Knowledge Graph Analysis of the Evolution of Research Hotspots in China' s Environmental Regulation: Postprint

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Date: 2023-10-08T00:00:00+00:00

Abstract

[Purpose / Significance] Current environmental challenges have become sensitive social and political issues in China. Systematically reviewing existing environmental regulation literature and analyzing the evolution of its research hotspots holds significant importance for the development of both environmental regulation practice and theory. [Method / Process] This study selected 1,473 core journal articles in the field of environmental regulation in China from January 1, 1998, to July 2, 2019, employed Citespace visualization analysis for time-slice processing, and utilized keywords as the core along with research hotspot cluster analysis to clarify the evolutionary trajectory of research in the environmental regulation field and predict future development trends, thereby exploring future research directions. [Result / Conclusion] Research in the environmental regulation field is grounded in theoretical foundations such as the Porter Hypothesis, Environmental Kuznets Curve, and evolutionary game theory, and primarily employs research methods including the spatial Durbin model and directional distance function to analyze the environmental regulation field across different periods. Currently, research predominantly concentrates on the relationships between environmental regulation and technological innovation, economic development, industrial competitiveness, and industrial structure, yet neglects the optimization of environmental institutions, corporate compliance with environmental regulations, regional environmental disparities, and the important role of cooperation between civil society organizations and government in environmental governance. Consequently, these aspects represent emerging trends for future development in the environmental regulation field.

Full Text

Knowledge Map Analysis of the Evolution of Research Hotspots in China' s Environmental Regulation

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Abstract:
[**Purpose/Significance**] Environmental challenges have become sensitive social and political issues in China. Reviewing existing literature on environmental regulation and analyzing the evolution of research hotspots holds important implications for the development of both environmental regulation practices and theoretical frameworks.

[**Method/Process**] This study selected 1,473 core journal articles in the field of environmental regulation from China between January 1, 1998, and July 2, 2019. Using CiteSpace visualization tools for time-slice analysis, with keywords as the core and based on research hotspot cluster analysis, we clarified the evolutionary trajectory of environmental regulation research and predicted future development trends to explore future research directions in this field.

[**Results/Conclusions**] Research in environmental regulation relies on theoretical foundations such as the Porter Hypothesis, Environmental Kuznets Curve, and evolutionary game theory, primarily employing research methods like the Spatial Durbin Model and directional distance function to analyze the field across different periods. Currently, research predominantly focuses on the relationships between environmental regulation and technological innovation, economic development, industrial competitiveness, and industrial structure. However, it has overlooked aspects such as the optimization of environmental institutions, the degree of enterprise compliance with environmental systems, regional environmental differences, and the important role of cooperation between civil society organizations and government in environmental governance. These neglected areas represent future development trends in environmental regulation research.

Keywords: Environmental Regulation, Knowledge Map, Cluster Analysis, Porter Hypothesis

1 Introduction

The Fourth Plenary Session of the 19th Central Committee explicitly proposed implementing "the strictest ecological and environmental protection system," demonstrating unprecedented government commitment for environmental governance and making innovation in environmental governance institutions and optimization of environmental regulation inevitable. On January 1, 2015, the newly revised Environmental Protection Law—dubbed "the strictest environmental law in history" [1]—officially took effect, requiring the construction of a modern environmental governance system featuring multi-stakeholder co-governance and joint prevention and control, while emphasizing government responsibility for environmental regulation management.

Years on, however, the environmental situation remains severe, compelling us to re-examine critical questions: How should the environmental system be optimized? How can environmental regulation be effectively supervised? How can various social sectors be encouraged to cooperate with government in environmental governance? How can environmental policies address regional environmental differences? Based on these questions, we reviewed over 20 years of research achievements in environmental regulation to explore the field' s research trajectory and clarify the relationship between environmental regulation and ecological civilization society, thereby guiding future research directions and providing scientific evidence for environmental regulation policy formulation.

