Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 17, No. 1, 2024

The Impact of Factor Market Distortions on Environmental Pollution Control - A Study of the Mediating Effect Based on Technological Innovation

Ye Yang

School of Statistics and Applied Mathematics, Anhui University of Finance and Economics, Bengbu, Anhui 233030, China

Abstract: The core driving force of economic development is technological innovation, which, as the main driving force for the coordinated development of the environment and the economy, can provide important support for reducing environmental pollution. China has been committed to promoting the process of marketisation, and most studies have shown that factor market distortions can significantly exacerbate environmental pollution. Although existing studies have explored the effects of technological innovation and factor market distortion on environmental pollution, few studies have examined the relationship between these three factors, and the research perspective is relatively narrow. This single-factor analysis model ignores the possible interaction between technological innovation and factor market distortion on environmental pollution. Therefore, this project investigates how technological innovation and factor market distortion affect environmental pollution from a quantitative perspective, and explores the intrinsic mechanism of technological innovation and factor market distortion on environmental pollution; it also provides theoretical and practical bases for the management of environmental pollution and the promotion of China's economic development with high quality from a new perspective.

Keywords: Technological innovation, Factor market distortions, Environmental pollution, High-quality economic development, Regional disparities.

1. Introduction

The conflict between rapid economic growth and environmental pollution is becoming increasingly prominent, with studies suggesting that the number of people who will die globally in 2023 from long-term exposure to outdoor and indoor air pollution reaches nearly 5 million from stroke, heart disease, lung cancer, diabetes and chronic lung disease. Pollution has become the largest environmental contributor to serious illness and unnatural deaths, posing a serious risk to human health. The United Nations Environment Program (UNEP) advocated solutions to mitigate environmental pollution and promote environmental and economic development at the 26th United Nations Climate Change Conference. Since its economic reform and opening up, China has experienced rapid economic growth and become the world's second largest economy.

However, rapid economic growth has accelerated the exploitation of natural resources and increased the emission of industrial pollutants, leading to serious environmental pollution problems. A series of ecological problems, such as environmental pollution and resource scarcity, are unavoidable objective facts in the process of China's sustained economic growth, and in this context, the realization of sustainable development has become a key topic of concern for academics and governments at all levels. In order to reduce environmental pollution, we must emphasize and explore the relationship between inputs and economic growth.

With the accelerated pace of innovation, technological innovation, as the main driving force for the coordinated development of environment and economy, can provide important support for reducing environmental pollution. Technological innovation provides green technology for production, promotes the transformation and upgrading of industrial structure, realizes the greening of production methods, reduces the consumption of natural resources per unit of output, and thus improves the utilization rate of energy, achieves large-scale savings and resource recycling, and reduces environmental pollution. Technological innovation can also improve technological progress in pollution control through increased investment. This may lead to the adoption of cleaner production processes and cleaner energy sources by producers and the use of pollution treatment equipment such as exhaust gas purifiers and sewage treatment machines for end-of-pipe treatment, reducing industrial pollutant emissions at the source and thus improving environmental quality. Therefore, technological innovation can have a positive impact on environmental pollution control and can effectively promote the coordinated development of the environment and the economy.

As the largest developing country, China has been committed to promoting the process of marketization, but it is worth noting that the marketization process of China's factor market lags far behind that of the product market in the pursuit of environmental pollution control. The increase in the quantity of factor uses as well as the decrease in utilization efficiency that may result from the serious undervaluation of factor prices, a phenomenon known as factor market distortion, is highly likely to have an impact on pollution emissions. In order to promote rapid economic growth, governments at all levels intervene and control the prices and allocation of various factors such as land, labor, capital, energy, etc., which leads to the obstruction of factor flows, rigidity of factor prices, differentiation of factor prices, underestimation of factor prices, and ultimately to factor market distortion.

