Study on the Influencing Factor of Haze Pollution About the City Along Chinese “The Belt and Road”

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Abstract. Relationships between china’s rapid urbanization and air pollution has been one of the most visible problems. This paper based on the monitoring data of prefecture-level cities from March 2016 to February 2017, gathered from 181 cities along “the belt and road”, we used the arcgis software to make a visual analysis of the distribution of air quality index(aqi) and proposed a new kind of spatial weight based on gravity model to establish spatial autocorrelation and spatial regression model by r software to quantitatively estimate the comprehensive impact and spatial variations of air quality and socioeconomic factors of the cities along “the belt and road” in china. The results show that a significant seasonal change and positive spatial dependence existed in air quality. The model of southern coastal area is low-low aggregation while high-high aggregation model appears in inner mongolia, shanxi and gansu province. In the view of space return, the aqi of those cities shows remarkable spatial spillover effect. The increase of per capita gdp and civilian car ownership has a significant positive effect on the increase of haze pollution degree, however, population density, foreign direct investment and urbanization rate have remarkable passive effect; additionally, the greening rate of urban built-up area on air pollution nearly does not remarkable.

Introduction

Xi jinpin, the president of the people’s republic of china, has put forward the conception of building “the silkroad economic belt” and “21st century maritime silk road” in both september and october, 2013. By the year of 2015, in march, the national development and reform commission released a document named “promoting the vision and action of building silk road economic belt together with 21st century maritime silk road”, which had made great project for china’s economic development under the situation called ‘new normal’, it had also lifted the development and construction of ‘the belt and road’ to the degree of nation. In the meanwhile, the project “the belt and road” has set 18 provinces as the significant ones, which were xinjiang, shanxi, ningxia, gansu, qinghai, inner mongolia, heilongjiang, jilin, liaoqing, guangxi, yunnan, xizang, shanghai, fujian, hainan, chongqing, respectively, in connection with 181 cities. The cities of “the belt and road” have the advantages of abundant resources and the unique district, which is the longest and the best improving economic corridor. At the same time, it has the prospect to become china’s and even the world’s economic increasing motivation[1].

Recently, with the fast improvement of industrialization and urbanization, the contradiction between environmental degradation and economic increase has become the barrier for china’s sustainable development. Since the spring in 2012, many areas of china have suffered the hit of haze, beijing-tianjin-hebei region and yangtze river delta has always become the worst polluted areas all around the world[2], which has brought serious influence of people’s health and daily life production. It was once said in research that pm2.5 was the origin of haze, which can easily be absorbed into human’s lung and does harm to blood circulation[3]. What’s more, enlarge the possibilities of cardiopulmonary system and respiratory disease. In china, severely hazardous ash haze causes 1.2-1.6
million premature deaths annually[4]. From the prospect of the environmental protection administration, during the 74 cities with the air test site in china, beijing-tianjin-hebei region has taken up 7 cities from the top 10 cities with bad air quality, by the meantime, the cities along middle and lower reaches of the yangtze river has suffered haze over 100 days[5]. Through the comparative analysis, in china’s top three plans (“the belt and road” construction, the development of yangtze river economy, the development of beijing-tianjin-hebei region) two planning areas have already occurred serious air polluted problems. The haze pollution has become a national emergency[6] that is attracting considerable attention from policy makes, scientists, and other public sector[7,8]. The air pollution prevention and control action plan(2013-2017) and new air quality index(aqi), issued by the state council of china in 2013, has had little impact. In 2015, only 73 cities (total 338 cities) met air quality standards. Regarding the importance of china’s “the belt and road” construction, in order to avoid the same mistakes of “first polluted and then governed”. So it is fatal to identify the main factor that cause haze pollution, and using rigorous quantitative empirical tools offer some useful results for policy makers to formulate proper and effective to reduce cities’ air pollution along chinese “the belt and road”.