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2 Data and Methods

2.1 Data Collection

We used the CNKI full-text journal database as our data source, selecting SCI source journals, EI source journals, Peking University Core Journals, CSSCI, and CSCD for precise full-text retrieval. The search condition was "subject = environmental regulation," with a time span from 1998 to 2019 and final data updated on July 2, 2019. After screening to remove invalid results such as conference announcements and duplicate literature, and standardizing the keywords, we obtained 1,473 authoritative and comprehensive academic papers.

2.2 Research Methods

Bibliometrics is a quantitative analysis method that uses literature as its object and applies mathematical statistics to analyze and summarize the research status and patterns in a particular field [2]. We employed bibliometric methods to analyze and summarize the current state of environmental regulation research in China, specifically utilizing literature analysis, word frequency statistics, and cluster analysis methods.

2.2.1 Literature Analysis Method Literature analysis refers to the quantitative statistics of bibliographies, abstracts, or indexes in a specific research field to derive statistical results or analytical conclusions [3]. This study collected citation data for environmental regulation literature in China using SCI, CSSCI, and CSCD citation databases.

2.2.2 Word Frequency Statistics Method Word frequency statistics primarily involves statistical analysis of keywords that reveal the core content of literature in a specific field [4]. Higher keyword frequency indicates greater attention in that area. This method can identify research hotspots and development status in a particular field.

2.2.3 Cluster Analysis Method Cluster analysis is a statistical method that divides research objects in a field into several groups, where objects within each group share similar characteristics and groups are mutually exclusive. This approach can create intuitive network diagrams of research objects in a field.

2.3 Research Tools

We utilized CiteSpace software to analyze and visualize knowledge maps of environmental regulation research, examining high-frequency keywords and co-occurrence networks. Through keyword timezone maps and time-series diagrams, we predicted development trends in the environmental regulation field, clarified the internal dynamic mechanisms of environmental regulation research, and explored disciplinary development to better understand this research domain.

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3 Results and Analysis

3.1 High-Frequency Keywords and Keyword Co-occurrence Network

Through statistical analysis of keywords from 1,473 domestic core journal articles in environmental regulation, we obtained information on keyword frequency, centrality, and the year of first appearance. Keyword frequency refers to the number of times a keyword appears. We statistically analyzed all keywords in the dataset, arranged them in descending order of frequency, and categorized them into four types: theoretical foundation, research methods, influencing factors, and economic consequences. We summarized information for top-ranking keywords, with results shown in Table 1 .

Centrality refers to the distance of a keyword from the central node of environmental regulation and its importance in the network; higher centrality values indicate closer proximity to the central node, more connected nodes, and a more central position in the network.

As shown in Table 1, the total frequency of theoretical foundation keywords is 127, including the Porter Hypothesis, Environmental Kuznets Curve, and evolutionary game theory, which first appeared in 2007 [5], 2011 [6], and 2013 [7], respectively. This indicates that as research gradually deepened, the theoretical foundation of China' s environmental regulation not only became richer but also that scholars recognized environmental regulation as dynamically evolving, requiring game analysis between regulators and regulated parties within the research framework.

The total frequency of research method keywords is 169, including threshold effect, directional distance function, and Spatial Durbin Model. The "threshold effect" was first introduced into environmental regulation research in 1998, while the "directional distance function" was not applied until 2011 [8]. With the development of spatial econometrics, the "Spatial Durbin Model" was first combined with environmental regulation research in 2018 [9].

The frequency of influencing factor keywords is 106. In 2006, scholars began focusing on the impact of foreign direct investment on environmental regulation [10], and in 2011, some scholars proposed that industrial structure also influences environmental regulation [11]. This demonstrates that influencing factors, as an important aspect of environmental regulation research, have received extensive and in-depth discussion, though no consensus has been reached on a complete theoretical analysis framework for environmental regulation influencing factors. However, analysis of influencing factors has consistently run through environmental regulation research, highlighting the promoting effect of technological innovation.

The frequency of economic consequence keywords is as high as 449, indicating that economic consequences are the most concerning research content in environmental regulation, including environmental pollution, corporate performance, economic growth, total factor productivity, carbon emissions, technological progress, industrial structure upgrading, industrial transfer, and ecological efficiency. Among these, "environmental pollution" first appeared in environmental regulation literature in 2007 [12], "corporate performance" entered the field in 2011 [13], while "economic growth," "total factor productivity," "carbon emissions," and "technological progress" were combined with environmental regulation in 2012 [14-17].