Most studies have shown that factor market distortions significantly exacerbate environmental pollution. The environmental impacts of factor market distortions cannot be ignored and are categorized into scale effects and technological effects. In terms of scale effects, factor distortions make factor prices lower than market prices, and the increase in factor use inevitably exacerbates pollution emissions. Regarding the technology effect, scholars have studied the negative environmental impact of the technology effect of factor market distortion. Low-cost factors brought about by factor market distortions increase the scale of production of non-technological knowledge-intensive products and stimulate research and development of production technologies in traditional manufacturing industries. In contrast, the tertiary industry, which is less pollution-intensive, is hampered and is not conducive to industrial structure upgrading, which inhibits the improvement of regional environmental quality.

2. Theoretical Analysis and Research Hypothesis

The impact of factor market distortion on environmental pollution management is a multidimensional and complex issue, which involves resource allocation efficiency, technological progress, industrial structure upgrading and other aspects. The study shows that there is a significant positive correlation between factor market distortion and environmental pollution, i.e., factor market distortion exacerbates the environmental pollution problem by affecting resource allocation efficiency. By constructing a spatial dynamic panel model, it is found that environmental pollution has a spatial spillover effect, and there is a spatial autocorrelation between both factor market distortion and environmental pollution (Kan University, Lv Lianju, 2016). Foreign direct investment (FDI) has a positive effect on haze control in promoting industrial structure upgrading and environmental technology spillovers, but factor market distortions weaken these positive effects (Huang Yuran, Lu Zhiqiang, Li Zhibin, 2018). The empirical analysis of energy factor market distortions shows that energy factor price distortions have a significant positive effect on haze pollution, which mainly exacerbates haze pollution by hindering the technological progress of enterprises and the upgrading of industrial structure (Ai Hongshan, Guan Mengmeng, 2020). In addition, the interaction between industrial structure upgrading and factor market distortion makes the factor market distortion weaken the role of industrial structure upgrading to reduce pollution, resulting in the actual urban environmental pollution level higher than the moderate pollution level (Huang Yuran, Lu, Li, Zhibin, 2018).

In terms of regional differences, the positive impact of energy factor price distortion on haze pollution is greater in the western region than in the central and eastern regions, which may be related to the looser policy environment and higher degree of factor marketization in the eastern region (Ai Hongshan, Guan Mengmeng, 2020). The strengthening of environmental regulation, especially the implementation of the new environmental protection law, has significantly improved the environmental performance of heavy polluters, especially in the eastern region the effect is more obvious. Factor market distortion not only directly affects environmental quality, but may also have an indirect impact on environmental quality by influencing technological progress, industrial structure upgrading, and energy efficiency improvement. Therefore, promoting the marketization process of the factor market and improving environmental quality is an urgent problem to be solved at present. To this end, it is recommended that greater efforts be made to promote the reform of the marketization of energy factors, to optimize the structure of energy consumption, to create a good competitive environment for enterprises and to encourage them to innovate on their own.

2.1. Technological Innovation and Regional Environmental Pollution

Technological innovation capacity reflects a country's position in the international division of labor and its ability to capture trade benefits. Technological innovation often leads to changes in industrial structure and technological conditions, not only in the form of complementary adjustments to local industries and the introduction of advanced technologies, but also in the corresponding changes in the production structure and technological conditions of local domestic enterprises caused by the effects of technological spillovers and industrial linkages. Therefore, this paper argues that technological innovation reduces regional pollution emissions mainly through the promotion effect of industrial structure upgrading and the driving effect of technological progress.

First, the promotion effect of industrial structure upgrading. Industrial structure is essentially a matter of resource allocation in what industries and enterprises. Technological innovation can affect a region's industrial structure and then affect the region's environmental pollution. When the technological innovation capacity is low, that is, China's manufacturing industry in the global value chain is at the low end of the lock, based on China's comparative advantage in trade, means that our country will be a large number of productions of labor-intensive and pollution-intensive commodities, at this time, the crude industrial structure of the formation of natural resources overconsumption and a rapid increase in pollution emissions. With the continuous improvement of technological innovation, China's manufacturing industry in the international value chain is also rising, in the field of trade has more “the right to speak” technological innovation is no longer too dependent on the consumption of resources and energy, but more dependent on technological innovation, productivity and management, organizational innovation, high-tech industries. Competitiveness enhancement, industrial structure gradually from heavy pollution industrial products to light pollution capital-intensive and technology-intensive products (Peng Shujun, Bao Qun, 2006), as a result, industry, especially heavy pollution in the industrial structure of the proportion of the industry is no longer rising or falling, and even through the international transfer of industry will be transferred out of the proportion of the service sector will rise, thus greatly reducing the energy consumption of manufacturing enterprises and pollution emissions. Pollution emissions.