Nowadays, the environmental problems of “the belt and road” cities in china laid emphasis on the macro-examination, including the building of green “the belt and road” development framework[9], the sustainable development of node areas during the process “silk road economic belt” energy cooperation[10]. However, the micro-examination on environmental problems showed emphasis on the virtual water trade of agricultural products and he investment of foreign company and the relationship of environmental pollution[11,12], lacking researches on air pollution.

The number of literature on the relationship between economic development and environmental quality has increased rapidly. Most of the empirical research are based on the environmental kuznets curve(ekc) which was first raised by grossman and krueger[13]. The research found an inverted u-shaped relationship between per capita income and urban air pollution. Most of the research laid emphasis on particulate, such as so2, co2, no, pm2.5 and pm10[14,15,16,17]. In the result of these studies, researchers have demonstrated different relationships between these pollutants and income, such as u-shaped relationship[20] and linear relationship[21], the empirical results show that no accordant conclusion has been drawn.

In addition to economic factor, haze pollution is mainly caused by population aggregation, industrial development, urbanization, vehicle gas emission. Several studies on the factors driving china’s air pollution have been published recent years. Limei found, the key way to reduce the haze pollution, that change the energy consumption structure and the industrial structure[20]. Li et [22]al have examined the spatial and temporal variation of air pollution and its association with meteorological condition in chinese cities. Shaoxue and shaozhou[23] found positive correlation between fdi and air pollution in china. Some other researchers found that population growth, industrialization, urbanization and energy use increase air pollution[2,3,6].

From the perspective of researching areas, the researches about china’s haze pollution show three dimensions: single city [(big city like guangzhou[22], xinjiang[10] et al.), city group (beijing-tianjin-hebei region[5] and yangtze river delta[16] et al.)and provincial level[20]. To the researching contents, some researches emphasized on the feature of haze space-time distribution, while others showed emphasis on using the method of spatial econometrics to find the relationship between haze and economic development, however, the existing studies about the spatial distribution of haze pollution showed a great limitation of spatial weight construction. For example, the adjacency space matrix ignores the influence of the remote transmission among different cities; geographic proximity space matrix ignores the level of haze in surrounding cities; economic matrix only takes the level of economy into consideration and geographic economic matrix ignores the haze level between cities. So, there is a lack of research on the air pollution influencing factors of cities along “the belt and road” by using empirical method. This paper attempts to fill the gap. This study builds a new space weight based on gravity mode, in order to describe the spatial effect of haze pollution among cities. We use arcgis10.2 and r to apply exploratory spatial data analysis and the spatial lag
mode (SLM), spatial error model (SEM) to analyze the spatial distribution and influencing factors from AQI records for 181 Chinese prefecture-level cities.

This paper is organized as follows. In section 1, we will describe in some details about our data and research methods, our analysis results are presented in section 2. In section 3, a summary of our findings is presented.

Data and Research Methods

Data

The whole data of AQI and PM2.5 are chosen from the weather post website, to be explicit, this platform has collected the air quality statistics of the whole country since October 2013. As for the alongside areas of “the belt and road”, the total number of city (including municipality and autonomous state) are 181, and this essay grasped the corresponding data from March 2016 to March 2017 in order to be put into the study of seasonal change and annual spatial distribution by using python software. Besides, the essay also makes full of the dimensional econometric model to explore and identify factors that affect the level of smog pollution. What’s more, the essay analyzes the chosen variable from seven dimensions ranging from economy, population, transportation, environment, foreign investment, urbanization and geographic area based on the passing research. The index for selection is as follows: economic factors use per capita GDP as proxy variables; population factors use population density as a proxy variable; traffic factors use civilian car ownership as a proxy variable; green factors use the green rate as the proxy variable; foreign investment factors use foreign direct investment as the proxy variable; the urbanization rate is used as the proxy variable for the proportion of the urban population in the whole city and the geographical area is defined by the Qinling mountains-huaihe river line. In the meanwhile, set the northern cities as zero and set southern cities as one.

