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*Original Research*

# Impact Mechanisms of Carbon Emissions, Industrial Structure and Environmental Regulations in the Yellow River Basin

**Yan Han[1,2]*, Yushuai Shao[1]****

[1]School of Economics and Management, Lanzhou Jiaotong University, Lanzhou 730070, China
[2]Institute of Geographic Sciences and National Resources Research, Chinese Academy of Sciences, Beijing 100101, China

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**Abstract**

As an important energy base in China, the high-quality development of the Yellow River Basin plays an important role in achieving the goal of "carbon peak and carbon neutrality" in China. Based on the theoretical framework of industrial structure, environmental regulation and carbon emission, a panel vector autoregressive model is adopted to examine the dynamic relationship between environmental regulations, carbon emissions, and industrial structure with the panel data of 79 prefecture-level cities in the Yellow River Basin from 2004 to 2019. The findings indicate that: (1) On the whole, the effect of environmental regulation on carbon emissions is initially boosted, then prevented. Industrial structure has an inhibitory influence on carbon emissions, but this inhibitory effect is with apparent lag. Environmental regulation prevents industrial structure upgrading in the near term. (2) From the regional viewpoint, it can be seen that the degree of coordination between the upper, middle and down reaches of the Yellow River Basin steadily diminishes from east to west during the period of 2004-2019. The down reaches areas basically achieved the coordinated development of among the three. In the middle reaches, the environmental regulation has the most obvious effect on reducing carbon emissions reduction, but the incentive effect on industrial structure upgrading is not obvious, and industrial structure upgrade is clearly insufficient to reduce carbon emissions. In the upper reaches, the effect of industrial structure upgrading on carbon emission reduction is clear, but the effect of environmental control on carbon emission reduction is significantly less than that of industrial structure upgrading. Finally, this study puts forward concrete policy recommendations to achieve the high-quality development in the Yellow River Basin.

**Keywords**: carbon emissions, industrial structure, environmental regulations, PVAR, variance decomposition

*e-mail: yingyuhy@163.com
**e-mail: 11200443@stu.lzjtu.edu.cn

## Introduction

Given the carbon emissions caused by global warming, various nations, cities, and big worldwide corporations have committed and initiated initiatives to reduce excessive carbon emissions during the last few decades [1]. China has eclipsed the United States as the world's largest carbon emitter since 2007, according to the Carbon Dioxide Information Analysis Center (CDIAC) [2, 3]. Achieving carbon peaking and even carbon neutrality would compel China's energy and industrial structures to constantly adjust and optimize, resulting in rapid expansion of clean energy and green sectors [4, 5]. However, there is a specific interaction between industrial structure, environmental regulation, and carbon emissions. The government's increased environmental regulatory intensity in pursuit of energy saving and emission reduction is certain to have an effect on industry restructuring and subsequent changes in carbon emissions. Industrial structure upgrading can also effectively reduce carbon emissions. Therefore, building a theoretical analysis framework among industrial structure, environmental regulation and carbon emissions, as well as clarifying the logical relationship between them, are critical to achieving the 2030 emission reduction target and promoting China's economy's high-quality development.

The Yellow River Basin (YRB), which accounts for 27.3% of the total area, 23.3% of the population and 21.8% of the total economy in China. It is an essential ecological barrier, economic zone, energy, and chemical industry base as well as a grain production base in China. However, local governments have traditionally been more inclined to economic expansion rather than environmental protection, resulting in the industrial structure being dominated by high-energy-consuming heavy chemical industries with high energy consumption, high emission and backward technology [6, 7]. More than 50% of the cities in the YRB are resource-based and old industrial cities, which seriously aggravates the carbon emissions in the YRB [8]. In 2019, the construction of ecological civilization and high-quality development in the YRB were included in the national plan [9]. The low-carbon and high-quality development of the YRB is not only a hot issue in Chinese academia, but also a significant component of regional sustainable development research [10]. In the context of high-quality of YRB, studying the relationship between carbon emissions, industrial structure, and environmental regulations helps to clarify the status of the YRB and provide decision-making basis for environmental management in the YRB.

In terms of environmental control and carbon emissions research,, environmental regulation may effect carbon emissions through energy consumption, technological innovation, and industrial structure, according to some experts. Sinn (2008) initially proposed the "green paradox" effect, which states that environmentally benign measures may hasten energy extraction. To put it another way, environmental regulations can encourage carbon emissions [11]. According to Sarkodie (2018), the impact of mandated environmental regulation on carbon emissions is inverted "U" curve, but the impact of market-based environmental regulations on carbon emissions is U-shaped [1, 12, 13]. In terms of research on industrial structure upgrading and carbon emissions, scholars primarily use the Logarithmic Mean Divisia Index (LMDI) method to investigate the contribution of industrial structure optimization and up-gradation in reducing carbon emissions, examining economic aggregate, industrial structure, energy intensity, and energy structure effects to investigate the contribution of industrial structure optimization and up-gradation in reducing carbon emissions. [14-16]. Yuan (2021) proposed a spatial autoregressive model to study their relationship, finding an inverted U-shaped curve effect of industrial structure on carbon emissions. They also found that industrial structure rationalization inhibited carbon emissions, whereas industrial structure up-gradation promoted carbon emissions [17]. In terms of the research on environmental regulation and industrial structure upgrading, there are three main viewpoints on the impact of environmental regulation on industrial structure. The first view is the "following the cost theory", which holds that with the continuous improvement of environmental regulation, on the one hand, the production cost of enterprises keeps increasing; on the other hand, enterprises increase their investment in environmental pollution, which weakens their technological innovation ability and thus inhibits the upgrading of industrial structure [12]. The second view is the "Pollution haven hypothesis", which states that enterprises restricted by environmental regulation policies will migrate to regions with weak environmental regulation intensity, which can promote the trans-regional transfer of polluting industries, but cannot promote the upgrading of industrial structure [18-20]. The third view is "Porter hypothesis", which believes that environmental regulation policies exert pressure on enterprises with low production efficiency, and enterprises will actively seek technological innovation, thereby promoting the upgrading of industrial structure [21].

To summarize, most academics are interested in the interaction between environmental regulations, carbon emissions, and industrial structure upgrading. However, few scholars systematically analyze the impact mechanism among environmental regulation, industrial structure upgrading and carbon emission by constructing the relationship between the three. Therefore, this paper established a panel vector autoregressive (PVAR) model of 79 cities in the YRB from 2004 to 2019 and deeply investigates the mechanisms of influence among environmental regulations, industrial structure, and carbon emissions by combining impulse response and variance analysis.

The contribution of this paper is mainly reflected in the following three points: (1) It constructs the index of industrial structure upgrading, examines the relationship between the rationalization of industrial structure and the upgrading of industrial structure from a new perspective, and expands the theoretical connotation of industrial structure upgrading; (2) An analytical framework is built between industrial structure, environmental regulation, and carbon emission, and the influence mechanisms of industrial structure, environmental regulation, and carbon emission are theoretically examined by means of dynamic analysis; (3) Taking the Yellow River Basin as the research object is helpful to provide targeted management policies and improvement measures for the region, as well as theoretical and empirical support for the YRB to take the lead in achieving peak carbon emissions.

## Materials and Methods

### Theoretical Hypothesis

Based on the existing research, this paper sorts out the relationship among environmental regulation, industrial structure upgrading and carbon emissions, as shown in Fig. 1.

#### *The Impact of Environmental Regulation on Carbon Emissions*

Environmental regulation can have two different effects on carbon emissions. On the one hand, environmental regulations have an inhibitory effect on carbon emissions. Specifically, the government further reduces the energy demand and increases enterprise costs through direct regulation and economic tools, namely, shutting down and rectification, and levying pollution tax and environmental protection tax, so as to reduce carbon emissions. On the other hand, environmental regulation has a promoting effect on carbon emissions, that is, high-polluting enterprises expect more and more strict government environmental regulation, which will promote enterprises to speed up energy exploitation, and subsequently affect the rise of carbon emissions in the short term, thus triggering the "green paradox" effect. In summary, this paper proposes hypotheses H1a and H1b:

H1a: Environmental regulation has a significant restraining effect on carbon emission.

H1b: Environmental regulation produces "green paradox" effect on carbon emission.