It was not until 2015, when President Xi Jinping emphasized strengthening supply-side structural reform at the Central Financial and Economic Affairs Leading Group meeting, that "industrial transfer" and "ecological efficiency" emerged and were integrated with environmental regulation research. "Industrial structure upgrading," which appeared in 2016, represents one of the consequences of environmental regulation development.

Meanwhile, "technological innovation" in Table 1 has the highest centrality, indicating its important position in environmental regulation research. Since 1998, it has consistently run through the entire process of China's environmental

regulation research, demonstrating that domestic scholars emphasize the impact of environmental regulation on technological innovation. The transformation from research method keywords and theoretical foundation keywords (before 2008) to economic consequence keywords (after 2008) is closely related to China' s macroeconomic environment.

Before 2008, China's economy grew rapidly through resource and environmental factor inputs. After 2008, Chinese academia fully recognized the environmental damage caused by this growth model and placed greater emphasis on the consequences of environmental regulation, leading to a rapid increase in publications and aligning environmental regulation research with China' s environmental policies that prioritize green economic development.

3.2 Research Hotspot Cluster Analysis

We employed the Log-Likelihood Ratio (LLR) algorithm for cluster analysis of research hotspots. The results clearly show which keywords occupy key positions in the literature network, enabling rapid and accurate identification of frontier hotspots in the research field. We selected the top 50 keywords from each document for statistical analysis and clustering, obtaining 262 keywords and generating a keyword co-occurrence network, as shown in Figure 1 [Figure 1: see original paper].

Through cluster analysis, environmental regulation research keywords were categorized into ten major directions: directional distance function, threshold effect, Porter Hypothesis, Spatial Durbin Model, foreign direct investment (FDI), technological innovation, evolutionary game, economic growth, pollution haven, and SBM model (see Figure 1). To clarify the research context and grasp frontier hotspots, we further divided these ten clusters into four categories: theoretical foundation, research methods, influencing factors, and economic consequences for specific analysis.

3.2.1 Theoretical Foundation Category The theoretical foundation category includes the Porter Hypothesis, evolutionary game, and pollution haven as basic theories in environmental regulation research. For example, Zhao et al. analyzed the impact of environmental regulation intensity on China' s pollution-intensive manufacturing industries against the theoretical background of the Porter Hypothesis [18]; Li and Zhang studied the evolutionary process of local government decision-making in air pollution control based on evolutionary game theory [19]; Ran and Wu tested the pollution haven effect of foreign investment based on the opposing theories of "pollution haven" and "pollution halo" [20].

3.2.2 Research Methods Category The research methods category specifically includes three methods: directional distance function, Spatial Durbin Model, and SBM model, indicating that these three models are primarily used for empirical testing in environmental regulation research. Li and Fan used the SBM directional distance function to analyze the impact of trade openness and

foreign direct investment on green total factor productivity [21]; Li and Ma measured the green innovation efficiency of 13 cities in the Beijing-Tianjin-Hebei region based on an SBM model with undesirable outputs [22]; Lu et al. analyzed the ecological environmental governance performance of Jiangsu Province using SBM model and total factor productivity index [23].

3.2.3 Influencing Factors Category The influencing factors category mainly includes foreign direct investment (FDI) and industrial structure. Additionally, economic development level, market environment, urbanization level, and information disclosure all influence environmental regulation. Figure 1 shows that FDI and technological innovation are two major influencing factors of environmental regulation.

For instance, Li and Yang found that FDI can significantly promote regional high-speed economic development [24]; however, Gong and Han argued that China' s outward foreign direct investment has deteriorated the local environment of the home country and failed to inhibit pollutant emissions in neighboring regions [25]; Ren and Wang, based on panel data from China' s three major coastal urban agglomerations from 2003-2016, concluded that industrial structure is a main influencing factor of environmental regulation in the Beijing-Tianjin-Hebei and Pearl River Delta urban agglomerations [26]; Fan argued that information disclosure can significantly improve environmental governance performance [27]; Sun believed that constraints from higher-level governments and cooperation among local governments can significantly improve the spatial spillover of pollution [28].