Since Chinese statistics bureau has not yet released the figures for 2016, we can only use the data in 2015 to conduct the spatial econometric analysis. The variables above mainly came from Chinese city statistics yearbook 2016 together with the 2015 national economic and social development bulletin of various prefecture-level cities, some of the missing data came from local statistical yearbooks of various prefectures. Besides, Chinese city statistics yearbook 2016 didn’t make analysis on the relating index of social economy along the cities of “the belt and road”, that is to say, the total number of observed objects by using the spatial econometric model were 142.

Research Methods

The Spatial Weight Matrix Construction Based on the Gravity Model. Anselin[24] has presented the way using the spatial weight matrix so that we can find the related relationship among the observed value. The selection of spatial weight will influence whether the final results of the model is good or bad. In the meanwhile, nowadays, most documents on spatial econometrics are using methods like binary adjacency, k-nearest and reciprocal squared distance method to build weight matrix, lacking other setting ways[25]. To be specific, haze pollution has many features. Firstly, there are usually many surrounding cities around a city while the effects of haze are different from the high haze level cities to the lower haze level cities. Secondly, with the increase between the distance of two cities, the haze influential degree among those cities will decrease by the increasing city distance. Given this problem, the essay has come up with the spatial weight matrix based on the gravity model in order to describe the haze relationship among cities clearly, the formula is as follows:

$$\omega_{ij} = \begin{cases} \frac{pm_i \times pm_j}{D_{ij}}, & i \neq j \\ 0, & i = j \end{cases}$$  \hspace{1cm} (1)
As it shown in the formula, $\omega_{ij}$ represents the spatial weight of city $i$ and city $j$, $pm_i$ and $pm_j$ represents yearly average of $pm_{2.5}$ in 2015 between city $i$ and city $j$, $d_{ij}$ represents the straight-line distance between the two cities’ governments location.

The Analysis of Spatial Autocorrelation. The analysis of spatial autocorrelation is divided into global autocorrelation and local autocorrelation. Global autocorrelation is used for the research of the degree of dependence of certain variables throughout the regions. Usually, people use the global exponential named Moran’s index to do research, the formula is as follows:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \omega_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} \sum_{j=1}^{n} \omega_{ij} (x_i - \bar{x})^2}$$

(2)

From this formula, where $n$ is the amount of city, $x_{ij}$ represents the $aqi$ index value of the area $i$, $\omega_{ij}$ represents the corresponding elements in the spatial weight matrix. Moran’s $i$ ranges from -1 to 1, if the value less than zero, it means that space is negatively related, however, if the value more than zero, it means that space is positively related, and if the value equals to zero, it means that the space are independent of each other.

During the process of the search in reality, there is some spatial heterogeneity within the study area, that is to say, it is necessary to analyze the relevance of the local area. Local spatial autocorrelation describes the degree of association between a specific space unit and its neighboring units, the formula is as follows:

$$I = \frac{\sum_{i=1}^{n} \omega_{ij} (x_i - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

(3)

The correlativity can be divided into four groups if the local spatial autocorrelation is clear, which was “high-high”(high value areas are surrounded by high value areas), “low-low”(low value areas are surrounded by low value areas), “low-high”(low value areas are surrounded by high value areas), “high-low”(high value areas are surrounded by low value areas), respectively[2].

Space Econometric Model. Given the existence of spatial dependence and spatial heterogeneity has violated the precondition that the influencing factors of the classical least square method are independent of each other, scientists decided to use the method of spatial econometrics in order to solve this problem. Besides, the model of spatial econometrics is usually divided into two sides for the process of sectional data, which were spatial lag model (slm) and spatial error model (sem).

