Research on the influence path of urban air quality in China--Based on the perspective of industrialization and urbanization

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Abstract: The rapid development of urbanization and industrialization in China has greatly promoted China's economic development, but it has also brought great pressure to the environment, especially the rapid decline of urban air quality, which has also attracted the attention of the government. This paper studies the current situation of air quality in 113 Chinese cities, establishes a structural equation model, and compares the difference between industrialization and urbanization in the impact path of urban air quality, to put forward corresponding suggestions and help relevant departments to make better decisions.

1. Introduction

China's rapid economic rise has come at the expense of the environment and public health. Rapid urbanization and industrialization have led to a host of environmental problems, such as urban congestion, water pollution, and air pollution. With the rapid development of urbanization and industrialization, the Chinese government has paid great attention to the bad environmental air quality. How to solve the problem of air pollution is the root of the problem.

The rapid development of industrialization and urbanization also brings certain disadvantages. Previous scholars have found the influence of industrialization and urbanization on air quality in Chinese cities by establishing models. Wang et al. (2017) studied the influence of urbanization on the city air quality from two dimensions of population and land, and found that in middle level of urbanization has the highest regional air pollution levels, on both ends of the low level of urbanization and higher pollution levels [1]. Shastra (2016) conducted the EKC test and used panel data to study the main factors leading to air pollution, namely the development of industrialization accompanied by economic development, the globalization of trade, the change of people's environmental awareness, and the progress of science and technology [2]. Ding et al. (2016) used the urbanization rate and GDP per capita as the main explanatory variables. He established a common panel regression model and spatial measurement panel model about the impact of urbanization on-air environment EKC test, vector autoregressive model and coupling coordination model, using panel to get the corresponding rule between the urbanization and the air quality [3]. Li et al. (2017) creatively introduced structural equation model between industrialization, urbanization and urban air quality research and no longer confined to the study of the relations between them, but the research of industrialization and urbanization is how to influence the urban air quality, he didn`t compare the two difference influence path [4].

2. Methodology

2.1 Theoretical models

Based on the results of previous studies, we found that in the process of industrialization and urbanization, in addition to the direct impact, there may be an indirect impact. Based on this, the relationship between industrialization, urbanization, exhaust emission, and urban air quality may be as follows:

(1) Industrialization and urbanization directly affect urban air quality, namely

industrialization/urbanization -- > urban air quality;

(2) Industrialization and urbanization affect air quality by producing waste gas, namely industrialization/urbanization -- > exhaust emission -- > urban air quality;

2.2 Research methodology

Structural equation modeling (SEM) is a statistical model to analyze the relationship between variables based on the covariance matrix of variables. In the structural equation model, there are four kinds of variables: endogenous variables, exogenous variables, latent variables, and observational variables. The structural equation model is made up of two simultaneous equations, namely the measurement equation and the structural equation. We use the maximum likelihood estimation method in structural equation modeling.

The measurement equation is defined as follows:

$$\eta = \beta\eta + \Gamma\xi + \zeta) \quad (1)$$

Moreover, the structural equation model is expressed as follows:

$$X = \lambda_X\xi + \delta, \ Y = \lambda_y\eta + \varepsilon \quad (2)$$

In this model, the meanings of each symbol are as follows:

η: endogenous latent variable; ξ: exogenous latent variable;β; Γ: the correlation between potential variables, namely the path coefficient;ζ: random disturbance term; X: observation variables of exogenous latent variables; Y: observation variables of endogenous latent variables; λ_X; λ_y: the relationship between potential variables and observed variables, namely factor loading; δ; ε : measurement error of observation variables

3. Structural equation modeling and data

3.1 Variable selection and data source

According to the original basic theoretical model, and the availability of data, we determined the measurement indexes of each latent variables. Among the air quality indexes, the measurement indexes are determined as the annual average concentration of sulfur dioxide (C-SO_2), the annual average concentration of nitrogen dioxide (C-NO_2), the annual average concentration of pm10 (C-pm10), the daily mean concentration of carbon monoxide at the 95th percentile (DMC-CO), and the annual average concentration of fine particulate pm2.5 (AAC-pm2.5). Industrialization is measured by the proportion of secondary industry in GRP (P-SI); Measuring urbanization by the population ratio of municipal districts (P-MD); Exhaust emission is measured by the density of smoke (powder) dust emission (D-S/P). The data are from the China city statistical yearbook 2016.

This paper selects 113 key cities for environmental protection, including 4 municipalities directly under the central government, 27 provincial capitals, and 82 prefecture-level cities.

3.2 Data processing

Firstly, data are standardized to eliminate the influence of dimension on model results. The method adopted in this paper is "maximum-minimum standardization", namely: $x_i - \min(X)/\max(X)$.