3.2.4 Economic Consequences Category The economic consequences category summarizes a series of consequences brought by environmental regulation, such as technological innovation, industrial structure upgrading, and technological progress. Zhang and Geng found that the impact of environmental regulation on green technology innovation output presents a "U-shaped" relationship —as environmental regulation intensity increases, green technology innovation first decreases and then increases [29]; Xu argued that environmental regulation can produce continuous positive impacts on technological innovation [30]; Tao and Hu believed that environmental regulation has a non-linear impact on the quality of China' s economic growth—strengthening environmental regulation inhibits economic growth, while weakening it promotes economic growth [31]; Liu et al. argued that investment-oriented environmental regulation can promote regional industrial structure upgrading, while cost-oriented environmental regulation inhibits it [32].

Currently, research in this field in China focuses more on the positive consequences of environmental regulation, such as technological innovation, industrial structure upgrading, and technological progress, while neglecting issues like regional environmental differences, lagging ecological civilization institutions, and inadequate corporate environmental responsibility. Future environmental regu-

lation research should pay greater attention to these aspects.

3.3 Keyword Evolution and Trend Prediction

Environmental regulation is an important means to solve environmental problems and is closely related to economic development. By combining the keyword time-series diagram (Figure 2 [Figure 2: see original paper]) and keyword timezone diagram (Figure 3 [Figure 3: see original paper]) of environmental regulation research, we can clearly observe the changes in this research field from 1998 to 2019. The horizontal axis represents each year, while the vertical axis represents keyword clusters.

The keyword time-series diagram of environmental regulation research intuitively displays how research directions change over time. However, relying solely on this diagram is insufficient to clearly define research stages. Therefore, combining the keyword timezone diagram with China' s economic development stages, we roughly divide the research field into three stages: the theoretical research stage (1998-2009), the transition development stage (2010-2013), and the deepening development stage (2014-2019).

In the theoretical research stage (1998-2009), scholars mainly focused on the theoretical foundations and research methods of environmental regulation, such as threshold effects and directional distance functions. This indicates both the importance of theoretical foundations and research methods in environmental regulation research and that scholars primarily used threshold effects to analyze research questions in this field.

In the transition development stage (2010-2013), after 2010, China' s economy began shifting from high-speed to high-quality development, and environmental regulation research started focusing on issues like low-carbon development and environmental protection investment.

In the deepening development stage (2014-2019), as China' s economy continued high-quality development and industrial structure changed, scholars focused on ecological efficiency, industrial transfer, industrial structure upgrading, and green total factor productivity. In August 2014, the State Council issued the "Guiding Opinions on Accelerating the Development of Producer Services to Promote Industrial Structure Upgrading," proposing to promote the development of service industries oriented by industrial structure transformation and upgrading needs, enabling industries to move toward the high end of the value chain and promoting China' s industrial structure upgrading. This further demonstrates that environmental regulation research is deeply influenced by national macro policies.

The different emphases of environmental regulation research across these three periods are mainly caused by China' s environmental problems, environmental policies, and economic development stages in different eras, indicating that domestic environmental regulation research has strong "timeliness." In summary,

research on basic theories and methods has maintained relatively long-lasting popularity, while some special hotspot issues have shorter durations and are easily influenced by the macroeconomic environment at the time.

Under the guidance of President Xi Jinping' s important strategic thoughts on ecological civilization construction, China' s environmental governance efforts are unprecedented. Particularly, the implementation of the "strictest in history" new Environmental Protection Law will significantly improve regional environmental differences, lagging ecological civilization institutions, and unclear corporate environmental responsibilities. Environmental regulation will develop toward improving the ecological civilization system, establishing corporate environmental responsibility, emphasizing regional environmental differences, and strengthening cooperation between government and civil society organizations for environmental co-governance, gradually achieving harmonious coexistence between humans and nature and jointly building a beautiful China.