Second, the driving effect of technological progress. It not only comes from the efficiency improvement brought by the specialization of production based on comparative advantage, but also may come from the change of the connotation of technology, which is reflected both in the progress of production technology and in the pollution control technology. First of all, the increase in technological complexity means that the technological research and development and technology absorption capacity of China's manufacturing enterprises has been strengthened, at which time China can import advanced machinery and equipment, raw materials and other intermediate inputs from developed countries that dominate the value chain, and learn, imitate and absorb the existing technologies of developed countries at a relatively low cost, and further enhance the production efficiency of enterprises through the input-output effect, improve the utilization of natural resources, and make resources Get a lot of savings and recycling, thus reducing the unit output of natural resources consumption and emissions, reduce environmental pollution; Secondly, the higher the technological complexity, environmental protection requirements and standards are often higher, forcing OEM enterprises to learn and catch up with the developed countries' environmental protection technology and management experience, and accept the supervision and help of multinational corporations with high requirements and standards and other active spillover in order to enhance the ability of self-innovation. Moreover, through the internalization of multinational corporations, that is, domestic enterprises through multinational corporations to establish forward and backward economic links, multinational corporations may through the upstream and downstream linkage to domestic enterprises to provide more advanced environmental protection technology directly, or to promote the domestic enterprises to take more effective pollution control measures. As a result, in order to meet the high environmental standards under the high technological sophistication of developed country consumers or multinational corporations, i.e., upstream and downstream demands, regional manufacturers are more willing to adopt cleaner production processes, cleaner energy sources, and pollution treatment equipment in the production process to strengthen the environmental friendliness of their products, which will in turn lead to the improvement of regional environmental quality.

Accordingly, research hypothesis 1 is proposed: technological innovation has a positive contribution to regional pollution reduction.

2.2. The Effect of Factor Market Distortions on The Relationship Between Technological Innovation and Regional Environmental Pollution

Under the incentives of fiscal decentralization and political promotion, local governments have strong incentives to intervene and control the allocation, pricing and control of factor resources such as land, capital and labor in order to pursue GDP growth, resulting in the reform of the factor market lagging behind the reform of the product market (Zhang J. et al., 2011).

According to the above content, manufacturing technology innovation capacity mainly through the "technology" effect and "structure" effect to reduce regional environmental pollution, we believe that the distortion of the factor market is also mainly through the inhibition of these two effects, and then on the manufacturing technology innovation capacity to promote the reduction of regional environmental pollution (Zhang Jie et al., 2011). We believe that the distortion of factor market also mainly inhibits these two effects, and thus inhibits the positive effect of manufacturing technology innovation ability to promote the reduction of regional environmental pollution.

To a certain extent, the distortion effect of market factors has solidified the crude industrial structure of certain regions. Usually, in a mature and competitive market environment, the price mechanism can encourage enterprises to invest in areas with strong demand, high profits, advanced technology, low resource consumption and low cost. In contrast, those enterprises with insufficient demand, backward technology and high resource consumption will gradually shrink due to their weak profitability and high costs, ultimately realizing the reasonable distribution and optimal allocation of resources among different industries and sectors.

In addition, for those industries with insufficient demand and excess capacity, enterprises with high costs and high consumption will find it difficult to survive in price competition and be eliminated through bankruptcy, merger or restructuring, and resources will thus flow to those enterprises with high efficiency, advanced technology and low energy consumption, so as to realize the optimal allocation of resources within the industry. In this way, low-cost development and overconsumption of energy can be reduced, and enterprises are pushed to improve the efficiency of energy use and increase the cost of non-compliance with the use of energy, thus reducing dependence on energy and reducing pollution emissions. However, in regions with more serious distortions of market factors, local governments may, out of considerations of taxation, employment and local economic development, provide certain industries or enterprises with resources at below-market prices by means of tax incentives, subsidies, and low-priced land, which distorts the cost and revenue structure of enterprises.