(1) spatial lag model. This kind of model contains the lagged terms of explained variable for the sake of solving air quality problem in the surrounding provinces due to the transmission mechanism of a city’s haze. The formula is as follows:

$$y = \rho W y + X\beta + \varepsilon$$

(4)

From the formula, $W$ is the spatial matrix, $Wy$ represents the lagged term of explained variable, $\rho$ represents the influential degree caused by the observed value of the interpreted variables in the surrounding cities, $x$ represents the explained variable matrix, $\beta$ represents a vector of regression coefficient and $\varepsilon$ stands for a vector of random error.

(1) spatial error model. This model contains the lagged term of errors, it is built to solve the problem of the overflow of haze levels caused by explanatory variables in different cities. The formula is as follows:

$$y = X\beta + \varepsilon$$

(5)

$$\varepsilon = \lambda W\varepsilon + \mu$$

(6)
From the formula, $W_c$ represents the spatial lagged term of errors, $\lambda$ represents self-regression coefficient of spatial errors, $\mu$ represents the random error terms which followed the normal distribution.

**Results and Analysis**

**Spatial and Temporal Analysis of Haze Pollution**

**Seasonal Characteristics of Air Quality Distribution.** The essay uses a seasonal analysis of the AQI data from the cities of *Chinese "the belt and road"* from March, 2016 to February, 2017. According to the past researches[3], the average daily data that we're going to collect on average is the value of the air quality of the quarter which were divided by spring (December to February), summer (March to May), autumn (June to August), winter (September to November).

From the figure1, there is a significant seasonal variation of haze pollution among the cities along *Chinese "the belt and road"*. The majority of cities had better air quality in spring with less haze weather, while kezhou, akesu prefecture, kashi prefecture, baozhou prefecture and hotan prefecture in *Xinjiang* suffered heavy haze pollution; the air quality of summer is the best in the four seasons and most areas’ AQI ranged from 0 to 100 with their air quality being good and above, however, the air quality of akesu prefecture, kashi prefecture and hotan prefecture in *Xinjiang* turned out to be in bad quality; the air quality of autumn was second to that in summer. Regardless of the air quality of *Xinjiang* with bad air quality, naqo prefecture in *Xizang* together with xi’an, weinan, xianyang in *Shanxi* province occurred slight polluted climate; as the season goes on, the worst air quality occurred in winter and most cities suffered in haze weather, including most cities in *Xinjiang*, midlands of *Shanxi*, midlands of *Heilongjiang* and most cities in *Liaoning*, let alone laibing in *Guangxi* province, the quarter AQI was 100 and above on average. From the geographical location, if set the qinling - huai river line as the distributed line, the majority of city with worse air quality located in the northern part of China, however, air quality in southern part of China is good almost all year round with the only exception that occurred in laibing of *Guangxi* province, which suffered with slight pollution in winter.

![Figure 1. The seasonal change of air quality about the cities along "the belt and road" in 2016.](image-url)
Air Quality Space Autocorrelation Test. In this paper, the value of *moran's i* in 2016 is calculated as 0.571120, based on the weight matrix constructed by gravity model, and the value of *p* is $2.2 \times 10^{-16}$ which indicates that haze pollution in cities along "the belt and road" in China showed significant positive spatial correlation in 2016. Just as what Anselin said[26], the *moran* scatter diagram is a useful visualization tool to verify the existence of spatial autocorrelation. According to photo 2-a, the x-axis represents the concentration of the aqi, while the y-axis represents the spatial lagged value of the sample point aqi. The aqi of sample cities is mainly distributed in the first and third quadrants in 2016, which are high-high and low-low, two main types of air quality agglomeration.

![Moran scatterplot](image)

Figure 2. Analysis of aqi spatial correlation about the cities along "the belt and road" in 2016.