#### *The Impact of Industrial Structure Upgrading on Carbon Emissions*

Industrial structure upgrading is conducive to reduce carbon emissions. Some scholars have empirically tested that industrial structure upgrading can effectively reduce carbon emissions through different methods. Industrial structure upgrading can promote enterprises to improve technological level, improve resource allocation efficiency and optimize energy consumption structure, thereby further reducing carbon emissions. First, the optimization and upgrading of industrial structure can directly or indirectly affect the level of technological innovation. Technological innovation can reduce carbon emissions by improving production technology and developing clean and renewable energy. Secondly, the detailed degree of industrial and sector division will also have a difference in carbon emission intensity. The division and improvement of various industrial sectors can promote the effective allocation and utilization of resources, so that pollution emissions can be effectively restrained. Thirdly, industrial restructuring can improve energy efficiency and reduce carbon emissions In summary, research hypothesis H2 is proposed:

H2: Industrial structure upgrading can effectively reduce carbon emissions.

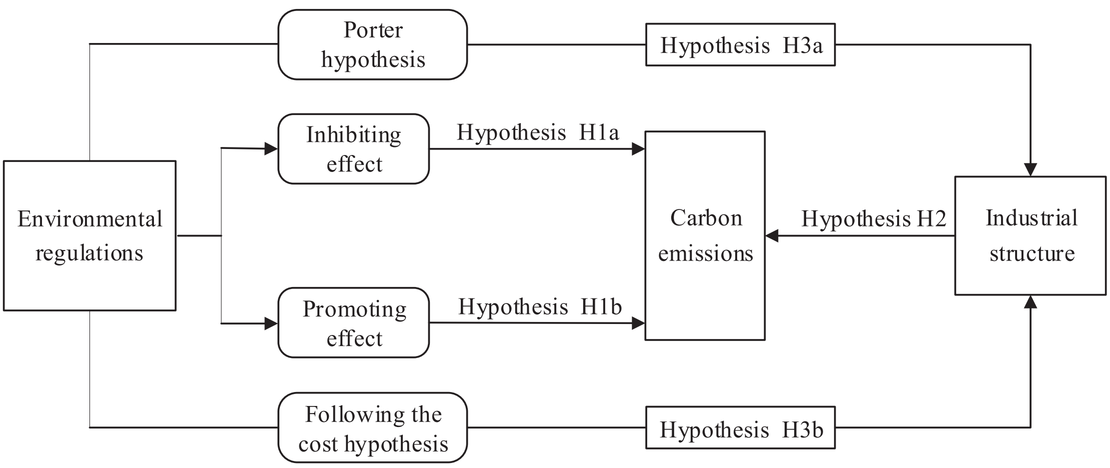


Fig. 1. Theoretical hypothesis model.

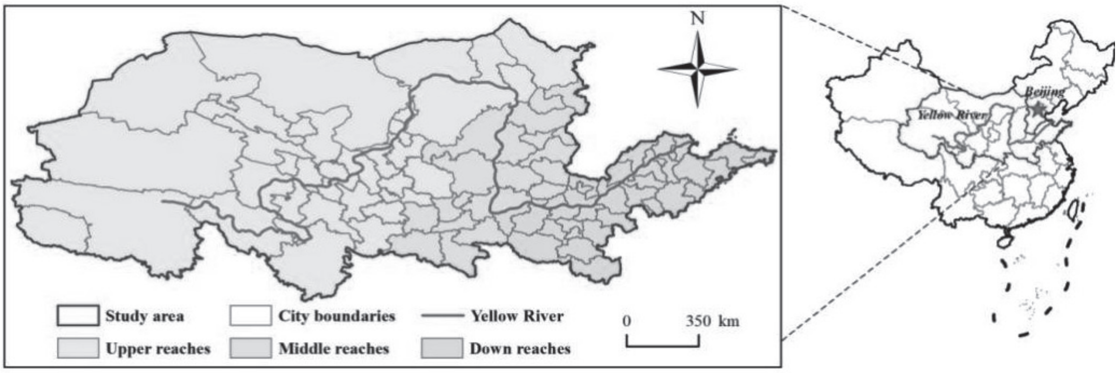


Fig. 2. The YRB area.

Table 1. Study area and division of the YRB.

| Region | Province | City |
|---|---|---|
| Upper reaches | Qinghai, Gansu, Ningxia, Inner Mongolia | Xining, Lanzhou, Jiayuguan, Jinchang, Baiyin, Tianshui, Wuwei, Zhangye, Pingliang, Jiuquan, Qingyang, Dingxi, Longnan, Yinchuan, Shizuishan, Wuzhong, Guyuan, Zhongwei, Hohhot, Baotou, Wuhai, Ordos, Bayannur, Ulanqab |
| Middle reaches | Shanxi, Shaanxi | Xi'an, Tongchuan, Baoji, Xianyang, Weinan, Yan'an, Hanzhong, Yulin, Ankang, Shangluo, Taiyuan, Datong, Yangquan, Changzhi, Jincheng, Shuozhou, Jinzhong, Yuncheng, Xinzhou, Linfen, Lvliang |
| Down reaches | Henan, Shandong | Zhengzhou, Kaifeng, Luoyang, Pingdingshan, Anyang, Hebi, Xinxiang, Jiaozuo, Puyang, Xuchang, Luohe, Sanmenxia, Nanyang, Shangqiu, Xinyang, Zhoukou, Zhumadian, Jinan, Qingdao, Zibo, Zaozhuang, Dongying, Yantai, Weifang, Jining, Tai'an, Weihai, Rizhao, Laiwu, Linyi, Dezhou, Liaocheng, Binzhou, Heze |

### *The Impact of Environmental Regulation on Industrial Structure Upgrading*

Environmental regulation has two different effects on the change of industrial structure. On the one hand, environmental regulation has a "Porter hypothesis" effect on industrial structure, that is, environmental regulation policies will force enterprises to purchase sewage discharge equipment, prompting pollution-intensive enterprises to use more low-carbon and energy-saving production technologies. With the continuous improvement of environmental regulation intensity, the profits of small and medium-sized enterprises entering the market are less than the cost of environmental protection, and they are forced to withdraw from the market. With the continuous elimination of pollution-intensive enterprises, regional industrial upgrading is effectively promoted. On the other hand, environmental regulation may also have "following the cost theory" effect on industrial structure. Market-based environmental regulations will increase the production cost of enterprises and weaken their investment in other aspects, thus inhibiting the upgrading of industrial structure. In summary, hypothesis H3a and hypothesis H3b are proposed:

H3a: Environmental regulation plays a positive role in promoting the upgrading of industrial structure.

H3b: Environmental regulation has a negative effect on industrial structure upgrading.

## Study Area

This study's research area includes eight provinces in the YRB: Qinghai, Gansu, Ningxia, and Inner Mongolia in the upper reaches, Shanxi and Shaanxi in the middle reaches, and Henan and Shandong in the down reaches. The specific study area is presented in Fig. 2 and Table 1.[1]

In terms of regional differences, the YRB covers an area of 745,100 square kilometers. It spans eight provincial-level administrative regions and runs through three economic belts of the East, the Middle and the West. The upper reaches of the YRB are mainly the Qinghai-Tibet Plateau conservation and restriction development zone, including the Lanxi Urban Agglomeration, Yinchuan Plain Urban Agglomeration and Hubaoe Urban Agglomeration. The middle reaches are mainly loess Plateau resource development zones, including Taiyuan city cluster and Guanzhong city

[1] Due to missing data, areas excluded are Haidong City, Haibei Tibetan Autonomous Prefecture, Huangnan Tibetan Autonomous Prefecture, Hainan Tibetan Autonomous Prefecture, Guoluo Tibetan Autonomous Prefecture, Yushu Tibetan Autonomous Prefecture, Haixi Mongolian Tibetan Autonomous Prefecture, Linxia Hui Autonomous Prefecture, Gannan Tibetan Autonomous Prefecture, Chifeng City, Tongliao City, Hulunbeier City, Xing'an League, Xilingol League, and Alxa League.

cluster. The down reaches area is mainly the modern and high-quality coordinated development area of the North China Plain, including the Central Plains urban agglomeration and the Shandong Peninsula urban agglomeration.

From the perspective of industrial structure, the total GDP of 79 cities in 8 provinces and regions of the Yellow River Basin in 2019 was 19.08 trillion yuan, five times that of 2004, accounting for 19.74 % of China 's GDP. The proportion of industrial structure is shown in Fig. 3. During 2004-2019, the proportion of primary industry in the YRB decreased from 13.5% in 2004 to 7.63% in 2019, while the proportion of secondary industry increased first and then decreased, rising from 53.68% in 2004 to 56.18% in 2008. Then there was a downward trend, falling to 42.09% in 2019. The proportion of the tertiary industry kept rising, rising from 33.83% in 2004 to 50.28% in 2019. In 2017, the proportion of the tertiary industry surpassed that of the secondary industry.