Such low-cost resources not only enable the survival of backward production capacity and high-consumption, high-pollution and high-cost industries that should have been eliminated, but may also prompt enterprises to increase production and profits by obtaining low-cost resources, or even engage in unfair price competition with market-oriented enterprises. This ultimately makes it difficult for excess capacity to be eliminated through market competition and for resources to flow to more efficient enterprises, resulting in waste and misallocation of resources. Under such circumstances, enterprises will have less incentive to gain an edge in technological innovation by improving their productivity and competitiveness, and increasing their investment in R&D and technology, and will be more likely to favor the production of products with lower technological content, which will put them at a disadvantage in the competition for technological innovation, and make them vulnerable to being locked into the lower end of the global value chain. Overall, the distortion of market factors protects backward production capacity and high-consumption, high-pollution, low-efficiency industries, hinders the optimization and upgrading of the regional industrial structure, and creates a lock on the crude growth model, which is not conducive to the improvement of regional environmental quality.

Distorted factor prices hinder the development of technologically innovative enterprises in technological progress. Usually, in regions with seriously distorted factor markets, the government has greater influence over the pricing and allocation of key resources. In environments where the rule of law is not yet sound, firms that are close to the government may obtain low-cost resources through illegitimate means, which reduces their intrinsic incentives to promote technological innovation. At the same time, under the policy orientation of taking economic growth as the main goal, local governments are more likely to provide preferential resource conditions to large state-owned enterprises or local enterprises, which may lead to misallocation of resources, reduce the efficiency of resource utilization, and thus weaken the technological development of technologically innovative enterprises. In the long run, such distortions in factor markets reduce the incentives for firms to engage in technological innovation and lead to over-reliance on low-cost resources, which not only makes it difficult for firms to improve resource efficiency through technological innovation, but also reduces their willingness to adopt environmentally friendly production methods and equipment. As a result, resource consumption and pollution emission levels remain high, which may ultimately lead to further deterioration of regional environmental quality.

Accordingly, research hypothesis two is proposed: in regions with more serious factor market distortions, the contribution of manufacturing technological innovation capacity to regional pollution reduction is significantly weakened.

3. Research Design

3.1. Data Sources and Processing

Due to the large amount of missing data for Tibet, Xinjiang and Ningxia, these provinces were not included in the final analysis sample, so this study is based on the panel data of 28 provinces and cities in mainland China from 2010 to 2023, aiming to conduct an in-depth analysis. The data were collected from China Statistical Yearbook and China Environmental Statistics Yearbook. When processing the data, for missing data, the researcher used the interpolation method to complete these data, by which the study ensured the completeness and accuracy of the data and provided a solid foundation for further analysis.

3.2. Model Setting and Description of Variables

Based on the theoretical analysis above, the following basic analytical model was developed.

$$\ln Pollutant_{it} = \alpha + \beta \ln TIC_{it} + \lambda \ln X_{it} + \mu \tag{1}$$

$$\ln Pollutant_{it} = \alpha + \beta \ln TIC_{it} + \zeta \ln F_{it} + \lambda \ln X_{it} + \mu \tag{2}$$

$$\ln Pollutant_{it} = \alpha + \beta \ln TIC_{it} + \gamma \ln esi_{it} * \ln F_{it} + \lambda \ln X_{it} + \mu \tag{3}$$

Where Eq. (1) is the baseline test model, Eq. (2) is the test model considering factor market distortions, and Eq. (3) is the test model incorporating the cross-multiplication term between technological innovation capacity and factor market distortions. α denotes the constant term, and μ denotes the random perturbation term. The explanatory variable $Pollutant_{it}$ denotes the pollution emission intensity in year t in region i. Considering the availability of data, drawing on the practice of most studies such as Zhang Peng (2013), and in order to overcome the influence of city size, this paper mainly selects per capita dust emission, which reflects the air pollution status, as the indicator, and takes per capita industrial soot emission as the explanatory variable for the robustness test. The core explanatory variable TIC_{it} denotes the technological innovation capacity of region i in year t. F_{it} denotes the degree of factor market distortion in region i in year t. In addition, in order to make the estimation more accurate, referring to the existing studies, this paper also adds other control variables, including: industrial structure (SP), expressed as the proportion of added value of the tertiary industry to the GDP; openness to the outside world (OP), measured as the proportion of foreign direct investment to the GDP; and the degree of urbanization (UB), expressed as the ratio of the total year-end population in the towns and cities to the total year-end population in the region. Measurement of the technological innovation capacity of manufactured goods (ESI) and factor market distortion (F) are the focus of this paper.

