Research on the Influence of Industrial Structure Change of Urban Agglomeration on Ecological Efficiency: An Empirical Analysis Based on Bidirectional Fixed Effect Model

Jingjing Deng(✉)

School of Business Administration, Northeastern University, Shenyang, China
jingjingdeng111@163.com

Abstract. Previous studies have shown that the change of industrial structure is an important factor affecting economic growth and ecological efficiency, and the impact on resource consumption and environment in the process of economic growth depends on industrial structure. In this paper, firstly, the theoretical mechanism of the impact of industrial structure changes on ecological efficiency is analyzed from the two dimensions of industrial structure upgrading and rationalization. Then, based on the panel data of urban agglomeration in central and southern Liaoning, China, econometric analysis is carried out with Eviews. The data of nine prefecture-level cities in this urban agglomeration from 1990 to 2019 are empirically tested, and a fixed effect model with variable intercept is constructed. Finally, according to the results of econometric analysis, this paper puts forward some policy suggestions to improve ecological efficiency in the process of industrial structure change in urban agglomerations.

Keywords: Multiple Linear Regression · Fixed Effect Model · Factor Analysis · Changes In Industrial Structure · Ecological Efficiency

1 Introduction

At the moment, China's regional economic development is entering a growth phase, with a renewed emphasis on supply-side structural change. After a lengthy period of medium and high-speed growth, economic expansion is putting more strain on resources and the environment.

The sample of this empirical study is the urban agglomeration of central and southern Liaoning. Using this urban agglomeration's statistics as the research sample, it is because the urban agglomeration of central and southern Liaoning is facing the historical environment of "Northeast Revitalization" economic transition and industrial development change, which has a huge fluctuation influence on the economic coordination of internal cities. Because of changes in industrial structure, the economic functions of cities in urban agglomerations are changing subtly, and it reflects different influence results in different time periods.

S. H. B. D. M. Zailani et al. (Eds.): ICMSEM 2023, 259, pp. 1274–1283, 2024.
https://doi.org/10.2991/978-94-6463-256-9_130

2 Model Setting and Data Description

2.1 Eco-Environmental Quality Measurement

Calculation formula of factor model.

The expression equation of common factor score is shown in Formula (1):

$$F(i) = Xj \times aij \tag{1}$$

Among them: F(i)——the i-th common factor score.

X_j—— refers to the value of the j-th index.

a_{ij}—— the component coefficient of the I-th common factor in the index.

The comprehensive score of the target sample can be calculated after computing the common factor score for each sample by applying the common factor's known contribution rate, such as formula (2).

$$F_a = \sum_{i=1}^{m} d_i f_a(i) \tag{2}$$

Among them: F_a——a is the comprehensive score of the sample.

d_i——indicates the contribution rate of the ith common factor.

$f_a(i)$——refers to the score of sample A in the ith common factor.

Survey and selection of indicators and sample data.

(1) Selection of samples and indicators.

According to the pressure-state-response model established by the OECD, this paper constructs an ecological environment evaluation index system, according to Table 1.

10 data indicators are selected from three aspects in this analysis. The specific code-level meanings are shown in Table 1. All of the sample data in this study were taken from China Urban Statistical Yearbook and Liaoning Statistical Yearbook from 1990 to 2020.

(2) Adaptability test of factor analysis method.

After inputting the data into SPSS software, the test results shows that the selected indexes are suitable for factor analysis.

Measurement process of ecological environment quality.

Using principal component analysis method, the standardized eco-environmental data are analyzed, and the correlation coefficient matrix and initial factor load matrix are obtained. The rate of cumulative contribution of the first four components extracted according to the standard with eigenvalue greater than 1 exceeds 80%. The principal component equation is shown in Formula (3):

$$F_i = \alpha_{i1}C_1 + \alpha_{i2}C_2 + ... + \alpha_{ip}C_p \quad i = 1, 2,...,m \tag{3}$$

α_{ip} is the load value of the k-th principal component and C_p is the normalized index value.