From the perspective of carbon emissions, the total carbon emissions in the YRB showed an upward trend, rising from 1.175 billion tons in 2004 to 2.749 billion tons in 2019 with an average annual growth rate of 8.9%. The carbon emissions of the upper, middle and down reaches are shown in Fig. 4. The total carbon emissions of the upper, middle and down reaches showed a rising trend, and exceeded that of the middle and down reaches in 2016. From 2004 to 2011, the carbon emissions of the middle and down reaches kept rising, and gradually stabilized after 2012.

## Research Method

### *PVAR*

The PVAR model has the advantage of a VAR model in which all variables are regarded as endogenous and can also introduce individual and time effects to improve the accuracy of result [22, 23]. In this study, the PVAR model is utilized to investigate the dynamic connections between environmental regulation, industrial structure, and carbon emissions in 79 cities across the YRB. The following is the suggested panel VAR model:

$$Y_{i,t} = \sum_{j=1}^{p} W_j Y_{i,t-j} + \alpha_i + \gamma_i + \mu_{i,t} \tag{1}$$

In formula (1), $Y_{i,t}$ indicates the column vectors of all variables in regio i on year t, wherein i = 1, 2,..., 79, representing 79 prefecture-level cities in the YRB; t = 2004, 2005, ..., 2019, indicating the year; $Y_{i,t}$ is a vector containing the three variables of environmental regulations, industrial structure, and carbon emission p represents the lag order; $W_j$ is a parameter matrix with different lag periods; $\alpha_j$ and $\gamma_j$ are individual fixed effect vector and time trend effect vector, respectively; and $\mu_{i,t}$ is a random perturbation term.

The construction of the PVAR model includes the following steps:

Step 1: Select the lag order of the PVAR model.

Step 2: Use the generalized method of moments (GMM) estimation to estimate the model and explain the regression relationship between endogenous variables.

Step 3: Using a dynamic impulse response diagram, calculate the impulse response function and reflect the influence of each endogenous variable on itself and other endogenous variables.

Step 4: Decompose the error term of variance to further explain the degree of influencing factors of the error term.

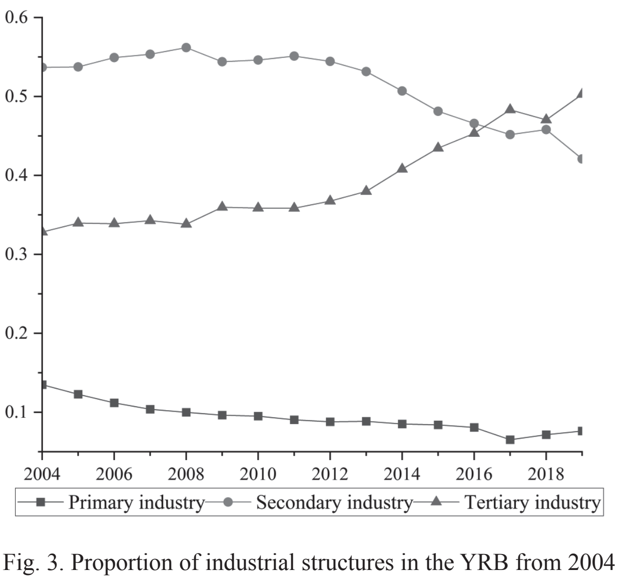


Fig. 3. Proportion of industrial structures in the YRB from 2004 to 2019.

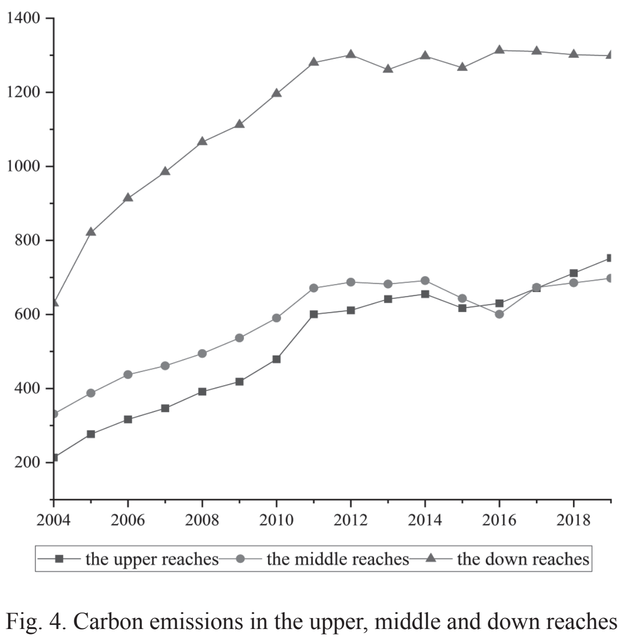


Fig. 4. Carbon emissions in the upper, middle and down reaches of the YRB from 2004 to 2019.

*Impulse Response Function*

The impulse response function examines the dynamic impact on all the endogenous variables in the system when a specific impact or disturbance is given to the VAR model [24], the response of all the endogenous variables when they are impacted through the VAR model. The general VAR(p) model is:

$$y_t = \varphi_1 y_{t-1} + \cdots + \varphi_p y_{t-p} + \varepsilon_t \quad (2)$$

In formula (2), $\varphi_1$, ..., $\varphi_p$ is p parameter number matrix, and the random disturbance $\varepsilon_t$ is white noise sequence, which is called a simplified form of impact vector. The vector average moving model (VMA) obtained by Equation (2) is:

$$y_t = \psi_0\varepsilon_t + \psi_1\varepsilon_{t-1} + \psi_2\varepsilon_{t-2} + \cdots + \psi_p\varepsilon_{t-p} + \cdots \quad (3)$$

In formula (3), $y_t$ of the first i a vector to $y_{i,t}$, $\varepsilon_t$ of the first j a disturbance to $\varepsilon_{j,t}$, $\psi_p = (\psi_{p,ij})$ for the coefficient matrix, the elements of the first i row first j column for $(\partial y_{i,t}/\partial y_{j,t-p})$, it said, when the disturbance term $\varepsilon_{j,t-p}$ of the first j variable increases by one unit in the $(t-p)$ period, the influence on the value $y_{i,t}$ of the first i variable in the t period, namely, the response function of variable i caused by the pulse of variable j.

The impulse response function is used to determine how one standard deviation unit affects the industrial structure, environmental control, and carbon emissions of an endogenous variable. The impact response to the other two endogenous variables reflects the dynamic influence among them.

*Variance Analysis*

Variance decomposition examines the contribution of each component shock to endogenous variables, which is helpful to evaluate the relative importance of each shock to endogenous variables and the influence of exogenous variables on the relative importance of each shock [25]. Based on the impulse response function, the variance decomposition of the model is further used to calculate the contribution of some two endogenous variables to another endogenous variable after being impacted respectively. The variance contribution degree is evaluated according to the first j disturbance term based on the impact of impact on the first i variable from the past to the present time point by variance.

To estimate the variance contribution of each disturbance term to $y_{i,t}$ variance contribution rate (RVC) is used to measure:

$$\mathrm{RVC}_{ij}(s) = \frac{\sum_{q=0}^{s-1}(\psi_{q,ij})^2\sigma_{ij}}{\mathrm{var}(y_{i,t})} = \frac{\sum_{q=0}^{s-1}(\psi_{q,ij})^2\sigma_{ij}}{\sum_{j=1}^{k}\left\{\sum_{q=0}^{s-1}(\psi_{q,ij})^2\sigma_{ij}\right\}} \quad (4)$$

In Formula (4), $\psi_{p,ij}$ is the impulse response function, $\sigma_{ij}$ is the standard deviation of the first j variable, $y_{i,t}$ is the first i vector of the auto-regressive vector, and $RVC_{ij}(s)$ represents the variance contribution rate of the firstj variable to the first i variable. The larger $RVC_{ij}(s)$ is, the more influence the first j variable has on the first i variable, and conversely, the smaller $RVC_{ij}(s)$ is, the less influence the first j variable has on the first i variable.

## Indicator Selection

*Industrial Structure*

In this paper, we use the entropy weight method to construct an indicator of industrial structure upgrading level (*IS*) to measure the industrial structure from two aspects: rationalization of industrial structure (RIS) and advanced industrial structure (*AIS*), based on relevant research results [26].

The rationalization of industrial structure (RIS) is referred to the aggregation quality of industries. On the one hand, it represents the degree of cross-sectoral cooperation. On the other hand, it represents the efficient of resources [27]. According to the Theil index, in order to assess the degree of connectivity between factor input structure and output structure, this study redefines and produces the industrial structure rationalization index. The calculation method is as follows:

$$RIS_{it} = \left[\sum_{j=1}^{3}\frac{Y_{ijt}}{Y_{it}}\ln\left(\frac{Y_{ijt}/L_{ijt}}{Y_{it}/L_{it}}\right)\right] \quad (5)$$

In formula (5), $RIS_{it}$ indicates the rationalization index of industrial structure in area i on year t; j indicates the type of industry; $Y_{it}$ is the GDP in region i on year t; $Y_{ijt}$ represents the industrial added value in region i on year t in industry j; $L_{it}$ indicates total employment in region i on year t; and $L_{ijt}$ is industrial employment in region i on year t in industry j. A higher $RIS_{it}$ indicates a greater ease with which economic development deviates from equilibrium and a more irrational industrial structure. An $RIS_{it}$ closer to 0 indicates a more reasonable industrial structure.

