0486	0.0070
			(0.2288)	(0.0089)
lnGDP			1.2492	-0.0142
			(0.7762)	(0.0111)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	28.3808***	3.7864***	37.6367***	4.0433***
	(0.0109)	(0.0008)	(5.1319)	(0.0711)
N	12959	12014	11030	10296
R-squared	0.558	0.756	0.563	0.769

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

In general, the Atmosphere Ten Articles significantly improves enterprises' total factor productivity of enterprises. That is to say, this environmental regulation policy does not sacrifice the economic benefits of enterprises, and can be a win-win environmental policy. In addition, the implementation of the Atmosphere Ten Articles also increased corporate social responsibility performance significantly. This means that the policy not only improves environmental quality by temporarily forcing enterprises to reduce their emissions, but also enhances the environmental awareness of enterprises and enhance their social responsibility. From the long-term perspective, the policy is beneficial.

5.2 Heterogenous test

5.2.1 Corporate life cycle heterogeneity

The methods used to classify enterprise life cycle can be summarized into the following two categories: comprehensive index method (Anthony and Ramesh, 1992) and cash flow model (Dickinson, 2011). The premise of the comprehensive index method assumes that there is a linear relationship between operating cash flow, sales revenue, listing years and accounting surplus, which has some defects due to the reality that the relationship cannot be completely linear. The cash flow model method reflects the characteristics of operating risk, profitability and growth rate in different life cycles through the net cash flows of three kinds of activities: operation, investment and financing, It can not only avoid the interference of inherent industry differences, but also avoid the subjective assumption on the sample distribution of the life cycle (Chen, 2008; Cao, 2010; Huang et al., 2016). As shown in Table 3, we used the cash flow model to determine the enterprise life cycle and divides the samples into four stages: the start-up, growing, maturity and recession. The cash flow pattern sign for each life cycle stage is shown in Table 3.

Table 3. The characteristics of cash flow in different corporate life cycle stages

	Start-up	Growing	Mature	Recession				
	Introduction	Growing	Mature	Shake-out	Shake-out	Shake-out	Decline	Decline
Cash flows from operating activities	−	+	+	−	+	+	−	−
Cash flows from investing activities	−	−	−	−	+	+	+	+
Cash flows from financing activities	+	+	−	−	+	−	+	−

For the heterogeneity of regulated polluting enterprises, we divided our sample into

four life cycle stages according to the cash flow model mentioned above. Four subsamples are constructed, and the empirical results are shown in Table 4 and 5.

Table 4. The life cycle heterogenous impact on CSR

	(1) Start-up	(2) Growing	(3) Mature	(4) Recession
AT	1.9067	1.5934**	-0.2942	0.1633
	(1.7565)	(0.5074)	(0.7335)	(1.2456)
Control variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	36.1271**	35.1909***	43.5336***	2.9618
	(13.1200)	(5.9137)	(4.2299)	(12.2436)
N	1261	3212	5194	1151
R-squared	0.606	0.567	0.572	0.552

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

Table 5. The life cycle heterogenous impact on TFP

	(1) Start-up	(2) Growing	(3) Mature	(4) Recession
AT	0.0258	0.0844**	0.0768**	0.0663
	(0.0267)	(0.0281)	(0.0328)	(0.0500)
Control variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	3.5432***	3.8992***	4.2382***	4.2708***
	(0.4439)	(0.1790)	(0.1576)	(0.6290)
N	1203	2960	4865	1061
R-squared	0.787	0.788	0.757	0.810

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

These results show that the implementation of the Atmosphere Ten Articles has the most significant positive impact on the performance of enterprises CSR in the growing stage, while enterprises in other life cycle stages have no significant response. This suggested that under the pressure of environmental policies, enterprises in the growing period may be more inclined to improve their social responsibility from the inside, rather than just adhere to the policy. This can be due to the enterprises in the growth stage have got out of the predicament of the start-up stage and gained a foothold in the market. The core task of the enterprises in this stage is to expand market share, extend the customer base and improve their corporate image. At this period, enterprises may pay more attention to corporate reputation, so they may focus on the performance of CSR, and strive to build a good reputation among stakeholders.

The results on TFP show that after the implementation of the Atmosphere Ten

Articles, enterprises in the growing and mature stages may have more motivation to improve their productivity, while enterprises in other stages have little significant intention to improve their productivity. According to the definition, the strategy in the growing and mature stage shifts from survival to development. In addition, enterprises in these two stages have a strong equity base and the ability to obtain external funds, their innovation is at the peak, and the proportion of funds spent on daily operation is significantly lower. Moreover, enterprises in the stages may be more willing to carry out research and development activities with high investment and long return cycle, and they have high management efficiency and strong resource allocation ability. To sum up, the Atmosphere Ten Articles will be more conducive to the growing and mature enterprises to improve their total factor productivity.