For factor market distortions, the indicators constructed by Zhang et al. (2011a) to measure factor market distortions are commonly used: FAC1= (Marketization index of product market - Factor market development index)/Marketization index of product market, and FAC2= (Marketization index of overall market - Factor market development index)/Overall marketization index of the market. However, Lin Boqiang et al. (2013), among others, point out that this method may smooth out the relative degree of factor market distortion between regions. Therefore, this paper draws on Lin Boqiang et al. (2013) and uses the relative gap between the degree of factor market development in each region and the highest degree of factor market development in the sample, FAC3, as a proxy variable for factor market distortion. Meanwhile, this paper also adopts FAC1 as a proxy for factor market distortion for robustness testing.

4. Analysis of Empirical Results

4.1. Regression Analysis of Technological Innovation Capacity and Environmental Pollution

In order to avoid the estimation bias that may be caused by multicollinearity, this paper firstly carried out the test of multicollinearity before regression. The mean value of the multicollinearity VIF test is 1.53, and the maximum value is 2.35, indicating that there is no obvious multicollinearity among the variables. In order to maintain the smoothness of the data, the variables are logarithmized in this paper. The paper gives empirical results using ordinary least squares on panel data. In particular, column 2 reports the robust OLS estimation results, column 3 reports the WLS estimation results corrected for White's heteroskedasticity, and columns 4 and 5 give the FE and RE estimation results, respectively.

Table 1. Results of Hypothesis 1

	Robust OLS	WLS	FE	RE
lnESI	-1.9928***	-1.5783*	-0.5389	-0.6994
	(-2.61)	(-1.72)	(-0.87)	(-1.12)
lnSP	-1.3452***	-1.1905***	-1.3256***	-1.6243***
	(-4.71)	(-4.09)	(-2.67)	(-3.89)
lnUB	-0.3156*	-0.5082***	-0.3985***	-0.4790***
	(-1.82)	(-3.12)	(-3.13)	(-3.69)
lnOP	-0.2132***	-0.2798***	0.4012***	0.1996***
	(-3.59)	(-4.39)	(4.91)	(3.23)
c	22.9789***	15.0217*	7.2890	10.2132
	(2.57)	(1.69)	(1.12)	(1.39)
R^2	0.38	0.47	F=20.1	Wald=76.12
			(0.00)	(0.00)

Table 1 demonstrates the results of the test of Hypothesis 1. The data show that, in general, the core variable of this study, technological innovation capability, exhibits a significant negative correlation in both robust OLS (ordinary least squares) and WLS (weighted least squares) estimates. This implies that, by and large, increased technological innovation complexity in the manufacturing sector has a positive impact on the improvement of regional environmental quality. The reasons for this effect may include two aspects: firstly, the increase in technological innovation complexity of the manufacturing industry helps to promote the manufacturing industry to move upstream in the international value chain and enhance its international competitiveness, reducing the dependence on labor-intensive and pollution-intensive products and shifting more to capital-intensive or technology-intensive products, which helps to shift the regional industrial structure from heavily polluting industries to lightly polluting industries; secondly, the The increase in technological complexity helps to bring technological spillover effects to domestic manufacturing enterprises through the competitive demonstration effect, personnel training and mobility, and the backward and forward linkage of the industrial chain, promoting the development of energy-saving, emission reduction and environmentally friendly technological equipment in the production process, thus enhancing the environmental quality of the region. This finding is consistent with the previous theoretical analysis.