Table 1. Comprehensive evaluation index system of ecological environment quality

Target layer	criterion layer	index layer
liaozhongnan city groups Ecological environment Evaluation index system	Ecological environment stress B1	Industrial wastewater discharge C1
		Industrial sulfur dioxide emission C2
		Industrial soot emission C3
		Population density C4
	Ecological environment endowment B2	Total water resources C5
		Total cultivated land resources C6 at year end
	Ecological environment response B3	Industrial wastewater discharge standard C7
		Rate of total use of general industrial solid waste C8
		Sulfur dioxide elimination in industry C9
		Industrial smoke removal C10

Obtain the score coefficient matrix table, according to the output components, and then substitute the component matrix data into Formula (2) to obtain the expression of factor analysis model score as shown in Formula (4):

$$F1 = -0.449c_1 + 0.104c_2 - 0.156c_3 + 0.012c_4 + 0.105c_5 - 0.068c_6 + 0.451c_7 - 0.044c_8 + 0.150c_9 - 0.149c_{10}$$

$$F2 = -0.046c_1 + 0.025c_2 + 0.060c_3 + 0.402c_4 - 0.330c_5 + 0.242c_6 - 0.057c_7 + 0.394c_8 - 0.073c_9 - 0.085c_{10}$$

$$F3 = -0.106c_1 - 0.228c_2 + 0.052c_3 - 0.090c_4 + 0.082c_5 + 0.258c_6 - 0.083c_7 + 0.024c_8 + 0.446c_9 + 0.579c_{10}$$

$$F4 = +0.016c_1 + 0.567c_2 + 0.477c_3 + 0.172c_4 + 0.090c_5 + 0.129c_6 - 0.040c_7 - 0.044c_8 - 0.253c_9 - 0.030c_{10}$$

$$F = (32.184 * F1 + 23.208 * F2 + 14.382 * F3 + 10.732 * F4)/80.506 \quad (4)$$

2.2 Measurement of Industrial Structure Change

According to the standpoint of Gan Chunhui (2011)[1], the study takes the rationalization and upgrading of industrial structure as the research dimensions to measure the industrial structure changes of agglomerations of cities.

In view of the availability of data, this analysis selects per capita GDP, regional GDP, the primary industry's additional value, the ratio of the primary industry's additional value to GDP, the added value of secondary industry, the added value of tertiary industry, the ratio of the added value of tertiary industry to GDP, the number of employees in primary industry, the amount of workers in secondary industry and the amount of workers in tertiary industry to calculate the relevant index of industrial structure change.

Measurement of rationalization of industrial structure.

The essential connotation of rationalization of industrial structure refers to a measure of the coordination between reasonable input and output structure of production factors such as capital, labor and land among the three major industries. The study adopts Theil index to measure the rationalization degree of industrial structure, Formula 5 depicts its computation technique:

$$TL = \sum_{i-1}^{n} \frac{Y_i}{Y} \ln(\frac{Y_i}{Y}/\frac{L_i}{L}) \tag{5}$$

Measurement of Advanced Industrial Structure.

When measuring the upgrading of industrial structure, most existing literatures use the change of share between industries, that is, the output value ratio of secondary and tertiary industries.

$$TS = \frac{Y_3}{Y_2} \tag{6}$$

Brief introduction to the measurement results.

The economic development of nine prefecture-level cities differs. As a result, the rationalization and upgrading of each city's industrial structure are calculated. And the results are compared to analyze the industrial structure of each city. The average level of rationalization and upgrading among cities can be clearly seen from Fig. 1. [1].

Judging from the changes in the rationalization level of industrial structure of cities in urban agglomeration, most cities' industrial structures are gradually deviating, and the rationalization level is low. In order to implement the rationalization of industrial structure and increase the rational exploitation level of resource endowments in diverse places, it is important to rationally alter the industrial structure according to the actual layout of the industrial structure of cities.