5.2.2 Ownership heterogeneity

In order to explore the potential heterogeneous impact of the Atmosphere Ten Articles on enterprise performance of different ownership types, we divide the samples into state-owned enterprises (SOEs) and private enterprises according to the actual controller attributes. Table 6 presents the empirical results.

State-owned enterprises are more responsive to environmental policies than private enterprises. From the perspective of social performance, after the implementation of the Atmosphere Ten Articles, the social responsibility index of state-owned enterprises has been significantly improved, while that of private enterprises has not changed significantly. In the sample of state-owned enterprises, the proportion of polluting enterprises (that is, enterprises that emit sulfur dioxide) is significantly higher (Table 7). Therefore, the restriction of air quality policies on state-owned enterprises is expected to be more obvious. Secondly, by definition, state-owned enterprises are mandated to assume more responsibilities for the society, and their economic behaviors are bound to have more positive externalities, while private enterprises may be more profit-driven. From the perspective of total factor productivity, the policy has a significant promoting effect on both state-owned and private enterprises.

Table 6. The ownership heterogenous impact

	CSR		TFP	
	SOE	Private Enterprise	SOE	Private Enterprise
AT	1.4877***	-0.7643	0.0638***	0.1036*
	(0.3401)	(0.5680)	(0.0158)	(0.0474)
Control variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	47.5640***	20.6787***	4.1181***	3.9127***
	(8.6189)	(3.6932)	(0.1074)	(0.1105)
N	6693	3555	6160	3418
R-squared	0.568	0.567	0.830	0.695

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

Table 7. Different ownership and SO_2 emission enterprises distribution

	Equity nature	
	SOEs	Private enterprises
SO_2-Emitting	5,690	1,306
Non-SO_2-Emitting	2,039	2,944

6. Robustness check

6.1 Different measurement of TFP

We conduct several tests to check the robustness of the positive impact of merger on TFP. In this section, we used another measurement of productivity based on Levinsohn & Petrin (2003). Table 8 shows the result that correspond to the Table 2. The results remain robust through control variables (column 2). Table 9 change the TFP measurement of Table 5 and 6 and the results are still significantly consistent with above. All the coefficients of *AT* are statistically positive, indicating that between 2010 and 2019, firms have higher scores in production efficiency under the 'Atmosphere Ten Articles' regulation. These findings verify our main results.

Table 8. Impacts of 'Atmosphere Ten Articles' on TFP

	(1) TFP_LP	(2) TFP_LP
AT	0.0730***	0.0675***
	(0.0195)	(0.0165)
Control variables	No	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
_cons	4.0433***	7.5091***
	(0.0711)	(0.1147)
N	10296	9482
R-squared	0.769	0.868

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

Table 9. Life cycle and ownership heterogeneity on TFP

	(1) Start-up	(2) Growing	(3) Mature	(4) Recession	(5) SOEs	(6) Private enterprises
AT	0.0377	0.0917***	0.0633*	0.0576	0.0616***	0.0605*
	(0.0342)	(0.0268)	(0.0344)	(0.0318)	(0.0146)	(0.0281)
Control	Yes	Yes	Yes	Yes	Yes	Yes

variables						
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
_cons	6.9644***	7.3855***	7.7982***	7.3823***	7.5493***	7.1918***
	(0.4173)	(0.2654)	(0.1256)	(0.5380)	(0.2400)	(0.0863)
N	1132	2739	4446	988	5778	3055
R-squared	0.884	0.874	0.867	0.877	0.901	0.814

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

6.2 Placebo robustness test

One underlying assumption of the DID method is the common trend assumption, which requires that the treatment group and control group should have parallel trends in terms of the outcome variable before the implication of the policy. To test the assumption, we use the placebo test. The basic idea of the placebo test is to randomly select a policy period, and perform the same DID analysis to check if there is a significant impact of 'Atmosphere Ten Articles' on firm's CSR and TFP. The empirical results for which if the atmospheric regulation occurs between 2009-2013, 2010-2014 and 2011-2015 are shown in Table 10. Therefore, we can conclude that, after controlling other impacting factors, the change of CSR and TFP do not precede the policy. Both TFP and CSR improves immediately after the 'Atmosphere Ten Articles' regulation.

Table 10. Placebo test in different treatment period

	2010-2014		2011-2015	
	Start-up	Growing	Mature	Recession
AT	-0.4407	0.0081	-0.1523	0.0487
	(0.2486)	(0.0309)	(0.3201)	(0.0280)
Control variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	39.1248***	4.0458***	38.0195***	4.0157***
	(5.4833)	(0.0708)	(5.4050)	(0.0704)
N	11030	10296	11030	10296
R-squared	0.563	0.769	0.563	0.769

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

7. Verification of mechanism

So far, our results show that in 2013, implementation of the Atmosphere Ten Articles policy significantly promoted TFP, and the effects vary across different enterprises with different equity and life cycle stages. Since total factor productivity is

a comprehensive Solow residual, it can be decomposed into two aspects: technological innovation effect and resource allocation effect. We further determine the mechanism of the Atmosphere Ten Articles on corporate performance from the two aspect.