The advanced industrial structure (*AIS*) means that the industrial structure is constantly evolving from a low level to a high level in transformation and adjustment [28]. In this paper, the advanced degree of industrial structure is measured by the ratio of tertiary industry output value to secondary industry output value. The measurement method is as follows:

$$AIS_{it} = \frac{Y_{3,it}}{Y_{2,it}} \quad (6)$$

In formula (6), $AIS_{it}$ indicates the advanced index of industrial structure in area i on year t, $Y_{3,it}$ denotes the tertiary industry's yearly production value in region i on year t, and $Y_{2,it}$ represents the annual output value of secondary industry in region i on year t.

Index weight is determined by the entropy weight approach, which overcomes the unpredictability of subjective weighing and solves the problem of information overlap among multi-index variables. The specific process is as follows:

Firstly, each index value is dimensionless.

Positive indicators:

$$R_{ijt} = (X_{ijt} - X_j^{min})/(X_j^{max} - X_j^{min}) + 0.01 \quad (7)$$

Negative indicators:

$$R_{ijt} = (X_j^{max} - X_{ijt})/(X_j^{max} - X_j^{min}) + 0.01 \quad (8)$$

In the above formula, $X_{ijt}$ represents the original value of j index in region i on year t, and $X_j^{max}$ and $X_j^{min}$ represent the maximum and minimum value of j index respectively. To eliminate the possible zero value and negative value, add 0.01 respectively to obtain the standardized value $R_{ijt}$.

Secondly, the standardized value $R_{ijt}$ of the indicator is normalized, and then the information entropy value of indicator j is calculated, and the different coefficient of indicator j is calculated to obtain the weight:

$$P_{ijt} = \frac{R_{ijt}}{\sum_{i=1}^{n}\sum_{t=1}^{r} R_{ijt}} \quad (9)$$

$$G_j = -\frac{1}{lnrn}\sum_{i=1}^{n}\sum_{t=1}^{r}(P_{ijt} * lnP_{ijt}) \quad (10)$$

$$E_j = 1 - G_j \quad (11)$$

$$W_j = \frac{E_j}{\sum_{j=1}^{k} E_j} \quad (12)$$

In the above formula, $P_{ijt}$ is the normalized value of the first j index, $G_j$ is the information entropy value of the first j index, $W_j$ is the different coefficient of the first j index, $W_j$ is the weight of the first j index, *r* is the number of years, and *n* is the number of cities. Then, the annual upgrading level of industrial structure in each region can be obtained by the sum of the product of each index and weight.

As shown in Table 2, the weight of rationalization of industrial structure is 0.599, and the weight of upgrading of industrial structure is 0.401. The weighted sum of rationalization and upgrading of industrial structure using the obtained weight is the annual upgrading level of industrial structure in each region.

### *Environmental Regulation*

Based on the findings of the current study, this article calculates the environmental control intensity using a weighted average of four indicators: wastewater discharge compliance rate, $SO_2$ removal rate, industrial smoke (powder) dust removal rate, and solid waste complete utilization rate [29]. According to the value range of [0,1], every single index is linearly standardized. The specific methods are as follows:

$$UE_{ijt}^{x} = \frac{UE_{ijt} - MinUE_j}{MaxUE_j - MinUE_j} \quad (13)$$

In formula (13), $UE_{ijt}$ indicates the removal rate of pollutants of industry j in region i on year t, $MaxUE_j$ and $MinUE_j$ are the maximum and minimum pollutant removal rates of industry j in different regions, $UE^x_{ijt}$ represents the standard value of pollutants in industry j in region i on year t. The environmental regulations intensity of each city is calculated as follows:

$$ENV_{it} = \sum_{i=1}^{4} UE_{ijt}^{x}/4 \quad (14)$$

In formula (14), $ENV_{it}$ indicates the degree of regional environmental regulations in region i on year t, $UE^x_{ijt}$ is the standardized value of the rate of pollutant removal of industry j in region i on year t, including the wastewater discharge compliance rate, $SO_2$ removal rate, industrial smoke (powder) dust removal rate, and comprehensive solid waste use rate.

## Data Source

The carbon emissions of county-level cities in the YRB from 2004 to 2019 are extracted from China Carbon Accounting Database (https://www.ceads.net/data/county/) and added to the prefecture-level cities to facilitate the research [30]. This data is inversed by the National Geophysical Earth Data Center's night light data from DMSP/OLS and NPP/VIIRS, which has the advantages of a long time and extensive geographic coverage.

Table 2. Evaluation index system of industrial structure upgrading in YRB.

| Primary index | Secondary index | Tertiary index | Weight |
|---|---|---|---|
| *IS* | *RIS* | Theil index | 0.599 |
| | AIS | Ratio of output value of tertiary industry to secondary industry | 0.401 |

Note: *IS* stands for industrial structure upgrading level, *RIS* stands for rationalization of industrial structure, *AIS* stands for advanced industrial structure.

The indicators involved in this paper are all from the China Urban Statistical Yearbook, the China Energy Statistical Yearbook, provincial statistical yearbooks, and statistical yearbooks of prefecture-level cities from 2004 to 2019. Some missing data are supplemented using geometric growth rate and mean value methods. All variables are standardized to decrease heteroskedasticity and eliminate the dimensional impact of variables. Table 3 shows the basic statistics of the whole region and the variables in the upper, middle and down reaches of the YRB.

## Results

### Unit Root Test

Before estimating of the model, a unit root test is conducted on the industrial structure rationalization index, environmental regulations intensity and carbon emissions. For the homogeneous unit root test, we select LLC to test the variables. We use an IPS test to test variables [31]. If the variable passes the test, the sequence is considered to be stable. Otherwise, it is not.

Table 4 shows that all *IS*, *ENV*, and *CO* sequences rejected the original hypothesis of non-stationarity of variables. Moreover, the P-value of each variable is less than 0.01, indicating that the initial hypothesis is rejected at a 99% confidence level; therefore, the sequence is stable and can be used for regression analysis.

### GMM Estimation

The lag order of the model is chosen using the AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), and HQIC (Hannan-quinn Criterion), with a smaller value corresponding to a more optimal lag order [32]. As shown in Table 5, the lag model is identified as six phases in this study.

The PVAR model is estimated using GMM estimation to evaluate the impact of lag factors on variables. To reduce the effects of the temporal effect and individual fixed effect on coefficient estimation, the mean difference technique and first-order forward difference method are applied. Table 6 shows the results.

When carbon emissions are used as the explanatory variable, the carbon emissions of lag phases 1 and 5 has a large positive influence on present carbon emissions, but then the impact gradually decreases. In each lag period, the industrial structure has a substantial influence on carbon emissions. In the lag period, the impact of industrial structure on carbon emissions is beneficial in the short term, but is unfavorable in the long term. While the lag phase 1 environmental regulation has a positive impact on carbon emissions and passed the significance test at the 5% level, the lag phase 3 and lag phase 5 environmental regulations have a negative impact on carbon emissions and passed the significance test at the 5% level. It shows that during the research period, the environmental regulation policy in the short-term lag period does not inhibit the carbon emission of the YRB, but promotes the enterprises to accelerate the exploitation of energy, increase the carbon emission in the short-term, and trigger the "green paradox" effect, then hypothesis H1b is tested. However, in the long-term lag period, environmental regulation has a significant inhibitory effect on carbon emissions.