Secondly, the normality test is carried out. Because the maximum likelihood estimation is used to estimate the structural equation model, the method requires the data to conform to the normal distribution. The Kolmogorov-Smirnov test will be used in this study, and the results are shown in Table 1.

Table.1. Normality test result

	Kolmogorov-Smirnov[a]		
	statistic	df	Sig.
$C\text{-}SO_2$	0.043	113	.200*
DMC-CO	0.157	113	0
C-pm10	0.064	113	.200*
P-SI	0.108	113	0.07
P-MD	0.097	113	0.011
D-S/P	0.37	113	0
AAC-pm2.5	0.083	113	0.054
$C\text{-}NO_2$	0.043	113	.200*

Table.2. Single-Factor Confirmatory anaysis

	initial	extration
$C\text{-}SO_2$	1	0.336
C-pm10	1	0.891
DMC-CO	1	0.564
$C\text{-}NO_2$	1	0.445
AAC-pm2.5	1	0.832

From Cole's elder brother rove - m's inspection, under the significance level of 0.05, DMC-CO, P-MD, D-S/P did not pass the normality test, presenting the skewness distribution. Data reveals that the $C\text{-}SO_2$ and D-S/P of Lhasa are zero, leading to serious deviation from the normal distribution of data as outliers. Then, the above three variables were transformed into logarithms to show a better normal distribution.

Finally, the validity of the measurement model is verified. A single-factor confirmatory analysis model was established to measure the factor loading of indicators, and the results are shown in Table 2. From the results, it can be seen that the C-PM10, AAC-pm2.5 have large factor loads, both greater than 0.80, so the measurement indexes of latent variable air quality are determined as the above two indexes.

The structural equation model is established in Figure 1.

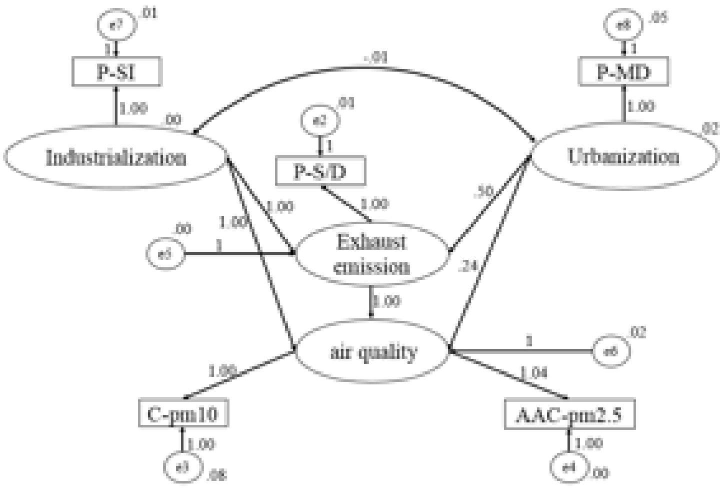

Figure 1. Structural Path Diagram

The statistical results of the model parameters are as follows:

Table.3. goodness of fit of the model

matching index		actul value
RMSEA	Less than 0.08, good matching	0.063
SRMR		0
IFI	Greater than 0.9, good matching	0.996
CFI		0.995
TLI		0.977
NFI		0.986

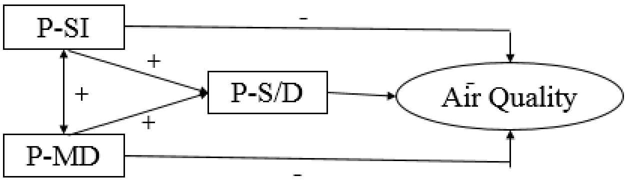

Figure 2. Influence Path Diagram

According to the index value of the goodness of fit of the evaluation model, the goodness of fit of the model is high, and the fitting effect of the model is good. There is no significant difference in the path of industrialization and urbanization on urban air quality, only in the degree of influence.

4. Conclusion

There are two ways for industrialization and urbanization to affect urban air quality. First, industrialization and urbanization have a direct positive impact on urban air quality and show a linear relationship. However, from the perspective of the path coefficient, the impact of industrialization is greater than that of urbanization. Second, both industrialization and urbanization indirectly affect urban air quality through the emission of waste gas, but the impact of urbanization on the emission of waste gas is smaller than the impact of industrialization on the emission of waste gas.

The specific path diagram is shown in Figure 2. Through the structural equation model obtained in this paper, it can be found that there is an interaction between industrialization and urbanization, which not only promotes the increase of the urban population but also promotes the development of the secondary industry.

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