System Integration of Urban Agglomerations and Haze Governance in China

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Abstract: It is urgent to explore the path of urban haze governance, and regional integration is a feasible route. This paper uses the characteristics of urban agglomeration integration and PM$_{2.5}$ spatial distribution raster data to investigate the impact of urban agglomeration institutional integration on haze pollution in Chinese cities. Improving the integration of urban agglomeration systems has a significant inhibitory effect on urban haze pollution, and from a numerical point of view, for every 1% increase in the level of urban agglomeration integration, the average urban haze concentration will drop by 0.08%-0.10%. The policy enlightenment of this paper is that the government should accelerate the integration of urban agglomeration systems, strengthen cooperation in environmental protection between regions, to promote urban haze reduction.

1. Introduction

Since the reform and opening up in China, with the continuous advancement of urbanization and industrialization, China has achieved sustained and rapid economic growth and the people's living standards have been continuously improved. However, at the same time, Chinese cities generally face air pollution problems represented by haze pollution, and they have received extensive attention from government departments and scholars. The 2017 Chinese Government Work Report pointed out that “resolutely win the blue sky defense war” as an important task, and put forward a series of policy measures to strengthen haze management. Existing studies have shown that haze pollution has caused obvious negative effects on health and economic development (Mukherjee and Agrawal, 2017). Therefore, the policies and measures to tackle the problem of haze management are urgent.

Urban agglomeration refers to a collection of multiple cities radiating to the surroundings with the central city as the core. The modern urban system breaks the limitation of single-center cities, and usually crosses established urban boundaries to form urban agglomerations of a certain scale around functional areas. China's urban agglomerations are the inevitable product of the country's new industrialization and new urbanization in the past 30 years. Within urban agglomerations, the links between previously separated cities have become more and more complex. From the perspective of China's current urbanization development trend, regional integration led by urban agglomerations has become the current development trend of urban regional spatial organization. The integration of urban agglomerations emphasizes the interconnection of transportation and commerce within the urban agglomeration, the significant advancement of institutional coordination, and the continuous strengthening of cultural integration, so as to truly realize the interconnection and sharing of infrastructure, market systems, policies and measures. In theory, the integration of urban agglomerations will promote all-round cooperation between cities through transportation and logistics facilities and
market sharing mechanisms, and promote the high-quality development of urban agglomerations in terms of economic efficiency, environmental friendliness and social harmony. However, local governments have competed for growth for a long time in China. While actively promoting local economic development, they have neglected the protection of the ecological environment. The cross-border coordination and coordination of ecological environment governance has become a major problem that needs to be solved urgently. This paper aims to calculate the level of institutional integration of China's 22 urban agglomerations, and to explore the impact of institutional integration on urban haze pollution governance, so as to provide a theoretical evidence for the development of Chinese urban agglomerations.

2. Literature Review

Existing research on the subject of China's haze pollution governance, scholars have tried to launch useful discussions in terms of energy consumption, traffic congestion, and urbanization (Ma et al., 2016; Lin and Zhu, 2018; Xie et al., 2019), many useful discussions on the causes of haze pollution. However, for China, a developing country undergoing economic transition, there are institutional reasons that cannot be ignored when exploring the problem of haze pollution. The fiscal pressure and market segmentation of local governments under the fiscal decentralization system are considered to exacerbate haze. Important factors of pollution (Peng and Dong, 2019; Bian et al., 2020). Bian et al. (2020) analyzed the impact of market segmentation among local governments on haze pollution, which is consistent with this paper's institutional perspective on haze pollution governance. However, the existing literatures do not try to analyze the problem of haze management in China from the perspective of regional integration, and this paper is based on the integration of urban agglomerations, which is also one of the marginal contributions of this paper.

The key to the integrated evaluation of urban agglomerations lies in the selection of samples, the establishment of index systems and the selection of comprehensive evaluation methods. First of all, the selection of samples for regional integration studies by foreign scholars mainly focuses on transnational regions within Europe or Asia. For example, the Dutch scholar Meijers et al. (2018) measured the integration of 117 urban agglomerations in Europe, and the American scholar Aggarwal et al. (2005) Study the level of economic integration in Northeast Asia. The main research samples selected by Chinese scholars include the middle reaches of the Yangtze River urban agglomeration, the Beijing-Tianjin-Hebei urban agglomeration, the Yangtze River Delta urban agglomeration, the Chengdu-Chongqing urban agglomeration, and the Chang-Zhu-Tan urban agglomeration as a whole. In addition, there are very few comprehensive evaluations of the integrated development status of China's 18 urban agglomerations like Song and Ni (2015). It can be seen that most scholars are mainly concerned about the integration of a certain city group or city group, and it is the first time that the integration level of China's 22 city groups has been measured in the same bid evaluation system. Secondly, with regard to the establishment of a comprehensive evaluation index system, there is currently no literature that uses the coefficient of variation method to measure the level of integration of Chinese urban agglomerations.