Taking the industrial structure as the explanatory variable, the effect coefficient of the industrial

Table 3. Variable descriptive statistics.

| Area | Variable | Value | Mean | Variance | Min | Max | Standard deviation |
|---|---|---|---|---|---|---|---|
| Whole basin | *IS* | 1264 | 0.1774 | 0.0078 | 0.0233 | 0.6489 | 0.0884 |
| | *ENV* | 1264 | 0.7553 | 0.0216 | 0.1146 | 0.9976 | 0.1468 |
| | *CO* | 1264 | 28.4992 | 391.495 | 2.2272 | 108.4795 | 18.7482 |
| Upper reaches | *IS* | 384 | 0.1799 | 0.0136 | 0.0233 | 0.6489 | 0.1165 |
| | *ENV* | 384 | 0.6965 | 0.0213 | 0.2017 | 0.9819 | 0.1461 |
| | *CO* | 384 | 21.7035 | 443.7469 | 2.5318 | 108.4795 | 21.0653 |
| Middle reaches | *IS* | 336 | 0.1578 | 0.004 | 0.0676 | 0.3763 | 0.0632 |
| | *ENV* | 336 | 0.7133 | 0.0242 | 0.1146 | 0.9791 | 0.1555 |
| | *CO* | 336 | 27.7719 | 241.2151 | 2.2272 | 63.2784 | 15.5311 |
| Down reaches | *IS* | 544 | 0.1877 | 0.0058 | 0.0425 | 0.4736 | 0.0761 |
| | *ENV* | 544 | 0.8228 | 0.0121 | 0.49 | 0.9976 | 0.1098 |
| | *CO* | 544 | 33.7453 | 295.1936 | 3.8064 | 79.0205 | 17.1812 |

Note: *IS* stands for industrial structure, *ENV* stands for environmental regulation, *CO* stands for carbon dioxide emissions.

Table 4. Unit root test of panel data.

| Variable | Test | | Result |
|---|---|---|---|
| | LLC | IPS | |
| *IS* | -8.131<br>(0.0000) | -6.460<br>(0.0000) | Stable |
| *ENV* | -18.647<br>(0.0003) | -4.650<br>(0.0000) | Stable |
| *CO* | -89.784<br>(0.0000) | -6.375<br>(0.0000) | Stable |

Table 5. Selection of lag order.

| Lag order | AIC | BIC | HQIC |
|---|---|---|---|
| 1 | -1.481 | -0.367 | -1.06 |
| 2 | -0.652 | 0.573 | -0.187 |
| 3 | -0.042 | 1.31 | 0.473 |
| 4 | -1.777 | -0.279 | -1.203 |
| 5 | -1.202 | 0.466 | -0.561 |
| 6 | -3.047* | -1.178* | -2.325* |
| 7 | -2.762 | -0.65 | -1.942 |

Note: The * indicates a 10% significance level.

structure with one lag period on the present period is 0.715, through the significant test at the 1 % level. It demonstrates that the industrial structure is heavily reliant on the industrial structure in the first lag period, while the influence coefficient of other industrial structures in the later lag period decreases gradually with time. The negative influence coefficients of environmental regulation lagging behind the first and second periods on industrial structure upgrading indicate that environmental regulation slows industrial structure upgrading to some extent, which is the consequence of "following the cost theory", hypothesis H3b is tested. The carbon emission effect coefficient on the industrial structure is small in each lag period, indicating that carbon emission has a minor impact on the industrial structure.

Using environmental regulation as an explanatory variable, environmental regulation with lag phases 1 and 2 has a considerable beneficial influence on the present period, whereas the impact coefficients of the other lag phases have declined dramatically and are no longer significant. In the lag phase 2, industrial structure has adverse effects on environmental control, and passed the 10 % level of aboriginality test, demonstrating that industrial structure optimization can lessen the severity of environmental regulation, although there is a lag. The influence coefficient of carbon emission in the lag period on environmental regulation is small and insignificant.

## Impulse Response Analysis

The impulse response analysis is used to investigate the influence of a variable's standard deviation on itself and the other two variables. Considering the length of time series, the number of periods of impact action is set to eight. The impulse response diagrams of the entire area, upstream, middle, and downstream of the YRB are shown in Figs 5, 6, 7, and 8. In the image, the abscissa indicates the number of impulse response periods, the ordinate represents the degree of impulse response, the short dotted line represents the impulse response value, and the upper and lower solid lines reflect the confidence levels of 5% and 95%, respectively. According to Figs 5-8, the following conclusions can be drawn:

First, when facing the impact of one standard deviation, industrial structure, environmental regulation and carbon emission mainly show positive effects, which have the most significant impact on the current period and gradually converge to 0. It shows that the three variables have an obvious inertial effect on their impact.

Second, when environmental regulation faces a standard deviation impact on carbon emissions, the response values of all phases in the whole region, upper and down reaches are positive and show an inverted U-shaped curve. The response value of the middle reaches is positive before phase 6 and negative after phase 6. It shows that under the influence of carbon emissions, the intensity of environmental regulation in the YRB has increased. When carbon emissions face a standard deviation impact of environmental regulation, the current response values in the whole region, upper, middle and down reaches are 0, and then the response values in each period of upper and down reaches are negative, the response value of the middle reaches is also negative at the initial stage, that is, environmental regulation has an inhibitory effect on carbon emissions, while the response values in each era of the YRB are positive, showing that environmental control has the "green paradox" effect, promoting an increase in carbon emissions, which further validated the hypothesis H1b.

Third, when a standard deviation of carbon emissions has an influence on the industrial structure, the response values of the whole region and the upper reaches are positive, while the response values

Table 6. GMM estimation results.

| Variable | | IS | ENV | CO |
|---|---|---|---|---|
| L1 | IS | 0.7155***<br>(0.000) | 0.134<br>(0.317) | 4.0616<br>(0.134) |
| | ENV | -0.0247<br>(0.580) | 0.4063***<br>(0.000) | 3.7511**<br>(0.016) |
| | CO | 0.0021<br>(0.326) | -0.0003<br>(0.950) | 1.0187***<br>(0.000) |
| L2 | IS | -0.0482<br>(0.556) | -0.1746*<br>(0.094) | -0.3247<br>(0.895) |
| | ENV | -0.0197<br>(0.357) | 0.1632***<br>(0.007) | 1.3839<br>(0.279) |
| | CO | -0.0011<br>(0.265) | 0.0013<br>(0.506) | -0.1336<br>(0.181) |
| L3 | IS | 0.0391<br>(0.472) | 0.0231<br>(0.811) | 3.501<br>(0.163) |
| | ENV | 0.0387*<br>(0.093) | 0.0139<br>(0.779) | -2.1165**<br>(0.033) |
| | CO | -0.000004<br>(0.995) | -0.0016<br>(0.286) | -0.0714<br>(0.405) |
| L4 | IS | 0.01<br>(0.871) | 0.0251<br>(0.792) | -4.0531**<br>(0.035) |
| | ENV | -0.009<br>(0.591) | 0.0208<br>(0.636) | 1.3135<br>(0.174) |
| | CO | 0.0013<br>(0.112) | 0.0012<br>(0.335) | -0.249***<br>(0.004) |
| L5 | IS | -0.0455<br>(0.505) | 0.0323<br>(0.697) | 1.8775<br>(0.242) |
| | ENV | 0.009<br>(0.653) | 0.0189<br>(0.630) | -2.2847**<br>(0.014) |
| | CO | -0.0004<br>(0.655) | 0.0013<br>(0.418) | 0.3374***<br>(0.000) |
| L6 | IS | 0.0173<br>(0.670) | -0.0657<br>(0.305) | -0.564<br>(0.625) |
| | ENV | 0.0238<br>(0.140) | 0.0356<br>(0.373) | -0.0528<br>(0.956) |
| | CO | -0.0005<br>(0.493) | -0.0016<br>(0.237) | -0.1281**<br>(0.014) |

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

of the midstream region are positive before phase 3 and then become negative, and the response values of the down reaches are negative in each phase. It demonstrates that, under the influence of carbon emissions, the upper reaches will encourage the upgrading of the industrial structure. When carbon emissions are impacted by a standard deviation of industrial structure, the current response values in the whole region, upper, middle and down reaches are all 0. Then the response values in each period of upper, middle and down reaches are mostly negative, hypothesis H2 is tested, while the response values in each period of the whole region are positive. It may be due to the low efficiency of resource utilization in the YRB promotes carbon emission in the face of the impact of industrial structure.