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4 Conclusion and Outlook

We examined the domestic environmental regulation research field, compiled relevant literature from authoritative core journals, and used CiteSpace for keyword extraction, network co-occurrence, clustering, and burst analysis to reveal the basic overview of environmental regulation research over the past two decades. Based on environmental development concepts and economic development stages in different periods, we divided China' s environmental regulation research since 1998 into three stages: theoretical research, transition development, and deepening development.

The study found that current environmental regulation research in China relies on theoretical foundations such as the Porter Hypothesis, Environmental Kuznets Curve, and evolutionary game theory, mainly employs research methods like the Spatial Durbin Model and directional distance function, and focuses on economic growth and industrial structure upgrading as core content.

Overall, although China' s environmental regulation research began relatively late, it has shown multi-level and wide-angle trends based on foreign research. These studies revolve around verifying the "Porter Hypothesis" [33], employ research methods such as threshold effects and Spatial Durbin Models, focus on market-based environmental regulation policies, and advocate for market-based environmental regulation policies from the perspective of improving resource allocation efficiency [34]. Scholars believe environmental regulation policies have positive impacts on corporate green technology innovation, pollution control, and industrial structure adjustment [35-37].

Research conclusions fully confirm that environmental regulation is closely related to technological innovation, economic development, industrial competitiveness, and industrial structure. Zhang et al. [38] argued that different types of

environmental regulation policies have different impacts on corporate technological innovation, and policies should highlight specific focuses; Yao et al. [39] believed the government should fully consider the impact of economic development on environmental regulation and strengthen corporate environmental supervision; Cheng et al. [40] argued that the type and standard of environmental regulation greatly affect corporate competitiveness, and the government should flexibly use various types of regulatory policies; Zhang et al. [41] believed that environmental regulation tools can effectively promote industrial structure upgrading.

Currently, domestic environmental regulation research still focuses on the positive impacts of environmental policies. However, as new environmental problems continue to emerge and environmental issues become increasingly serious, future environmental regulation research in China must focus on the following points in combination with the current state of environmental and economic development:

4.1 Environmental Regulation Optimization Becomes Inevitable for Ecological Civilization System Construction

The 19th Party Congress report clearly stated the need to accelerate ecological civilization system reform and build a beautiful China. Environmental regulation optimization has become an inevitable choice for building a beautiful China. Based on this, the environmental regulation research system should shift toward green development, addressing prominent environmental problems, strengthening ecosystem protection, and reforming the ecological environment supervision system.

Furthermore, we must improve China' s environmental regulation laws and regulations, perfect the legislative, enforcement, and supervision systems for environmental regulation, and establish a sound public participation mechanism in environmental management, allowing environmental regulation to penetrate all aspects of people' s lives and work and making environmental violations difficult to conceal.

4.2 Coupling Research on Environmental Regulation and Corporate Environmental Responsibility Will Attract Scholarly Attention

Government regulation is an effective way to correct corporate environmental responsibility behavior. However, constrained by the demand-led, spontaneous, path-dependent, and difficult-to-transplant characteristics of the social responsibility system' s induced changes [42], different regulatory pressures have varying impacts on corporate environmental responsibility fulfillment. Existing research focuses on analyzing the indirect effects of environmental regulation on corporate productivity, competitiveness, export trade, and scale distribution, but rarely explores the environmental behaviors that enterprises undertake under environmental regulation.

Research lacks investigation into corporate behavioral choices in response to environmental regulation and offers few in-depth discussions on the coupling between environmental regulation and corporate behavior. The interaction between corporate environmental responsibility fulfillment and environmental regulation cannot be ignored [43-44]—government environmental regulation not only affects corporate environmental responsibility fulfillment, but corporate environmental responsibility fulfillment also reacts to government environmental regulation, ultimately promoting each other' s behaviors.

Therefore, under the green development concept, environmental co-governance must break away from previous mindset patterns that isolatedly emphasized the role of government, enterprises, or the public in scheme design [46]. We must fully utilize the coupling effect between government environmental regulation and corporate environmental responsibility to enhance environmental regulation effectiveness and promote ecological civilization society construction.