According to figure 2-b, the aqi in the cities along "the belt and road" in China showed different agglomeration features in different regions in 2016. The high-high polluted features mainly occurred in Xinjiang, Gansu and Guanzhong prefecture of Shanxi in China. The reason why these places suffered such kind of pollution is that there is a few vegetation in Xinjiang region and the winter time is longer than other places of China. At the same time, the sandstorms occur frequently and caused the pollutants floating in the air, which seriously affects the air quality, however, as that for cities in Gansu and Shanxi, ownership of motor vehicle has surged due to the fast speed of urbanization, in the meanwhile, cities like Lanzhou and Baoji are heavy industrial cities with worse haze pollution, which will cause several side effects to its surrounding cities. Low-low pollution features mainly appeared on the maritime silk road economic belt, for the reason that the coastal city has larger sea breeze, which is conducive to the diffusion of pollutants, and the third industry of southern cities is developed which make the air quality better than other areas.

From the table 1, *moran's i* statistics of the four seasons in 2016 were all significant, especially the value in spring. The statistics had indicated that the spatial correlation of aqi was also changing with the change of seasons and showed a significant strong correlation in spring, while the winter showed a lower spatial correlation.

<table>
<thead>
<tr>
<th>Season</th>
<th>Moran's Index</th>
<th>Std</th>
<th>Z Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>0.625 514</td>
<td>0.015 9</td>
<td>39.585 3</td>
<td>0.001</td>
</tr>
<tr>
<td>Festival</td>
<td>0.598 255</td>
<td>0.016 2</td>
<td>37.085 4</td>
<td>0.001</td>
</tr>
<tr>
<td>Autumn</td>
<td>0.600 001</td>
<td>0.015 5</td>
<td>38.742 5</td>
<td>0.001</td>
</tr>
<tr>
<td>Winter</td>
<td>0.554 109</td>
<td>0.016 1</td>
<td>34.573 1</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Analysis of Social and Economic Factors Affecting the Air Quality in China's "The Belt and Road"

The analysis of the research above shows that, the areas of haze in the cities along "the belt and road" are of significant gathering characters, and the seasonal evolution is clear. Only when we get into
familiar with the social and economic factors that affects the haze pollution deeply can we provide scientific and effective basis for the formulation of the policy of haze control. Given that the value of \( aqi \) can represent the level of haze pollution, this paper uses the yearly \( aqi \) on average as the proxy variable for haze pollution. According to the classical \( ols \), scientists had established a regression model as follows:

\[
\ln aqi = \alpha + \beta_1 \ln pgdp + \beta_2 \ln popden + \beta_3 \lnvelpop + \beta_4 grera + \beta_5 fdi + \beta_6 urbrat + \beta_7 groloc + \varepsilon \tag{7}
\]

From this formula, the rest variables are transform into logarithmic form except geoloc (geographical location), grera (green rate of construction area) and urbrat (urbanization rate), besides, heteroscedasticity and multiple-colinearity are weakened. The explained variable is the annual value of \( aqi \) in 142 cities along “the belt and road” in China and they are divided into \( inpgdp \) (per capita gdp), \( lnpopden \) (urban population density), \( lnvelpop \) (civilian car ownership), \( grega \) (green rate of construction area), \( lnfdi \) (actual use of foreign capital), \( urbrat \) (urbanization rate), \( geoloc \) (geographical location). \( \alpha \) represents longitudinal intercept term, \( \beta \) is estimated parameter and \( \varepsilon \) stands for random error term.

Since there was significant spatial correlation between the subjects, the classical method of \( ols \) is useless. According to the discriminant method risen up by anselin[27], spatial lag model (\( slm \)) or spatial error model (\( sem \)) is used to determine the significance of \( lm \) (lagrange multiplier test) statistics based on the classical \( ols \) model. The choice of final model is judged by robust \( lm \) statistics unless both two of the models are clear. This paper set \( slm \) and \( sem \) as the following based on the definitions.

\[
\ln aqi = \alpha + \rho W \ln aqi + \beta_1 \ln pgdp + \beta_2 \ln popden + \beta_3 \lnvelpop + \beta_4 grera + \beta_5 fdi + \beta_6 urbrat + \beta_7 groloc + \varepsilon \tag{8}
\]

\[
\varepsilon = \lambda W \ln aqi + \mu \tag{10}
\]