Fourth, when environmental regulation faces a standard deviation impact of industrial structure, the current response value in the whole region, upper, middle and down reaches are 0, then the response value in the whole region and upper reaches is negative, then becomes positive and converges to 0, while the response value in the middle and down reaches are positive and then converges to 0. The reason for this might be that the secondary and tertiary industries dominate the industrial structure of the middle and down reaches, and the severity of environmental control may be bolstered in response to the influence of industrial

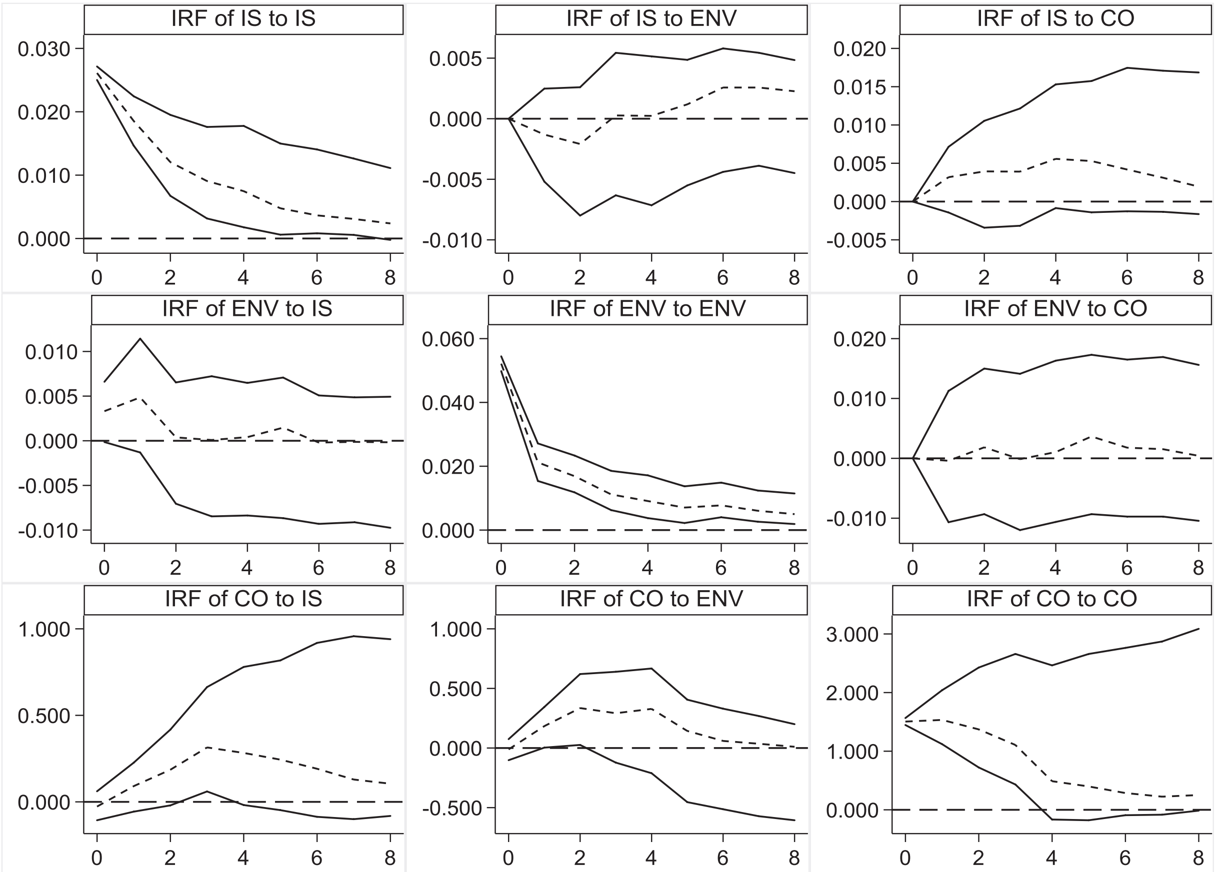


Fig. 5. Impulse response in the whole basin.

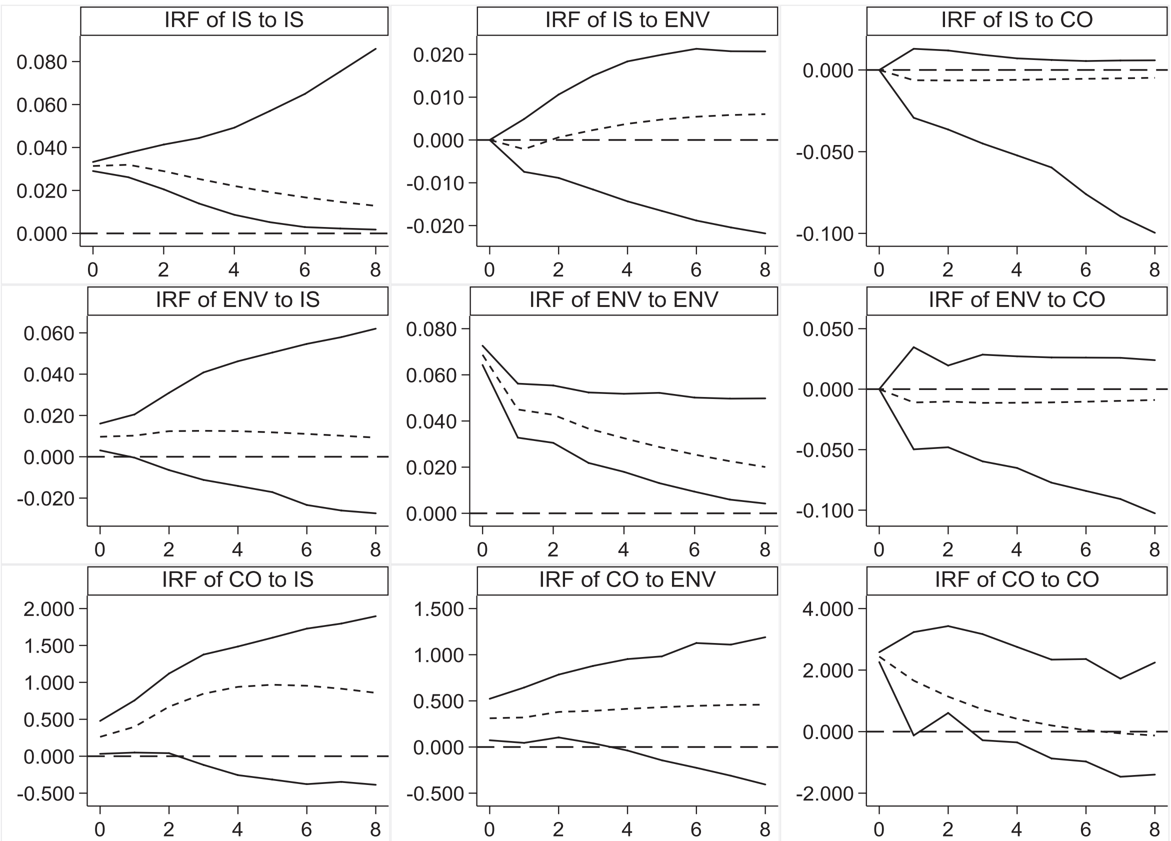


Fig. 6. Impulse response in the upper reaches.

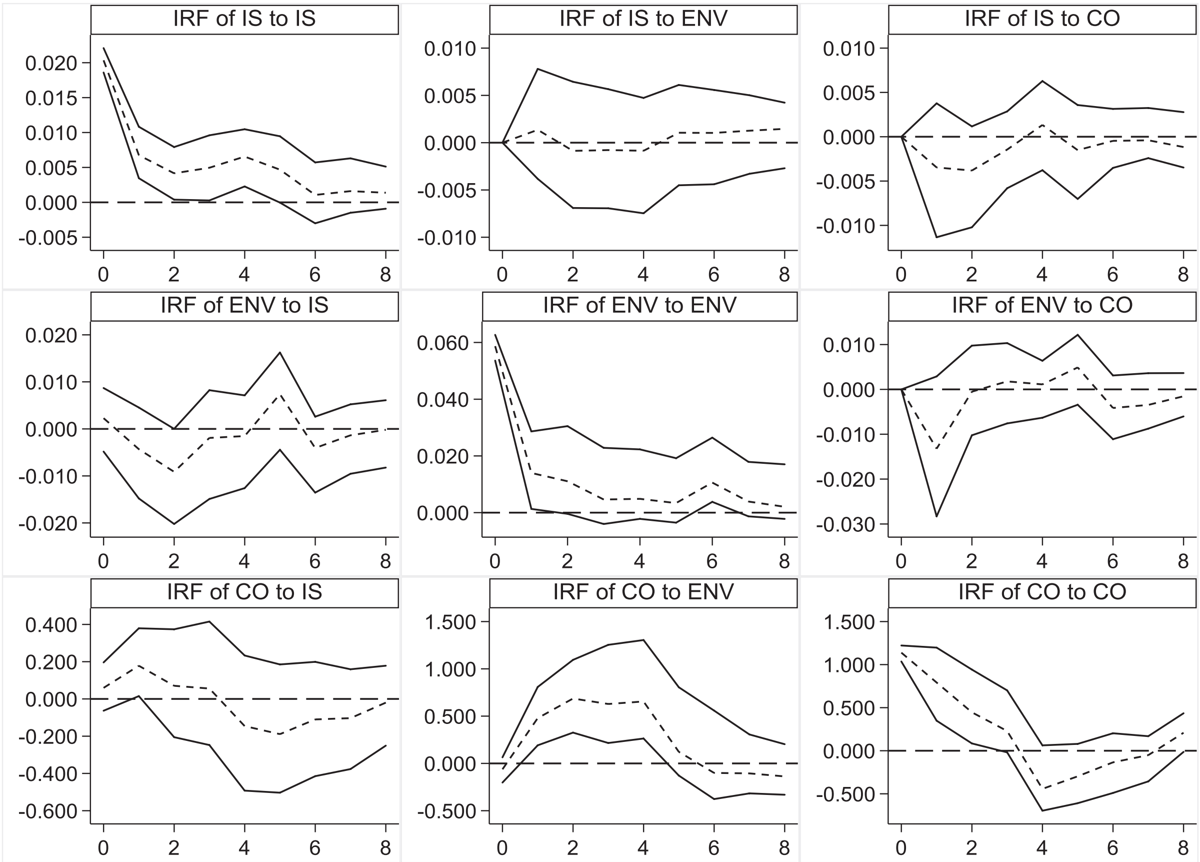


Fig. 7. Impulse response in middle reaches.