4.3 Regional Differences Will Make Heterogeneity Research a Mainstream Direction

Local governments play an important role in how environmental regulation affects corporate environmental responsibility fulfillment, and environmental regulation varies across different regions. If the local government where an enterprise is located has high environmental regulation efficiency and strong capacity, it will guide enterprises to attach importance to and invest in projects beneficial to all stakeholders, inevitably strengthening corporate environmental responsibility fulfillment within its jurisdiction and actively pursuing high value-added projects conducive to environmental protection, achieving a "win-win" situation for both economy and environment.

This shows that under the same national environmental regulation policy, environmental regulation effects differ across regions. Meanwhile, natural endowments and economic resources vary significantly across regions, which determines that environmental regulation policies must comprehensively consider local economic development and environmental conditions to avoid spatial spillover of environmental pollution caused by excessive regional differences in environmental regulation development. Therefore, regional differences leading to environmental regulation heterogeneity will become one of the mainstream research directions. Future research should pay more attention to regional environmental differences to promote the development of heterogeneous environmental regulation, thereby providing feasible solutions for addressing environmental problems according to local conditions.

4.4 Construction of Environmental Regulation Cooperation Mechanisms Is Imminent

Currently, the main body of China' s environmental regulation is the government. In future environmental governance, cooperation between civil society

organizations and government should be strengthened. The Chinese central government should further strengthen top-level design in environmental regulation, while environmental NGOs should utilize networks and media advantages to strengthen environmental publicity, education, and information disclosure, giving full play to the role of government and environmental NGOs in jointly governing environmental issues to achieve a harmonious and win-win pattern of modern ecological environment governance.

As the coordinator and main implementer of economic development and environmental protection, the government bears key responsibility for environmental governance and prevention. However, media behavior, social public, marketization, and legalization processes may all affect the government' s supply of environmental regulation. Therefore, the interaction and integration mechanisms between government and environmental NGOs, media, and social public have become important means to resolve current environmental problems.

In summary, the optimization of environmental regulation is not only a gradual process but also a process where stakeholders express preferences based on micro-motivations. The alignment between government-led environmental regulation and corporate environmental responsibility fulfillment is key to effectively advancing environmental protection work.

References

[1] Wu Xue' an. "The Strictest Environmental Protection Law in History" Boosts the Construction of "Beautiful China"[J]. Disaster Prevention Panorama, 2015(2):50-53.
[2] Dai Yan. Bibliometric and Visual Analysis of Chemistry Education Research in Chinese Middle Schools (2010-2019)——Based on Four Journals Included in CNKI [D]. Chongqing: Graduate School of Southwest University, 2020.
[3] Qiu Junping. Theory, Method and Application of Bibliometrics [J]. Library and Information Service, 1984(4):43-46, 54.
[4] Chu Heting. Major Research Methods in Library and Information Science: Understanding, Selection and Use [J]. Library and Information Service, 2019, 63(1):146-152.
[5] Wang Binyi. Foreign Debates on the "Porter Hypothesis" and Their Implications [J]. Special Zone Economy, 2007(1):256-257.
[6] Mou Xinli, Qi Junsheng, Huang Yu, et al. Evaluation of Environmental Kuznets Curve of Agricultural Non-point Source Pollution in Chongqing [J]. Guizhou Agricultural Sciences, 2011, 39(01):228-230.
[7] Wang Liping. Evolutionary Game Analysis of Corporate Environmental Technology Innovation Behavior [J]. Modern Management Science, 2013(1):85-87.
[8] Yang Wenju. Green Economic Growth Accounting Based on DEA: Taking China' s Regional Industry as an Example [J]. Quantitative & Technical Eco-