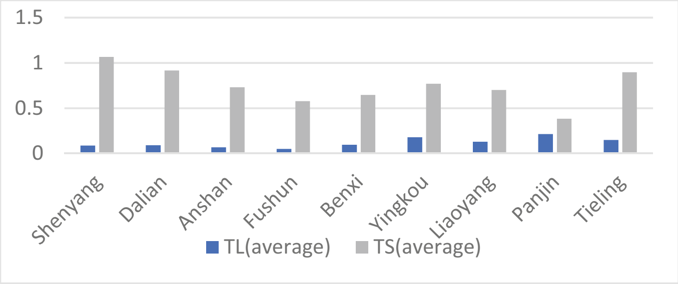

Fig. 1. Average level of rationalization and upgrading of industrial structure in urban agglomerations in central and southern Liaoning from 1990 to 2019

2.3 Model Setting

variable setting.

(1) Explained variables

Eco-environmental quality comprehensive evaluation index (F).

(2) Explanatory variables

Industrial structure rationalization (TL) and industrial structure upgrading (TS).

(3) Control variables

There are many factors affecting eco-efficiency, which Han Yonghui et al. (2016) [2] classified into four categories: economic factors, structural factors, institutional factors and foreign investment factors. Therefore, the following control variables are included in the empirical model, and the control variable codes are shown in Table 2.

Model Construction

In this paper, the data is selected as panel data combining cross-sectional data and time series data. The spatial panel model is more accurate and convincing than the model constructed by simply considering cross-sectional data or time series data.

In the empirical analysis, in order to make the empirical results more stable and reliable, this paper constructs the model in the logarithmic form of each variable. This

Table 2. Control Variable Codes

Variable code	Variable meaning
AG	Per capita GDP
I	Gross industrial output value of foreign-invested enterprises
T	The level of investment in science and technology
EN	Energy structure

Table 3. Unit Root Test Results

Test variable	LLC	Fisher-ADF	Fisher-PP	Stationarity
lnAG	0.0000	0.0001	0.0014	stable
ΔlnEN	0.0087	0.4244	0.0000	First-order difference post-stationarity
lnF	0.0613	0.0066	0.0166	stable
lnI	0.0001	0.4301	0.8815	stable
ΔlnT	0.0000	0.0000	0.0000	First-order difference post-stationarity
lnTL	0.0000	0.0000	0.0000	stable
lnTS	0.0000	0.0000	0.0000	stable

paper will establish the following model, as shown in Formula (7):

$$\ln F_{it} = c_i + \beta_1 \ln TS_{it} + \beta_2 \ln TL_{it} + \beta_3 \ln T_{it} + \beta_4 \ln I_{it} + \beta_5 \ln EN_{it} + \beta_6 \ln AG_{it} + \varepsilon_{it} \tag{7}$$

In formula (7): c_i is a constant term, β_1-β_6 is a regression coefficient, and ε_{it} is a random disturbance term. $\ln F_{it}$ 、 $\ln TS_{it}$ 、 $\ln TL_{it}$ 、 $\ln T_{it}$ 、 $\ln I_{it}$ 、 $\ln EN_{it}$ 、 $\ln AG_{it}$ are the indicators of eco-environmental quality, advanced industrial structure, rationalization of industrial structure, scientific and technological level, foreign investment level, energy structure and economic level of The I-th prefecture-level city in the central and southern Liaoning urban agglomeration in the T-th year.

3 Parameter Estimation and Testing

3.1 Unit Root Test

In order to ensure the accuracy of panel regression and avoid false regression, the unit root test should be applied to variables first. At present, the test results of Fisher-ADF and LLC methods are often adopted. If any test result rejects the original hypothesis, the panel data can be judged to be stable, there is no unit root. [3].

In this paper, Fisher-ADF test for different root processes and LLC test for the same root process, supplemented by Fisher-PP test. Table 3 gives the unit root test results for 7 variables.