In terms of other control variables, the upgrading and optimization of regional industrial structure helps to reduce the intensity of regional pollution emissions, and the development of urbanization has a positive effect on the improvement of regional environmental quality, while FDI (foreign direct investment) in opening up to the outside world is detrimental to the enhancement of regional environmental quality, which may support the existence of the "Pollution Paradise" hypothesis. This may support the existence of the "pollution paradise" hypothesis.

4.2. Regression Analysis of Factor Market Distortions, Technological Innovation Capacity and Environmental Pollution

This study further introduces the interaction term between technological innovation capability and factor market distortion (lnESI*lnFAC3) to test Hypothesis 2 (see Table 2 for details). The analysis results show that this interaction term exhibits a significant negative correlation in the estimation of both fixed effect (FE) and random effect (RE) models. This suggests that the role of technological innovation capacity of manufacturing firms in improving local environmental quality is significantly weakened when the factor market distortion of the region is high, thus supporting Hypothesis 2 of this study.

The reason behind this result is that state-owned enterprises (SOEs) in regions with more severe factor market distortions tend to be able to obtain low-cost factor support from local governments more easily. Meanwhile, private and non-local firms often face identity and geographic discrimination as well as administrative monopolies in accessing factors, leading these firms to prefer low-cost factors through rent-seeking behavior. As a result, highly polluting backward production capacity has been given some form of "survival protection", while the technological innovation capacity of enterprises has not been enhanced. Enterprises have been locked into the low end of the international value chain for a long time, relying excessively on labor-intensive and pollution-intensive products, resulting in the regional industrial structure not being effectively optimized.

In addition, "protected" manufacturing enterprises lack the incentive to promote technological innovation and improve energy efficiency, while "neglected" enterprises lack the motivation and incentives to make high-risk, long-term investments in innovation. This has led to stagnant technological progress in the industry, making it difficult to improve productivity, and making it difficult to widely promote and apply green technologies with low energy consumption, pollution and emissions. As a result, the distorting effect of factor markets inhibits the potential positive impact of technological innovation capacity on enhancing regional environmental quality.

Table 2. Results of Hypothesis 2

	Robust OLS	WLS	FE	RE
lnESI	-2.1237**	-1.2031	-0.2994	-0.4092
	(-2.13)	(-1.31)	(-0.51)	(-0.49)
lnSP	-1.1279***	-1.1132***	-1.3146***	-1.4931***
	(-3.69)	(-3.59)	(-2.81)	(-3.80)
lnUB	-0.2742	-0.4603***	-0.4349***	-0.4876***
	(-1.61)	(-2.79)	(-2.98)	(-3.69)
lnOP	-0.1979***	-0.2398***	0.4012***	0.2297***
	(-2.98)	(-3.97)	(4.79)	(3.38)
lnESI*lnFAC3	0.0133	0.0102	0.0169*	0.0198**
	(0.79)	(0.81)	(1.79)	(2.29)
c	20.7659*	12.8361	5.0836	6.1438
	(1.91)	(1.19)	(0.47)	(0.69)
R^2	0.41	0.45	F=17.73	Wald=79.38
			(0.00)	(0.00)

4.3. Robustness Check

To further confirm the reliability of the above conclusions, this paper performs the following robustness tests, which in general do not change the original research conclusions. First, the conclusions of this paper may be affected by sample selectivity bias. Due to the variety of pollutants, this paper cannot be exhaustive but selects the per capita dust pollution emissions to focus on the analysis, but this may cause the sample self-selection problem. In order to control the unfavorable effects brought about by the sample selectivity bias, this paper also uses the per capita dust pollution emissions to conduct robustness tests (see Table 3). The regression results show that the main conclusions of this paper still hold.

Table 3. Robustness test results (1)

	Robust OLS	WLS	FE	RE
lnESI	-4.7365***	-4.1321***	-1.2m893*	-1.2984***
	(-7.03)	(-5.12)	(-2.03)	(-2.63)
lnSP	-1.9112***	-1.9032***	-1.0989***	-1.4132***
	(-9.31)	(-8.72)	(-3.38)	(-4.61)
lnUB	0.7632***	0.6938***	-0.1782*	-0.1423
	-6.12	-5.51	(-1.72)	(-1.29)
lnOP	-0.2423***	-0.3253***	0.1592***	0.1027*
	(-3.91)	(-7.37)	(3.19)	(1.69)
c	50.3725***	33.3284***	9.2826*	15.2845***
	(7.12)	(5.13)	(1.81)	(2.67)
R^2	0.41	0.52	F=11.96	Wald=47.34
			(0.00)	(0.00)