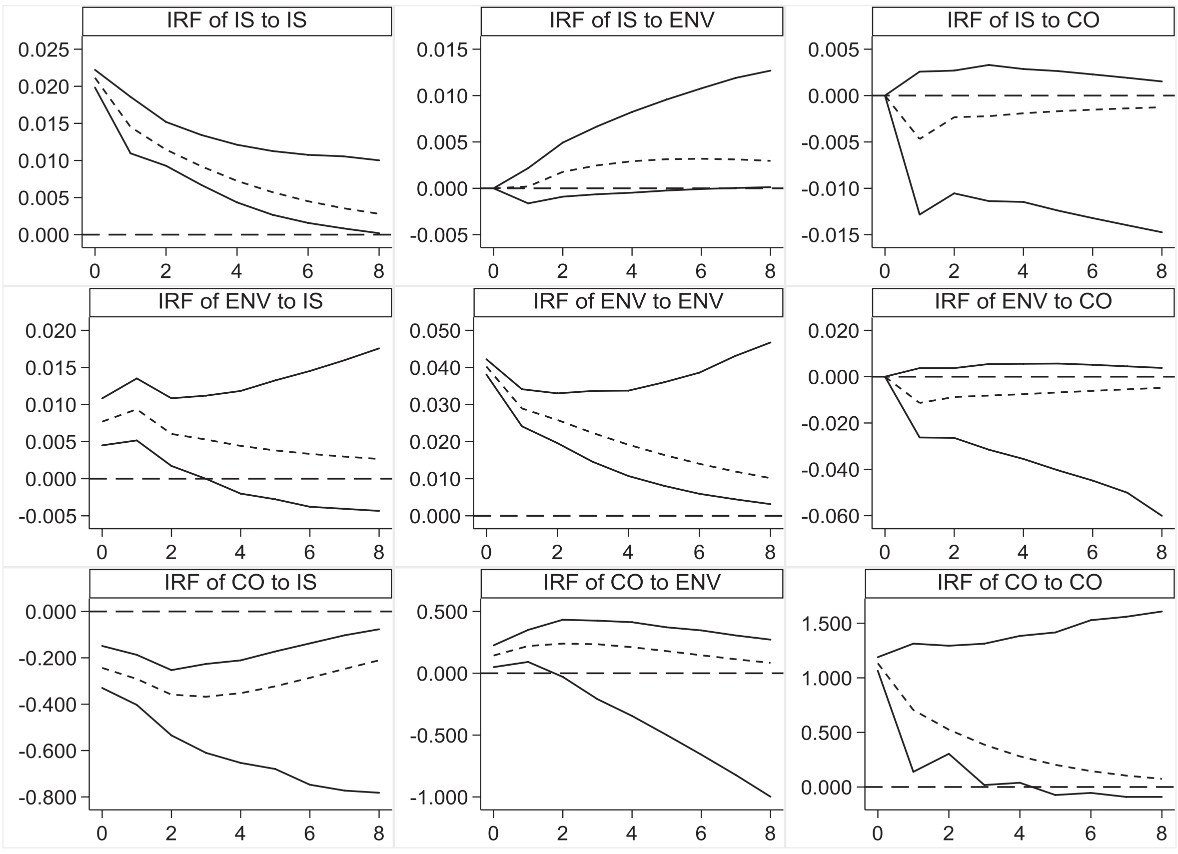


Fig. 8. Impulse response in the down reaches.

structure. On the contrary, when environmental control has a standard deviation influence on the industrial structure, the present reaction values of the entire area, upper, middle, and down reaches are positive. Then, the response values of the whole region, upper and down reaches continue to decrease and gradually converge to 0, while the response values of the middle reaches become negative and gradually converge to 0. The reason is that most of the middle reaches are energy consuming areas. Under the influence of environmental regulation, the production cost of enterprises will increase, which hinders the upgrading of industrial structure, and further verifies the hypothesis H3b, that is, "follow the cost hypothesis".

## Analysis of Variance

The variance decomposition is used to further investigate the contribution rates of distinct variable shocks to other variables, with the results displayed in Table 7.

In the variance decomposition of industrial structure, the industrial structure of the whole basin and each reach is mainly affected by itself, and the degree of influence decreases gradually with time. The down reaches environmental regulation has the largest contribution to the industrial structure, and the middle reaches have the smallest contribution, 7.9% and 1.8%, respectively. The reason is that Henan and Shandong Province in the down reaches have strong economic development and a high degree of an industrial structure optimization, while Shaanxi and Shanxi Province in the middle reaches are China's main coal energy provinces. The level of energy consumption is high, the carbon emission is significant, the industrial structure is heavily dependent on natural resources, and environmental control plays a little role in the industrial structure.

In the variance decomposition of environmental regulation, the contribution rate of environmental regulation in the whole basin and each reach are mainly affected by itself. The contribution of industrial structure in the upper reaches to environmental regulation is 8.3%, which is higher than that in the middle and down reaches, indicating that the upgrading of industrial structure in the upper reaches makes a more significant contribution to environmental regulation. The contribution of carbon emissions in the down reaches to environmental regulation is 9.2%, which is higher than that in the upper and middle reaches,

Table 7. Results of ANOVA.

| Area | Number of periods | *IS* | | | *ENV* | | | *CO* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *IS* | *ENV* | *CO* | *IS* | *ENV* | *CO* | *IS* | *ENV* | *CO* |
| Whole basin | 1 | 1.000 | 0.000 | 0.000 | 0.004 | 0.996 | 0.000 | 0.000 | 0.000 | 1.000 |
| | 5 | 0.944 | 0.004 | 0.052 | 0.009 | 0.989 | 0.002 | 0.026 | 0.040 | 0.934 |
| | 10 | 0.894 | 0.019 | 0.087 | 0.010 | 0.984 | 0.006 | 0.039 | 0.040 | 0.921 |
| | 15 | 0.889 | 0.023 | 0.088 | 0.010 | 0.984 | 0.006 | 0.040 | 0.041 | 0.919 |
| | 20 | 0888 | 0.024 | 0.088 | 0.010 | 0.984 | 0.006 | 0.040 | 0.041 | 0.919 |
| Upper reaches | 1 | 1.000 | 0.000 | 0.000 | 0.020 | 0.980 | 0.000 | 0.011 | 0.016 | 0.973 |
| | 5 | 0.956 | 0.006 | 0.038 | 0.055 | 0.905 | 0.040 | 0.167 | 0.049 | 0.784 |
| | 10 | 0.916 | 0.033 | 0.051 | 0.075 | 0.865 | 0.060 | 0.337 | 0.089 | 0.574 |
| | 15 | 0.887 | 0.055 | 0.058 | 0.081 | 0.852 | 0.067 | 0.376 | 0.118 | 0.506 |
| | 20 | 0.873 | 0.067 | 0.060 | 0.083 | 0.848 | 0.069 | 0.381 | 0.134 | 0.485 |
| Middle reaches | 1 | 1.000 | 0.000 | 0.000 | 0.001 | 0.999 | 0.000 | 0.003 | 0.003 | 0.994 |
| | 5 | 0.941 | 0.007 | 0.052 | 0.028 | 0.928 | 0.044 | 0.017 | 0.385 | 0.598 |
| | 10 | 0.928 | 0.016 | 0.056 | 0.042 | 0.903 | 0.055 | 0.029 | 0.374 | 0.597 |
| | 15 | 0.925 | 0.018 | 0.057 | 0.043 | 0.902 | 0.055 | 0.030 | 0.378 | 0.592 |
| | 20 | 0.925 | 0.018 | 0.057 | 0.043 | 0.902 | 0.055 | 0.030 | 0.378 | 0.592 |
| Down reaches | 1 | 1.000 | 0.000 | 0.000 | 0.035 | 0.965 | 0.000 | 0.043 | 0.015 | 0.942 |
| | 5 | 0.945 | 0.018 | 0.037 | 0.051 | 0.877 | 0.072 | 0.175 | 0.074 | 0.751 |
| | 10 | 0.902 | 0.057 | 0.041 | 0.050 | 0.863 | 0.087 | 0.242 | 0.086 | 0.672 |
| | 15 | 0.882 | 0.075 | 0.043 | 0.052 | 0.857 | 0.091 | 0.254 | 0.085 | 0.661 |
| | 20 | 0.877 | 0.079 | 0.044 | 0.052 | 0.856 | 0.092 | 0.255 | 0.085 | 0.660 |

indicating that provinces and cities in the down reaches of the YRB have higher requirements for the economic development model and environmental governance, and governments pay more attention to carbon emissions when formulating environmental regulation policies.