3. Index Measurement and Model Setting

3.1. Measurement of urban agglomeration system integration

System integration is the guarantee for the integration of urban agglomerations. Since institutional factors are the basis for regional coordinated development, different administrative entities have large differences in the drafting and implementation of policies and systems. Therefore, the establishment of an institutional coordination mechanism within the urban agglomeration is an important manifestation of the institutional integration of the urban agglomeration. The key to the system integration of urban agglomerations lies in three aspects. One is the integrated negotiation between governments within the urban agglomeration, the second is the integrated planning at the national level, and the third is the impact of existing provincial administrative divisions on system integration. Therefore, the institutional integration of urban agglomerations is mainly constructed from the following three indicators:
(1) Whether to establish a joint mayor meeting system. Based on the division of the city agglomerations, this paper assigns a value to whether each city group will hold a joint mayor meeting from 2000 to 2016. The year when the city group holds the mayor joint meeting is assigned a value of 1, and the year when it is not held is assigned a value of 0. The data comes from Internet searches.

(2) Whether it is approved as a national-level city cluster. National-level urban agglomerations are ahead of non-national-level urban agglomerations at the institutional level. Therefore, the value of 1 is assigned to the years after being approved as a national-level urban agglomeration, and 0 is assigned to the years that are not approved. The data comes from Internet searches.

(3) The number of cross-provincial administrative divisions. All cities are assigned a value of 0 for urban agglomerations in the same provincial administrative division, and 1 for urban agglomerations across two provincial administrative divisions, and so on. This indicator represents the degree of urban agglomeration segmentation, that is, the greater the value, the lower the level of urban agglomeration integration. The data comes from Internet searches.

Construction of evaluation index system: The index system of this paper is shown in Table 1, which is constructed by 3 secondary indexes. Among them, the four indicators of whether to establish a joint mayor meeting system and whether to be approved as a national-level urban agglomeration are positive indicators. The larger the positive indicator value, the higher the level of urban agglomeration integration; the number of inter-provincial administrative divisions is Reverse indicator, and the smaller the reverse indicator, the better the level of urban agglomeration integration.

Table 1 Comprehensive Evaluation Index System of Urban Agglomeration System Integration Level

| First-level index | Second-level index | Value range |
|-------------------|--------------------|-------------|
| System integration (Y) | Whether to establish a joint mayor meeting system (Y1, positive) | 0-1 |
| | Whether it is approved as a national-level city cluster (Y2, positive) | 0-1 |
| | Number of cross-provincial administrative division (Y3, inverse) | 0-1-2 |

Standardized processing of data. Due to the differences in the dimensions, magnitudes, and positive and negative orientations of the indicators in the indicator system, in order to evaluate the reliability of the results, the original data must be standardized before the comprehensive evaluation. This study adopts range standardization and normalization processing methods. Suppose there are m urban agglomerations and n evaluation indicators. For positive indicators:

$$
\alpha_{ij} = \frac{x_{ij} - \min[x_{ij}]}{\max[x_{ij}] - \min[x_{ij}]}, \quad (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)
$$

(1)

For reverse indicators:

$$
\alpha_{ij} = \frac{\max[x_{ij}] - x_{ij}}{\max[x_{ij}] - \min[x_{ij}]}, \quad (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)
$$

(2)

Selection of methods and determination of weights. This paper uses the coefficient of variation method for comprehensive evaluation, which assigns weights according to the degree of variation of the indicators to determine the objective evaluation method for the weight of each indicator. The greater the degree of variation of the index, the greater its influence on the comprehensive evaluation. Therefore, the coefficient of variation method can reflect the importance of indicators relatively objectively. The calculation method of the coefficient of variation is shown in formula (3), (4), and (5):

$$
V_i = \frac{\bar{x}_i}{\hat{s}_i}
$$

(3)

$$
\hat{s}_i = \sqrt{\frac{1}{m} \sum_{j=1}^{m} (\alpha_{ij} - \bar{\alpha}_i)^2}
$$

(4)

$$
\bar{\alpha}_i = \frac{1}{m} \sum_{j=1}^{m} \alpha_{ij}
$$

(5)