Table 4. Robustness test results (2)

	FAC1 as an indicator of factor market distortions		lnsmoke replaces lndust, FAC1 replaces FAC3	
	Robust OLS	WLS	Robust OLS	FE
lnESI	-2.1384**	-1.2362	-4.2463***	-0.1369
	(-2.17)	(-0.92)	(-5.89)	(-0.32)
lnSP	-1.0924***	-1.4152***	-1.3972***	-0.6389*
	(-2.75)	(-3.82)	(-4.81)	(-1.92
lnUB	-0.1927	-0.4198**	0.8012***	-0.1923**
	(-1.21)	(-2.52)	(6.12)	(-2.03)
lnOP	-0.1562**	-0.1812***	-0.2572***	0.1089**
	(-2.12)	(-2.98)	(-3.47)	(1.98)
lnESI*lnFAC1	0.0141	0.0129*	0.0113	0.0132***
	(1.49)	(1.81)	(1.51)	(2.99)
c	20.8372*	9.0482***	39.9284***	-0.2583
	(2.1)	(1.29)	(6.12)	(-0.04)
R^2	0.31	0.42	0.41	F=9.19
				(0.00)

Second, the factor market distortion indicator in the previous section was measured using the relative gap FAC3 between the degree of factor market development in each region and the highest degree of factor market development in the sample, and now the robustness analysis is conducted using FAC1 = (marketization index of product market - factor market development index)/marketization index of product market proposed by J. Zhang et al. (2011a) (see Table 4). The results show that the conclusions of this paper have not been substantially changed. Finally, the paper not only replaces per capita dust pollution emissions with per capita smoke pollution emissions, but also replaces FAC3 with FAC1, and the regression results show that the conclusions of this paper are still robust.

5. Conclusions and Implications of the Study

In recent years, with China's active participation in the international division of labor, China's technological innovation capacity has been gradually improved, and it is gradually becoming one of the important factors affecting the upgrading of regional industrial structure, technological progress and environmental quality. Based on the perspective of international vertical specialization division of labor, this paper takes the technological innovation capacity of manufactured goods as the research entry point, and focuses on the impact of the technological innovation capacity of manufactured goods on regional environmental quality through the empirical research on China's inter-provincial panel data. On this basis, this paper also further examines the disturbing effect of regional factor market distortion on regional environmental quality improvement. The main findings of this paper are as follows.

(1) In general, the improvement of technological innovation capacity of manufactured products can have a positive effect on regional environmental quality from the optimization of industrial structure and the promotion of technological progress; (2) On the whole, the distortion of regional factor market will interfere with the improvement of technological innovation capacity of manufactured products, hinder the technological innovation motivation of enterprises and the upgrading of the regional industrial structure, and then impede the improvement of regional environmental quality. Improvement of regional environmental quality is hindered.

The conclusions of this paper have important policy significance: one of the shortcomings exposed in the current marketization process in China is the distortion of the factor market, the reform of the factor market is lagging behind the reform of the product market, and the local government has too much control over the allocation, pricing and control of factor resources. This results in factor resources being reduced to a tool for safeguarding local interests, so that factor resources are not allocated to the hands of the most suitable economic subjects, and to a certain extent, it also hinders the improvement of regional environmental quality. Therefore, a full understanding of the shortcomings of factor market distortion, with greater vigor to promote the market-oriented reform process, obviously has been imminent. To solve the problem of factor market distortion, we need to thoroughly reform the institutional factors that form it.