From this formula, \( Wlnaqi \) represents the spatial lag of the explained variable, \( w \) represents spatial weight based on gravity, \( \rho \) represents spatial self-regression parameter. One thing to be added is that in order to avoid the the bias problem caused by the standardization of the weighting matrix, this paper adopts the maximum characteristic root to standardize the spatial weight[30].

\[
\ln aqi = \alpha + \beta_1 \ln pgdp + \beta_2 \ln popden + \beta_3 \lnvelpop + \beta_4 grera + \beta_5 fdi + \beta_6 urbrat + \beta_7 groloc + \varepsilon \tag{9}
\]

The estimated results of the regression model are shown in table 2, according to the estimated results of classical \( ols \), per capita \( gdp \), population density, car ownership and geographical location are significantly positive, which means that the more developed the economy, the more vehicles and the more densely populated cities in the northern part of \( china \) will have risks on increasing the concentration of air pollution. The green rate of the urban construction area is not significant, which indicates that the urban green rate has little effect on the concentration of air pollution. Given the spatial autocorrelation of \( aqi \), the classical \( ols \) model can only reveal the relationship between social economic factors and haze pollution to some extent.

According to table 2, the \( lm-lag \) and \( lm-error \) statistics were all significant at the level of 1%, while steady \( lm-lag \) and \( lm-error \) are also significant at the level of 1%. From the results of \( lm \) statistics, it is suitable to pick up spatial lagged model or spatial error model. Table 2 provides the measurement results of three kinds of models, and anselin provided three statistics for model comparison, which were log likelihood, akaike info criterion (aic) and schwarz's bayesian criterion(sbc), respectively. The larger the log base statistics, the better the model, while the smaller the \( aic \) and \( sbc \) statistics, the better the model. Transverse comparison of three models showed that the spatial lagged model and spatial error model of three statistic is superior to classical \( ols \) model which illustrates that the spatial
measurement model is superior to the classical ols model, while compared with the spatial lagged model and spatial error model, each of the three statistics of the spatial lagged model is better than the spatial error model. Just as the following: log likelihood-lag (93.2311) > log likelihood-error (87.9971); aic-lag (-136.904) < aic-error (-155.99); sbc-lag (-136.904) < sbc-error (-126.436). On top of that, moran’s i test is not related to whether the spatial lagged term and spatial error term of the variables are significant in the model which is only a simple method for determining whether the residuals have spatial autocorrelation or not. As a consequence, anselin made judgements on these three statistics, which was wald statistics, the likelihood ratio statistics(lr) and lagrange multiplier statistics(lm), and three of the statistics followed at the size of wald>lr>lm. According to the result of spatial lagged model, these three statistics strongly reject the original hypothesis at the significant level of 1%, at the same time, following the order of wald(87.084)>lr(66.788)>lm(48.773), which means that the spatial lagged model is the suitable choice. Through the comparison analysis above, it can be found that the spatial lagged model is the most suitable among the three models, that is why the results of this paper mainly based on the spatial lagged model and being made analysis on.

As it shown in the estimated results of spatial econometric model, there are no more than one factor that significantly affect haze pollution. It is also worth noting that both spatial self - regression parameter ρ and spatial self-regression coefficient λ reject the original hypothesis at the significant level of 1%, which indicates that the spatial regression model is a good solution to the spatial dependence of haze pollution, in the meanwhile, there is also a spatial spillover effect on haze pollution. On behalf of statistical sense, the aqi in the surrounding area will increase by 1%, and the aqi value in the region will increase by 0.8%, if other conditions are certain, which reflects the characteristics of “cities are closely interrelated to each other. As can be seen from figure.1, there is a clear pattern of regional agglomeration in the haze pollution’s distribution in the cities along "the belt and road" in china. The area of high concentration of haze is mainly located in the northern region and the area of the economic belt of the silk road, especially in Xinjiang. However, the low-concentration areas exist in the eastern coastal area, including the maritime silk road economic belt. The existing documents have also illustrated this point. Therefore, it is imperative to strengthen the coordination and defense mechanism of air pollution. Only when all cities along “the belt and road” make joint efforts can effectively control the haze pollution.