In the decomposition of carbon emission variance, the contribution rate of carbon emission to itself is the largest, showing that the YRB is dominated by energy production and consumption, extensive economic growth, and carbon emissions are strongly impacted by its causes. In the middle reaches, environmental regulation accounts for 37.8% of total carbon emissions, and the contribution of carbon emission by environmental regulation is also higher than that in the upper and down reaches, which indicates that the middle reaches are heavy industry-intensive areas, and environmental regulation policies have the most obvious impact on energy conservation and emission reduction.

## Discussion

The YRB is not only an important ecological security barrier in China, but also an important region for population activities and economic development. According to the "Outline of the Yellow River Basin Ecological Protection and High-quality Development Plan" released in October 2021, the YRB's most serious shortcoming is a lack of high-quality development, with the problems of low quality and low efficiency of industries. Based on the above model analysis, we believe that environmental regulation and industrial structure both contribute to carbon emission reduction in the YRB, while environmental regulation inhibits industrial structure upgrading to some extent.

### Environmental Regulation and Carbon Emissions

The government regulates the production and operation activities of manufacturers through pollutant discharge permits, administrative penalties, and collection of pollutant discharge taxes. Therefore, the expected purpose of the government's formulation of environmental regulations is to positively reduce pollutant emissions. However, good intentions do not always lead to good behaviors [11]. When fossil energy owners anticipate tougher environmental laws, they will expedite extraction, causing existing fossil energy prices to fall. In the short term, lower-priced fossil fuels will stimulate higher demand, leading to a rise in short-term carbon emissions. However, in the long run, the government implements environmental regulations to protect the environment by increasing the cost of corporate environmental governance. Companies are required to adopt more advanced energy-saving and emission-reduction technologies and utilize more clean energy as the cost of corporate environmental governance rises, limiting the market for high-carbon energy. Therefore, environmental regulatory policies tend to promote carbon emissions first, then repress them. This is consistent with the conclusion of this paper. As far as the YRB is concerned, it is necessary to implement energy-saving review, EIA approval and pollutant discharge permit system to improve the energy efficiency and clean production level of new projects from the source.

### Industrial Structure and Carbon Emissions

An economy's carbon consumption and emission intensity are determined by its industrial structure. The reason for this is that the inputs required by different industries or industries differ in composition. The more industries or industries with high consumption, high pollution and high emission, the higher their overall and per capita carbon consumption intensity and carbon emission intensity. Therefore, only when the proportion of resource-intensive industries in the industrial structure gradually decreases and the proportion of technology-intensive industries gradually increases, can carbon consumption and carbon emissions be fundamentally reduced.

From the perspective of industrial structure, the evolution of industrial structure determines the basic trend of carbon dioxide emissions. A large number of studies have proved that carbon emission intensity is negatively correlated with the proportion of the tertiary industry in GDP, and positively correlated with the added value of the secondary industry [33, 34]. In the current industrial structure of the YRB, the resource-based and heavy chemical industries have prominent structures with high energy consumption and large emissions, and the energy structure is biased towards coal, resulting in heavy industrial pollution. For example, Shanxi and Shaanxi provinces in the middle reaches of the YRB account for more than 40% of China's coal production. Moreover, for a longer period of time in the future, the staged rigid demand for energy indicates that as long as the economy of China will continue to grow and energy consumption will continue to expand [35]. Therefore, promoting the transformation and upgrading of the industrial structure to the tertiary industry will significantly help reduce carbon emissions.

### Environmental Regulation and Industrial Structure

The main object of environmental regulation is the individual or organization of the enterprise, which forces the adjustment of the industrial structure by affecting the production behavior of the enterprise. Different from the conclusion of most literature that environmental regulation promotes the adjustment of industrial structure by establishing a linear model, this paper argues that environmental regulation hinders the upgrading of industrial structure [36, 37]. The reason may be that the degree of accumulation of environmental regulation itself exhibits nonlinear characteristics, so the relationship between environmental regulation and industrial structure is not a positive or negative linear relationship, but more likely to be a U-shaped relationship. For example, Zhong believes that environmental regulation has a U-shaped relationship with regional industrial transfer and structural upgrading [38]. Only by crossing the threshold value of environmental regulation can environmental regulation play a negative role in industrial structure adjustment.

Although China has promulgated a series of policy measures, such as “Plan for Ecological Environmental Protection in the Yellow River Basin” issued in 2022. However, considering the current reality of the YRB, the intensity of environmental regulation may not yet reach the threshold value for promoting industrial upgrading, so it cannot play a positive role in the upgrading of the basin structure. Therefore, it is necessary to strengthen the intensity of environmental regulation, cross the threshold value of the U-shaped curve of environmental regulation and industrial structure upgrading as soon as possible.

## Conclusions and Policy Implications

Compared to relative literature putting more emphasis on the relationship between industrial structure, environmental regulation and carbon emissions, in this paper, we innovatively put the three in the same framework and dynamically analyze the relationship between the three. Especially, we creatively construct a more reasonable indicator to measure the industrial structure. Based on the data of 79 cities in the Yellow River Basin from 2004 to 2019, this paper used a PVAR model to empirically study the interaction between environmental regulation, industrial structure and carbon emissions in the whole region, upper, middle and lower reaches of the Yellow River Basin. The conclusions are as follows:

(1) From the perspective of the whole basin of the YRB, the effect of environmental regulation on carbon emissions is initially boosted, then prevented, which confirms the "green paradox" theory. Industrial structure has an inhibitory influence on carbon emissions, but this inhibitory effect is the same as environmental regulation, with apparent lag. To some extent, environmental regulation reflects the "follow cost theory" on the industrial structure. That is, environmental regulation hinders industrial structure upgrading in the short term.

(2) From each region of the YRB, the coordination degree of the relationship among the upper, middle and down reaches gradually decreases from east to west. The down reaches have basically realized the coordinated development among the three. The coordination degree of the three regions in the middle reaches is the second, and the environmental regulation has the most significant inhibition effect on carbon emission reduction, but the impetus of industrial structure upgrading to reduce carbon emissions is obviously insufficient. The impact of environmental regulation on industrial structure reflects the effect of "following the cost hypothesis", that is, inhibiting the upgrading of industrial structure. The industrial structure upgrading in the upper reaches has an obvious effect on carbon emission reduction, while the impact of environmental regulation on carbon emission reduction is lower than that in the middle and down reaches, and the impact of environmental regulation on industrial structure upgrading is limited. There is no positive interaction between the three, so coordination must be strengthened.In light of the foregoing results, to facilitate the healthy development of YRB in China to reach the national aims of Carbon Neutrality, we put forward the following policy suggestions:

(1) According to the economic development level and carbon emission intensity of various areas, the government should implement suitable environmental regulating measures. Reasonably adjust the structure of environmental protection investment, and increase the proportion of investment in the treatment of industrial pollution sources. Taking micro enterprises as the main body, starting from the source of pollution, driving the "source governance" based on enterprises.

(2) Promote industrial green transformation and upgrading and low-carbon industrial system construction. Optimize the scale of high-water consuming industry in Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Shandong and other provinces, and focus on promoting the economical and intensive use of water resources. Promote the elimination of excess capacity in key industries such as steel and coal, and encourage high-tech green industrial development. Promote the clustering, greening, and park-like development of chemical, coking, casting, alumina and other industries in the Fenwei Plain. Boost the deep processing of resource industry, and gradually complete the structural adjustment and upgrading of the energy industry.

(3) Given that provinces in the YRB are endowed with different resources, it should develop appropriate path according to local conditions. The “One belt, One road” policy should be fully utilized to strengthen economic cooperation between the upstream areas. In terms of the middle reaches, it should progressively raise the cost of pollution management and forces businesses to use green technology developments in order to minimize pollutant emissions. The down reaches of the YRB should take advantage of the leading role of critical cities, make full use of their advantages in money, talent, and technology, promote technical innovation, and create clean energy technologies and energy conservation and emission reduction technologies.

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## Conflict of Interest

The authors declare no conflict of interest.

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