Among them, $V_i$ is the coefficient of variation of the $i$-th index data, $S_i$ is the standard deviation of the $i$-th index data, and $\bar{\alpha}_i$ is the average value of the $i$-th index data. According to the corresponding coefficient of variation, the calculation method for the weight of the $i$-th index is shown in formula (6):
After calculating the weight of each index \( \omega_i \), the comprehensive evaluation of the integration score of the urban agglomeration is shown in formula (7):

\[
f(\theta) = \sum_{i=1}^{n} \omega_i \times \alpha_i
\]  

3.2 Measurement of urban haze pollution

The PM\(_{2.5}\) concentration reflects the degree of haze pollution in the city, which is the explained variable in this paper. This paper selects annual panel data at the municipal district level of a total of 286 cities in China, covering a total of 17 years from 2000 to 2016. The PM\(_{2.5}\) concentration of each city municipal district is through ArcGIS software, combined with the vector map of the administrative divisions of Chinese cities, to compare China The annual average surface PM\(_{2.5}\) concentration data is extracted, and the data comes from the global PM\(_{2.5}\) surface annual average concentration data provided by the Social Economic Data and Application Center of Columbia University in the United States.

3.3 Measurement model setting

In order to verify the relationship between institutional integration of urban agglomerations and haze pollution, this paper establishes a benchmark model for empirical regression as follows:

\[
\ln PM_{2.5it} = \alpha + \beta_1 \ln Integration_i + \beta_2 X_{it} + \mu_i + \gamma_t + \epsilon_{it}
\]  

In the above formula, \( \ln PM_{2.5it} \) represents haze pollution at the city level, \( \ln Integration_i \) represents the level of urban agglomeration system integration, \( i \) and \( t \) respectively refer to the city and year, \( \alpha \) is a constant term, \( \epsilon \) represents an error term, and \( X \) refers to other cities that may affect The set of control variables for haze concentration includes: the logarithm of the actual per capita income level (\( \ln rpgdp \)), and its square term (\( \ln rpgdp^2 \)), the logarithm of population density (\( \ln popdensity \)), and the logarithm of the proportion of fixed asset investment (\( \ln pinvest \)), logarithm of foreign direct investment (\( \ln pfdi \)), logarithm of per capita road area (\( \ln proad \)). In addition, the urban fixed effect \( \mu_i \) and time fixed effect \( \gamma_t \) that do not change with time are also controlled in the model. This research mainly focuses on the impact of institutional integration on urban haze pollution, that is, the sign and significance level of the parameter \( \beta_1 \) to be estimated, which can be interpreted as the effect of institutional integration on urban haze concentration, that is, every 1% change in the level of integration will result in a change in the percentage of urban haze pollution Except for the urban agglomeration system integration and urban PM\(_{2.5}\) indicators, the data calculated for other indicators are from the China City Statistical Yearbook and China Statistical Yearbook of the corresponding year.

4. Empirical Analysis

In the benchmark regression, we use the least squares method OLS to regress equation (8), and gradually add control variables such as per capita GDP, population density, and fixed asset investment proportion in the regression process. Table 2 reports the regression results based on the OLS method. It can be found from this table that no matter how many factors are controlled, the coefficient of the institutional integration variable \( \ln Integration \) is significantly negative. For every 1% increase in the level of integration, the average urban haze density will drop by 0.08%-0.10%. The reason is that through the establishment of a contact meeting system, positioning as a national-level urban agglomeration and less cross-provincial administrative divisions will help guide, supervise, and inspect the implementation of planning and policy measures, including environmental policies, such as compiling regional air quality compliance planning, regional linkage and simultaneous law enforcement, thereby reducing haze pollution.

| Table 2   | The Impact of Urban Agglomeration System Integration on Urban Haze Pollution |
|-----------|--------------------------------------------------------------------------------|
|           | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| OLS OLS OLS OLS OLS OLS OLS |
| lnIntegration -0.082*** | -0.087*** | -0.086*** | -0.083*** | -0.085*** | -0.097*** | -0.099*** |
| (0.011) (0.011) (0.011) (0.011) (0.011) (0.012) (0.012) |
Taking into account the differences in China’s geographic environment and regional development, we further investigated the effect of urban agglomeration system integration in different regions on haze governance on the basis of benchmark regression. Table 3 shows the regression results we focused on. From the first three columns of Table 3, it can be concluded that the integration of urban agglomeration systems in the eastern and western regions has had a significant impact on haze pollution, but the regression results in the central region are not significant. The possible reason is that the urban agglomerations in the eastern region have developed rapidly, and their degree of institutional integration is relatively high, so the suppression effect on haze pollution is more significant; the western region is sparsely populated, and the level of industrial development is relatively low. Under the premise of a relatively small progress in the integration of urban agglomeration systems, significant haze reduction functions can be produced. In contrast, the urban agglomeration system integration in the central region was underdeveloped and failed to exert a significant inhibitory effect on haze pollution.