3.2 Panel Data Cointegration Test

In this paper, the KAO test is selected, which is calculated by EVIEWS software system. The results show that the ADF statistic value is -3.371957, and the adjoint probability is 0.0004, which shows that the original hypothesis that there is no cointegration relationship is obviously rejected at the 1% level, so as to judge that the variables lnAG, lnEN, lnF, lnI, lnT, lnTL and lnTS have cointegration relationships.

3.3 Panel Data Regression Analysis

Panel data model verification.

First, perform F-test to test whethera mixed model or a fixed effect model should be established. Using EVIEWS software, it can be obtained that RSSr = 8.992766 corresponding to the mixed model and RSSu = 1.530063 corresponding to the individual fixed effect model in this paper are substituted into Formula (8):

$$F = \frac{(RSS_r - RSS_u)/(N-1)}{RSS_u/(NT - N - k)} \sim F(N-1, NT - N - K) \quad (8)$$

After calculation, we can get F = 155.4665776, and there is $F > F_{0.05}$ (8,255), so we should establish the individual fixed effect model.

Second, the Hausman test should be performed to determine if a fixed effect or random effect model should be established. The results of Hausmann test in this paper show that the model should be an individual time-point double fixed effect model.

Analysis of Regression Results.

Combining the results of F-test and Hausman test, and considering the different situations of cities, this paper sets a fixed effect model with variable intercept as shown in Formula (9). The estimated results of the model are shown in Tables 4 and 5.

$$\begin{aligned} \ln F_{it} = 0.970 + \alpha_i + \gamma_t + 0.021\ln TS_{it} + 0.016\ln TL_{it} + 0.073\ln T_{it} \\ - 0.022\ln I_{it} + 0.031\ln EN_{it} + 0.187\ln AG_{it} + \varepsilon_{it} \end{aligned} \quad (9)$$

.

Among them, α_i is the deviation of "individual effect" in region I from the average spontaneous level; γ_t is an individual constant that reflects the effects of a period, indicating changes brought about by changes in time points; I denotes 9 different prefecture-level cities; T is 1990–2019; ε_{it} is the error term.

The goodness of fit of the model reaches 0.950431; P = 0.0000, and the model is significant on the whole at 1% level. So the model has strong explanatory power.

Table 4. Regression Results of Model

Variable	Coefficient	Std.Error	t-Statistic	Prob.
C	0.969749	0.101697	9.535680	0.0000
lnTS	0.021260	0.030061	0.707231	0.4802
lnTL	0.015846	0.009793	1.618089	0.1070
lnT	0.073315	0.013123	5.586580	0.0000
lnI	-0.022035	0.008082	-2.726465	0.0069
lnEN	0.030706	0.024875	1.234415	0.2183
lnAG	0.187081	0.043538	4.296959	0.0000

Table 5. Estimation Results of Indidual Effect (α_i) and Time Point Effect (γ_t)

CROSSID	Effect		
Shenyang city	0.265504		
Dalian city	0.541230		
Anshan city	-0.015712		
Fushun city	-0.284672		
Benxi city	-0.285502		
Yingkou City	0.009255		
Liaoyang city	-0.008206		
Panjin city	-0.256954		
Tieling city	0.035057		
DATEID	Effect	DATEID	Effect
1999	0.252004	2005	0.115304
1991	0.266524	2006	0.099662
1992	0.216324	2007	-0.066100
1993	0.185416	2008	-0.101286
1994	0.164420	2009	-0.151685
1995	0.144999	2010	-0.189770
1996	0.133422	2011	-0.160045
1997	0.129998	2012	-0.187657
1998	0.149064	2013	-0.210043
1999	0.092734	2014	-0.184737
2000	0.089668	2015	-0.152007
2001	0.084188	2016	-0.191899
2002	0.071702	2017	-0.201341
2003	0.050219	2018	-0.235263
2004	0.037736	2019	-0.251551

4 Conclusion and Enlightenment

4.1 Conclusion

From the explanatory variables, the regression coefficient of rationalization and upgrading of industrial structure is positive, which shows that the change of industrial structure in this urban agglomeration has promoted the improvement of local ecological environment quality level, and the industrial structure needs to be transformed into an environment-friendly direction. From the control variables, the scientific and technological input level, energy structure, economic level and regression coefficient sign are positive, which indicates that its increase can promote the improvement of the ecological quality level.