According to the results of the spatial lagged model, the per capita gdp coefficient is positive relevant under the significance level of 5%, which indicates that with the increase of economy, haze pollution is becoming more and more serious compared with the past. The consequence is the same as majority of researches, which shows that the development model of the cities along “the belt and road” is still a crude production model based on resource consumption, which ignores environmental protection to some extent.

Given that the factor of population, the population density coefficient indicates negative influence at the significance level of 10%, which means that the aqi index was lower in the regions with higher population density. For insurance, first-tier and second-tier cities like Shanghai, guangzhou, shenzhen and xiamen have lager population density, however the aqi is lower than 50. on the contrary, in cities like jiuquan and bayannur, the population density are less than 30 people per square kilometers, but the average annual aqi index is 90 and even above. On the other side, it is also very closely related to the conversion of the major conflicts in society. The more developed areas of the economy, the higher the density of the population, the stronger the desire for the good life, the more likely to develop awareness of the environment.

In terms of traffic factors, the coefficient of car ownership is positively affected by the significance level of 1%. One of the major causes of severe smog pollution in some cities in the united states is the rapid increase in motor vehicles in 1950s. According to the result of the spatial lagged model, every 1% increase in the number of civilian car ownership will increase the aqi by 0.04 percent if other factors stay still, at the same time, the rapid growth of urban car ownership in china "the belt and road" is also a big challenge to air quality.
From the point of urban green rate, the coefficient of green rate of the construction area is still not significant, which indicates that the urban greening construction is not enough, which has a great relationship with the green quantity of the city and the lack of green space area. In the meanwhile, it is also pointed that the urban greening level is not a significant decontamination factor to air pollution.

In terms of foreign investment factors, this paper is corresponded with the results of zhang ming’s research and other studies. The foreign direct investment coefficient is negatively affected by the significance level of 5%, indicating that most of the foreign investors in the cities along “the belt and road” in china are technology-intensive enterprises. Besides, the enterprises in the city have a technological spillover effect and the demonstration effect, and the enterprises are generally green, which has reduced the pollution of the air totally. What is more, it has been proved that the “pollution shelter hypothesis” doesn't exist in the urban areas along "the belt and road" in china.

In view of the urbanization level, the coefficient of urbanization is negatively affected by the significance level of 5%, and in case of other conditions, the rate of urbanization is increased by 1% and the aqi is reduced by 0.021%. With the increase of urbanization rate, the rural population is heavily concentrated in the cities, which are generally the population of this kind restricted by knowledge and skills, and can only be employed in some simple tasks, such as construction, manufacturing and other energy-intensive industries, which aggravated the haze pollution to some extent. With the aggravation of haze pollution, the government and the public have to pay more attention to environmental issues, together with public voice being more concerned with the problem of haze pollution. At the same time, capital and labor-intensive enterprises also turn the development direction of the company into another aspect, transforming into low-energy, technology-intensive industries. As a consequence, the increase of urbanization rate will bring a large number of people into low-energy, low-pollution service industries, and air pollution will decrease in total.

From the point of geographical location, geographical location of regression coefficients under the level of 1% showed a positive influence. As can be seen from figure 1, the air quality in the northern cities is always worse than the southern air quality throughout the year. Besides, there have been studies that have shown that burning crops and fossil fuels[28], especially coal, would produce a lot of pm2.5 emissions, so the high - high concentration pattern would typically appear in northern cities. On the other hand, the southern terrain is mostly plain while the northern mountains are more prone to forming blocks and forming clusters. Tianshan and kunlun-mountains form a barrier in the xinjiang region, and the mining activities of the two regions are frequent, which is also a reason why the high-high model appears in xinjiang area.