nomics, 2011, 28(1):19-33.
[9] Ren Xiaojing, Qu Xiaoe, Zhang Leilei. Impact of Environmental Regulation on the Spatial Evolution of Environmental Pollution [J]. Journal of Beijing Institute of Technology (Social Sciences Edition), 2018, 20(1):1-8.
[10] Ying Ruiyao, Zhou Li. Foreign Direct Investment, Industrial Pollution and Environmental Regulation—Econometric Analysis Based on Chinese Data [J]. Finance & Trade Economics, 2006(1):76-81.
[11] Xia Chunwan, Lin Yong. Determination of Environmental Regulation Intensity to Achieve Economic and Environmental Win-Win in China' s Industrialization Process [J]. Ecological Economy, 2011(11):78-81, 91.
[12] Zhu Qirong. Empirical Analysis of the Relationship Between China's Export Trade, Industrial Pollution and Environmental Regulation [J]. World Economy Study, 2007(8):47-51, 87.
[13] Li Zhixue, Yang Yuan. Research on the Path of Environmental Regulation Policy' s Impact on Corporate Performance [J]. Territory & Natural Resources Study, 2011(4):81-82.
[14] Yin Baoqing. Import Intermediate Goods Carbon Emissions, Environmental Regulation and Local Enterprise Technology Innovation [J]. Academic Forum, 2012, 35(3):125-129.
[15] Zhang Zhongyuan, Zhao Guoqing. FDI, Environmental Regulation and Technology Progress—Empirical Analysis Based on Chinese Provincial Data [J]. Quantitative & Technical Economics, 2012, 29(4):19-32.
[16] Qu Xiaoe, Xi Yao. Research on Total Factor Productivity of Chinese Regions Under Dual Regulation of Resources and Environment—Empirical Analysis Based on 1996-2009 [J]. Business Economics and Administration, 2012(5):89-97.
[17] Xie Juan, Li Yushuang, Han Feng. Environmental Regulation and Economic Growth: Analysis Based on Simultaneous Equations of Chinese Provincial Panel Data [J]. Economic Survey, 2012(5):1-5.
[18] Zhao Li, Xue Yao, Hu Yiqun. Environmental Regulation Intensity and Technology Innovation—Empirical Evidence from Pollution-Intensive Manufacturing Industries [J]. Science & Technology Progress and Policy, 2019, 36(10):59-65.
[19] Li Junjie, Zhang Hong. Evolutionary Game and Simulation Study on Local Governments' Air Pollution Control Behaviors [J]. Operations Research and Management Science, 2019, 28(8):27-34.
[20] Ran Qiying, Wu Haitao. Will the Pollution Haven Effect of Foreign Direct Investment Always Exist?—Empirical Analysis Based on Dynamic Threshold Panel Model [J]. Ecological Economy, 2019, 35(4):152-159.
[21] Li Guanglong, Fan Xianxian. Trade Openness, Foreign Direct Investment and Green Total Factor Productivity [J]. Journal of Nanjing Audit University, 2019, 16(4):103-112.
[22] Li Jian, Ma Xiaofang. Analysis of Spatial-Temporal Differences and Influencing Factors of Green Innovation Efficiency in Beijing-Tianjin-Hebei Cities [J]. Systems Engineering, 2019, 37(5):51-61.
[23] Lu Zifang, Deng Wenmin, Zhu Weiwu. Dynamic Evaluation of Ecological Environment Governance Performance in Jiangsu Province—Based on PCA-