Table 3  Regression Results of Heterogeneity Analysis and Robustness Check

| (1) | (2) | (3) | (4) | (5) |
|-----|-----|-----|-----|-----|
|      | East Area | Middle Area | West Area | IV  | IV  |
| lnIntegration | -0.126*** | 0.009 | -0.147*** | -0.941*** | -0.480*** |
|         | (0.016) | (0.030) | (0.032) | (0.211) | (0.127) |
| _cons  | 2.378*** | 2.234*** | 5.921*** | 2.267*** | 2.018** |
|         | (0.741) | (0.840) | (1.494) | (0.268) | (0.894) |
| Control Variables | Y | Y | Y | N | Y |
| Instrumental Variables: | Undeveloped#i.year | — | — | — | Y |
| Anderson LM P-value | — | — | — | Y | Y |
| First-stage F Statistics | — | — | — | Y | Y |
| 15% maximal LIML size | — | — | — | Y | Y |
| Year fixed | Y | Y | Y | N | Y |
| City fixed | Y | Y | Y | Y | Y |
| N      | 3042 | 3005 | 3005 | 3001 | 2587 |
| R²     | 0.576 | 0.585 | 0.587 | 0.593 | 0.629 |

In the above, we used the least square method to estimate the model. But what has to be considered is that there are certain endogenous problems in the impact of institutional integration on haze pollution. On the one hand, the integration of urban agglomeration systems in this paper may have certain
measurement errors; on the other hand, although we control a series of variables that may affect haze pollution, it is impossible to completely control the interference of other factors. Therefore, in order to ensure that potential endogeneity issues do not affect the conclusions of this paper, we try to find instrumental variables to overcome possible endogeneity. This paper looks for instrumental variables of geographic types. Specifically, the product of the proportion of undeveloped land in each city and the fixed time effect is selected as an instrument variable. The reason for the rationality of the instrumental variable is as follows: First, the proportion of undeveloped land is determined by the behavior of local governments. One of the important determinants (Saiz, 2010), especially when the proportion of undeveloped land in local cities is high and land resources are relatively scarce, local governments will have a stronger willingness to seek cooperation with neighboring cities, so there is a certain degree of institutional integration. Secondly, the proportion of undeveloped land also meets the exogenous conditions, because it is determined a priori as a natural factor. The basic seismic acceleration is a long-term exogenous feature of the city. After controlling other influencing factors, it will not affect the urban fog. Haze pollution has a direct impact; finally, considering that the design basic seismic acceleration itself is cross-sectional data at the city level, the variables in this paper are in the form of panel data, so the scientific use of the instrumental variable method inevitably requires Consider the difference in time dimension. In order to solve this problem, this paper refers to the method of Angrist and Krueger (1991), and adopts the interaction term of the proportion of undeveloped land and the dummy variable of the year as an instrumental variable into the econometric model. The last two columns of Table 3 show the regression results. It can be found that after using instrumental variables to overcome endogeneity, although there are certain changes in the values, it still supports the core conclusions of this paper.

5. Conclusion
This paper attempts to explore the path of urban haze governance by taking the government action of urban agglomeration system integration as the starting point. In terms of empirical strategies, this research mainly reflects the level of institutional integration of China’s urban agglomerations from the perspectives of whether a joint mayoral meeting system has been established, whether it has been approved as a national-level urban agglomeration, and the number of cross-provincial administrative divisions, and combined with PM2.5 space Distribution of raster data, the regression results show that improving the degree of urban agglomeration system integration is helpful to urban haze pollution governance. This is due to the improvement of the level of urban agglomeration system integration, which has promoted the establishment of environmental protection standards and the implementation of policy measures within the region. According to the empirical results, the central government should continue to promote the integrated construction of urban agglomerations. At the same time, local governments need to strengthen cooperation and consultation in environmental protection and energy utilization, jointly formulate and implement environmental protection policies and measures, and govern urban haze pollution together.

Acknowledgments
Liu acknowledges the support from the key projects of Humanities and Social Science Fund of China: Study on the Formation Mechanism and Economic Impact of the Size Distribution of Urban System in Economic Transition of China, Project No. 18AJL011.

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