Table 2. The estimation results of regression model.

<table>
<thead>
<tr>
<th>explanatory variable</th>
<th>OLS</th>
<th>SLM</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Std.Error</td>
<td>Coefficient</td>
</tr>
<tr>
<td>α</td>
<td>2.102 3</td>
<td>0.4076</td>
<td>2.887 9</td>
</tr>
<tr>
<td>lnβ/α</td>
<td>0.862 0</td>
<td>0.099 2</td>
<td>0.973 9</td>
</tr>
<tr>
<td>lnpopap</td>
<td>0.076 7</td>
<td>0.035 7</td>
<td>0.062 6</td>
</tr>
<tr>
<td>lnlnpopen</td>
<td>0.030 9</td>
<td>0.016 3</td>
<td>-0.004 3</td>
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<td>—</td>
<td>93.231***</td>
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<tr>
<td>LagrangeMultiplier(err)</td>
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<td>—</td>
<td>Likelihood 93.231***</td>
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<tr>
<td>Robust LM(lag)</td>
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<td>—</td>
<td>SBC -136.904***</td>
</tr>
<tr>
<td>Robust LM(error)</td>
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<td>—</td>
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</tr>
<tr>
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<td>R² 0.734 7</td>
</tr>
<tr>
<td>R²</td>
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Note: *, **, *** respectively represent 10%, 5%, 1% significance level.
Conclusion

Haze pollution in China has increased in recent years and how to improve air quality has become a concern of the government and the public. Based on the spatial and temporal distribution characteristics of the air quality data of 181 cities along "the belt and road" in China, this paper builds spatial weight based on the gravity model and analyzes social and economic factors that influence the haze pollution in order to provide scientific decision-making basis for improving air quality.

From the perspective of seasonal change, the urban air quality in China's "the belt and road" turned out to be the best in summer, with little haze while the worst air quality turned out to be in winter, and the worst haze pollution appeared in Inner Mongolia. From the perspective of spatial correlation, there is significant positive spatial dependence of haze pollution, the economic belt of the maritime silk-road shows a low - low accumulation mode, while the high - high accumulation mode appears in the inner Mongolia region of the silk road and the provinces like Shanxi and Gansu. From the perspective of spatial regression, there is a significant spatial spillover effect on haze pollution among cities along China's "the belt and road". Both the increase in per capita GDP and the increase in the number of civilian car ownership have a significant positive impact on haze pollution, while the population density, foreign direct investment and urbanization rate have a significant negative impact on haze pollution. Besides, the green rate of urban construction areas has no significant impact on air pollution. On top of that, geographical location is also an important factor affecting haze pollution.

According to these conclusions above, in order to improve the haze condition in the city along "the belt and road" in China, and to adhere to the concept of "green water green mountain is the golden mountain and the silver mountain", the following countermeasures are proposed:

① The city should form a synergistic defense mechanism. Only by working together can we see the blue sky every day. No city can be "unique" in the process of air pollution control.

② Adhere to follow the road of green development, promote the development of low energy consumed industry and carry out the reform of the supply side deeply. At the same time, formulate corresponding policy support in order to help enterprises to carry out green transformation and technology upgrade.

③ Control the growth rate of car ownership, encourage the purchase of small cars and formulate relevant policies to support them so that the government can encourage people to try green and low-carbon travel. In the meanwhile, improve and promote new energy vehicles, together with exhausting gas filter in existing exhaust port in order to reduce the exhaust emission.

④ The government will energetically introduce foreign capital and invest in technology-intensive enterprises. On the other hand, to implement the supply-side reform from another angle, introducing the technological demonstration and relevant technology is a necessity.

⑤ To promote the development of new urbanization and pay more attention to the employment guidance of the population, the government can formulate relevant supportive policies to encourage people relearning, so as to lead more employment to the third industry with a lower carbon footprint.

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