In view of this, in the future, China should further promote the marketization of factor resources, reduce administrative approval, liberalize market access conditions, break the monopoly formed by the franchise, allowing all kinds of market players to enter the field of “no law prohibits” on an equal footing, to enhance market competitiveness, so that the factors of production in different sectors of the free flow of; at the same time, to further liberalize the price mechanism, especially the price of resources, and to further liberalize the price mechanism, especially the price of resources. At the same time, further liberalize the price mechanism, especially resource prices. Only market-oriented resource prices can truly reflect the market demand for products and resource scarcity, the cost of enterprises can also truly reflect the consumption of resources. The more scarce the resources, the higher the price, which will force enterprises to reduce resource consumption and costs through technological upgrading, improving management levels, or even withdrawing from high-resource-consuming industries, reducing the misallocation of resources, and providing effective market incentives for the adoption of environmentally friendly technologies. In addition, it provides property rights protection for market players, realizes the transformation from a government-led to a market-led economy, creates a growth space for market players that encourages innovation, and provides institutional safeguards and a social environment for building an innovation-driven country, promoting China's industries to the higher end of the global value chain, and advancing the construction of an ecological civilization.

Acknowledgements

Anhui University of Finance and Economics Graduate Research Innovation Fund Project (ACYC2022363).

References

[1] Kan D, Lv L. Do factor market distortions exacerbate environmental pollution--an analysis based on spatial dynamic panel data of provincial industrial sectors [J]. Finance and Trade Economics, 2016(5):146-159.

[2] Ai H, Guan M. Empirical analysis of energy factor market distortion affecting haze pollution [J]. Social Science Network, 2020:1-15.

[3] Huang Y, Lu Z, Li Z. Industrial Structure Upgrading, Factor Market Distortion and Environmental Pollution-Analysis Based on Panel Data of 283 Prefectural-level Cities from 2003 to 2015 [J]. Business Research, 2018(7):119-124.

[4] Zhang Y, Li Y, Jin P. Research on the spatial effect of factor market distortion affecting environmental quality in Chinese cities [J]. Finance and Economics Series, 2016, 32(7): 3-10.

[5] Peng S, Bao Q. Economic Growth and Environmental Pollution [J]. Research on Financial Issues, 2006, (8):3-16.

[6] Zhang J, Zhou X, Li Y. Factor market distortions inhibit R&D of Chinese firms [J]. Economic Research, 2011(8):78-90.

[7] Xu Y, Cai H, Yan C. Factor market distortion and haze pollution prevention in China [J]. Journal of China University of Geosciences (Social Science Edition), 2019, 19(01):27-38.

[8] Dong B, Xu Y, Sun W. Study on the carbon unlocking path of green technological innovation under the perspective of “structural adjustment”-the moderating effect of environmental regulation [J]. Research and Development Management, 2023:34-49.

[9] Fan X, Xu Y. Convergence on the haze pollution: city-level evidence from China [J]. Atmospheric Pollution Research, 2020:141-152.

[10] Xu Y, Gu P. Official promotion incentives, factor market distortion and high-quality economic development: An empirical study based on cities in the Yangtze River Economic Bel t[J]. Journal of Shanxi University of Finance and Economics, 2020:1-15.

[11] Guo J, Xu Y, Bai J. Housing, Amenities and Heterogeneous Labor Mobility-Micro-mechanisms and Welfare Effects [J]. Financial Research, 2022:135-153.

[12] Xu Y, Cai H, Yan C. Research on the Impact of Environmental Protection Tax on Haze Pollution Prevention and Control in China under the "New Normal" [J]. Journal of Central South University: Social Science Edition, 2019:70-77.

[13] Zhang J, Zhou X, Zheng W, et al. Do factor market distortions motivate Chinese firms to export [J]. World Economy, 2011(08):136-162.

[14] Liu S. Factor Market Distortions, Export Technical Complexity and Regional Environmental Pollution-An Empirical Study Based on Chinese Interprovincial Panel Data [J]. Exploration of Economic Issues, 2015(09):28-35.

[15] Wang J, Tan Z. Analysis of factor market distortion and R&D behavior of export enterprises [J]. Journal of the University of International Business and Economics: International Business Edition, 2019(4):1-14.

[16] Wen Z, Hou J, Zhang L. Comparison and application of moderating and mediating effects [J]. Journal of Psychology, 2005(2):614-620.

[17] Zhang Y, Li Y, Jin P. Research on the spatial effect of factor market distortion affecting environmental quality in Chinese cities [J]. Finance and Economics Series, 2016(7):3-10.