SBM Model and TFP Index [J]. East China Economic Management, 2019, 33(9):32-38.
[24] Li Nana, Yang Renfa. Can FDI Promote High-Quality Development of China' s Economy? [J]. Statistics & Information Forum, 2019, 34(9):35-43.
[25] Gong Xinshu, Han Junjie. Does Outward Foreign Direct Investment Improve the Home Country' s Environment?—Based on the Perspective of China' s Market Integration [J]. Ecological Economy, 2019, 35(12):112-118, 152.
[26] Ren Mei, Wang Xiaomin, Liu Lei, et al. Analysis of Spatial-Temporal Changes and Influencing Factors of Environmental Regulation Efficiency in China' s Coastal Urban Agglomerations [J]. Scientia Geographica Sinica, 2019, 39(7):1119-1128.
[27] Fan Yaxi. Information Disclosure, Environmental Regulation and Environmental Governance Performance—Empirical Evidence from Chinese Cities [J]. Ecological Economy, 2020, 36(4):193-198.
[28] Sun Cheng. Analysis of Local Government Strategic Behavior Under Pollution Spatial Spillover Conditions [J]. Ecological Economy, 2020, 36(2):167-170, 176.
[29] Zhang Juan, Geng Hong, Xu Gongwen, et al. Research on the Impact of Environmental Regulation on Green Technology Innovation [J]. China Population, Resources and Environment, 2019, 29(1):168-176.
[30] Xu Jinghong. Research on the Technological Innovation Effect of Environmental Regulation and Its Heterogeneity—Empirical Test Based on Data from 271 Chinese Cities [J]. Ecological Economy, 2020, 36(1):154-160.
[31] Tao Jing, Hu Xueping. Research on the Impact of Environmental Regulation on the Quality of China' s Economic Growth [J]. China Population, Resources and Environment, 2019, 29(6):85-96.
[32] Liu Manfeng, Chen Liang, Liao Jinqiu. Research on the Impact of Environmental Regulation Tools on Regional Industrial Structure Upgrading—Empirical Test Based on Chinese Provincial Panel Data [J]. Ecological Economy, 2020, 36(2):152-159.
[33] Gan Jiawu, Gong Min, Feng Kunyuan. Research on the Impact of China' s Environmental Regulation on Economic Development Mode—Based on the "Double Dividend" Perspective [J]. Ecological Economy, 2017, 33(1):14-20, 27.
[34] Zhao Yumin, Zhu Fangming, He Lilong. Definition, Classification and Evolution of Environmental Regulation [J]. China Population, Resources and Environment, 2009, 19(6):85-90.
[35] Wang Xueyu, Liu Qin. Analysis of the Impact Effect of Environmental Regulation on Corporate Green Technology Innovation [J]. Economic Research Guide, 2019(5):8-11.
[36] Lu Lijun, Chen Danbo. Pollution Control Effects of Environmental Regulation Strategies Among Local Governments: Mechanism and Empirical Evidence [J]. Collected Essays on Finance and Economics, 2019(12):104-113.
[37] Yang Shouyun. Promoting Industrial Structure Upgrading Through Environmental Regulation [J]. People' s Tribune, 2019(16):90-91.
[38] Zhang Ping, Zhang Pengpeng, Cai Guoqing. Comparative Study on the Impact of Different Types of Environmental Regulation on Corporate Technology

Innovation [J]. China Population, Resources and Environment, 2016, 26(4):8-13.
[39] Yao Sheng, Liang Haotian. Political Connection, Local Interest and Corporate Environmental Performance—Research Based on Property Right Classification [J]. Finance and Trade Research, 2015, 26(4):141-149.
[40] Cheng Dening, Wei Jinhui. Effect Analysis of Different Types of Environmental Regulation on China' s Industrial Competitiveness [J]. Journal of Guangdong University of Finance & Economics, 2019, 34(3):26-35.
[41] Zhang Xiuguang, Liu Xiaojun. Research on the Impact of Environmental Regulation on Regional Industrial Structure Optimization and Adjustment [J]. Technical Economics & Management Research, 2018(11):124-128.
[42] Xin Jie, Yu Junjun. Induced Change of Informal Institutions of Corporate Social Responsibility [J]. Journal of Hunan University of Science & Technology (Social Science Edition), 2014, 17(5):57-62.
[43] Frederiksen C S, Nielsen M E J. Corporate social responsibility and governance: theory and practice[M]. Switzerland: Springer International Publishing, 2015.
[44] Li Shenglan, Shen Chen, Lin Peina. Analysis of Environmental Regulation and Regional Economic Growth Effects—Empirical Test Based on Chinese Provincial Panel Data [J]. Collected Essays on Finance and Economics, 2014(6):88-96.
[45] Aguinis H, Glavas A. What we know and don' t know about corporate social responsibility: a review and research agenda[J]. Journal of management, 2012, 38(4):932-968.
[46] Shen Hongtao, Huang Nan, Liu Lang. Research on Micro Effects and Mechanisms of Carbon Emissions Trading [J]. Journal of Xiamen University (Arts & Social Sciences), 2017(1):13-22.

Author Contributions

Feng Lili: Conducted conclusion analysis and summary induction
Shi Yingying: Conducted data collection and analysis, wrote the paper
Feng Xin: Determined the article framework, provided writing guidance
Li Jiapei: Conducted data collection and analysis, performed experimental verification
Liu Yuan: Conducted language polishing and paper revision

Note: Figure translations are in progress. See original paper for figures.