7.1 Technological innovation

To explore whether the Atmosphere Ten Articles improve the total factor productivity of enterprises by promoting enterprise innovation, we use the total number of granted patents data from CSMAR as the measure for technological innovation. To test which type of patent is the key in promoting firm performance, we also take the total number of innovation patents, utility patents and design patents as the dependent variable. The empirical results are shown in Table 11. From the results, we can conclude that the Atmosphere Ten Articles significantly promoted the innovation of enterprises, especially the number of invention patents and utility patents.

Table 11. Innovative mechanism of 'Atmosphere Ten Articles'

	(1)	(2)	(3)	(4)
	Grants	Innovation grants	Utility grants	Design grants
AT	23.5026***	9.5750**	12.8450***	1.0827
	(5.9195)	(3.3688)	(2.5979)	(0.8254)
Control variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
_cons	-108.0144***	-46.9065***	-50.5983***	-10.5096**
	(25.6778)	(12.9093)	(11.8929)	(4.1493)
N	6175	6175	6175	6175
R-squared	0.817	0.780	0.769	0.764

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

7.2 Resource allocation

To test whether the Atmosphere Ten Articles promotes the total factor productivity and environmental performance of enterprises by improving the efficiency of resource allocation, we add innovation as a control variable in our baseline model to remove the technological innovation impacts on CSR and TFP. The results are shown in Table 12.

We can see that the coefficients of *AT* are still statistically positive, which indicate that the Atmosphere Ten Articles has significantly improved the capital allocation efficiency of enterprise, meanwhile, it also proves that the Atmosphere Ten Articles promote total factor productivity by improving the capital allocation efficiency of enterprises.

Table 12. Resource reallocation effects of 'Atmosphere Ten Articles'

	(1)	(2)	(3)
	CSR	TFP_OP	TFP_LP
AT	1.3254*	0.0606**	0.0591**

	(0.6317)	(0.0195)	(0.0202)
Control variables	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
_cons	41.8805***	4.0737***	7.5739***
	(3.8385)	(0.0918)	(0.1393)
N	6163	5770	5489
R-squared	0.645	0.852	0.913

Note: standard errors are in parentheses; *p<0.1，**p<0.05，***p<0.01.

8. Conclusion

The effectiveness of an environmental policy is reflected in its ability to promote innovation and improve economic efficiency while reducing emissions. How to motivate enterprises to carry out high-quality and environment-friendly innovation and realize the transformation of economic growth from "extensive" to "efficient" is an important issue faced by all stakeholders. Through the analysis of the Atmosphere Ten Articles as a quasi-natural experiment, we found that as the most stringent air pollution regulation enacted by the Chinese government so far has not only achieved better air quality improvement but also promoted enterprises performance in both corporate social responsibility and total factor productivity. From the perspective of life cycle theory, enterprises in the growth stage have the most motivation to improve their social responsibility performance and total factor productivity. Enterprises in the mature stage only have a significant increase in total factor productivity, while enterprises in the start-up stage and recession stage are not significantly affected. In terms of enterprise ownership, SOEs are more sensitive to policy with both CSR and TFP significantly improved, while private enterprises have only seen an increase in TFP. In order to further interpret the influence mechanism of Atmosphere Ten Articles, this paper also decompose the total factor productivity. We found that the Atmosphere Ten Articles can improve the total factor productivity of enterprises by promoting innovation and optimizing resource allocation.

This study fills the gap of research on air pollution control policy on enterprise performance by integrating the corporate life cycle theory into the assessment of environmental policy effectiveness, examines the effect of environmental policy from the enterprise development stage dimension, and also discusses the mechanism to further open the "black box" of environmental policy evaluation. It can provide new ideas for future policy research.

Based on the above empirical results, we can draw a conclusion that to solve the environmental pollution problem on the premise of high-quality economic development, we need to give full play to the regulatory role of policy regulation. The Atmosphere Ten Articles policy realizes the win-win situation of economic and environmental performance. This study also provides scientific support for government to appreciate the role of command-based environmental regulation in environmental governance.

Strengthening pollution control and improving the quality of economic development need not to have zero sum. The key is to make good use of flexible and appropriate environmental policies but provide incentives for innovation to enterprises. We find that the effect of the Atmosphere Ten Articles is different among enterprises at different life cycle stages and enterprises of different ownership. Therefore, future environmental policy design should consider enterprises heterogeneity. First, companies that are growing at a rapid pace can be given more support for innovation, and some incentives should be given for high-quality green behaviors. Considering the differences between enterprises under different ownership, government can also make differences in the implementation of environmental protection policies, strengthen the supervision on the social responsibility of private enterprises, and formulate emission reduction policies guided by the long-term goal of improving enterprises' environmental awareness.

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