Theoretically, the coefficient of panel regression model reflects the sensitivity of the explained variable to the change of the explained variable, and the intercept term measures the basic effect of the explained variable. The magnitude of the intercept term reflects the difference and gap of the basic effect intensity of ecological efficiency on industrial structure change. The larger the intercept term value, the stronger the basic effect, while the smaller the intercept term value, the weaker the basic effect.[3]From the intercept term of the variable intercept model, the public intercept term is 0.969749, and the intercept term of each city is different. According to the deviation of intercept terms from big to small, the order is Dalian, Shenyang, Tieling, Yingkou, Liaoyang, Anshan, Panjin and Fushun. The reason why there are different interceptions, that is, there are individual influences, the economic and social development of each city is uneven, the energy structure conditions are different, and the policy support of each city for industrial structure changes is different, so the basic effect of ecological efficiency on industrial structure changes among cities is different.

The inverted U-shaped theory put forward by Jeffery G. Williamson shows that spatial agglomeration will significantly improve regional economic efficiency in the early stage of economic development. However, when the level of economic development reaches a certain threshold, Agglomeration's significance in encouraging economic growth will shrink or even reverse.[4] This can explain to some extent that the unbalanced development of industrial structure and ecological environment is an insurmountable stage.

4.2 Enlightenment

According to the conclusion of the above empirical analysis, this empirical study has certain policy implications for the adjustment and upgrading of industrial structure, the improvement of ecological efficiency and the realization of the coordinated development of industrial structure adjustment and ecological efficiency.

First, actively encourage scientific and technological growth while reducing disparities in environmental advantages among cities. According to the findings, there are considerable regional disparities in ecological efficiency among cities, and technological growth is a vital driving factor in promoting the coordinated development of industrial structure and environmental quality. Therefore, in the future development, cities should focus on promoting scientific and technological progress, enhancing the ability of scientific and technological innovation and independent research and development of enterprises, and improving regional ecological efficiency. Cities with high ecological efficiency should continue to take a leading role in supporting environmental efficiency improvement in nearby areas.

Second, rationally promote the optimization and upgrading of industrial structure and promote the adjustment of industrial structure. We must follow the path of green and sustainable growth, create a spatial pattern and industrial structure that saves resources and protects the environment, and fully achieve the scenario of benign contact and coordinated development within the region.[5].

Third, all urban agglomerations should attach importance to the promotion of economic level, scientific and technological level, energy structure and other factors on the ecological environment, and all localities should emphasize the development concept of paying equal attention to economic benefits and ecological benefits.

References

1. Gan Chunhui, Zheng Ruogu, Yu Dianfan: The Impact of Industrial Structure Changes on Economic Growth and Fluctuation in China, Economic Research, No.5, 2011.
2. Han Yonghui, Huang Liangxiong, Wang Xianbin. Does the optimization and upgrading of industrial structure improve ecological efficiency? [J]. Technical and Economic Research of Quantitative Economy, 2016,33 (04): 40–59.
3. Liu Jiong. The impact of tourism development on farmers' income growth under the background of rural revitalization-an empirical analysis based on panel data in northern Anhui [J]. Journal of Leshan Teachers College, 2022,37(07):61–67.
4. Williamson, G.Jeffrey. Regional Inequality and the Process of National Development [J]. Economic Development and Cultural Change,1965 ,(7):3–45.
5. Tang Xiaoling, Feng Yanrong, Du Li. Evolution characteristics and coupling relationship between industrial structure adjustment and energy ecological efficiency-taking Guanzhong plain urban agglomeration as an example [J]. Technical Economy, 2021, 40(04):58–64.