Academic Journal of Business & Management
ISSN 2616-5902 Vol. 5, Issue 25: 28-32, DOI: 10.25236/AJBM.2023.052504

The Impact of Air Quality and Economic Development on Population Mobility: An Empirical Study of 284 Cities in China

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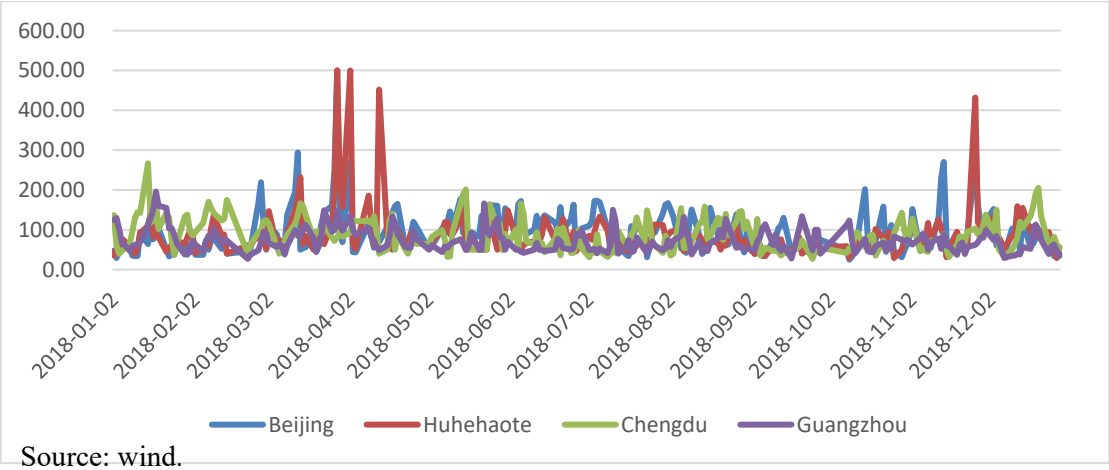
Abstract: *In recent years, China's development is very fast, its GDP maintains increment around 7%. However, behind the rapid economic growth is the inevitable environmental pollution, China has become the largest contribution to greenhouse gas emissions. Meanwhile, there are more and more migrations in China, which could be influenced by air quality and economic development of a city. So in this paper, using 10 years' panel data from 2007 to 2016 of 284 cities, I want to figure out whether air quality or economic development level affects population mobility more. Results show that both air quality and economic development level of the city will affect citizens choosing cities to live and work in. The better air quality and higher economic development level a city has, the more willing people are to come. And their impact effect varies under different circumstances.*

Keywords: *population mobility; air quality; economic development level; random effect*

1. Introduction

In China, we notice so much population mobility, every year in our country will has a famous population moving, which has the biggest scale in the world, called Spring Festival travel rush. As a Chinese, I know deeply that migration from city to city is normal, because people want to have more chances to get jobs or people want to give their family a better live condition, there are so many reasons for people's move. But nowadays, it seems that people will choose migration for more reasons instead of only focus on economic reasons. For example, some seniors living in the north will choose to move to some south city which is not more developed after their retirement. Obviously, these kinds of migrations almost have no relationship with finding job or other economic conditions.

We know that residents have amenity expectations to a city, and environmental conditions are a main part of amenity. For humans, everyone wants to choose a better environmental surrounding to live with instead of living with noise, trash, and bad air quality. And we know that the debates of air quality among cities are getting worse. More and more people begin to care about the air, for it does be harmful to our health. Hence, I choose air quality to be my research item, in order to see whether the air quality could affect humans' migration decision.



Source: wind.

Figure 1: AQI of 4 main cities.

ISSN 2616-5902 Vol. 5, Issue 25: 28-32, DOI: 10.25236/AJBM.2023.052504

Figure 1 is 4 main cities' AQI comparison. Beijing and Huhehaote are 2 northern cities while Chengdu and Guangzhou are 2 southern cities. We can see that the northern cities' air qualities are worse than the southern ones, at least among the 4 cities, this is true. We can infer that the air quality in north is worse than south generally, which can explain that why more northern people search air quality correlated things.

Actually, this is where I am interested in. Because in our Chinese tradition, people hate to leave a place where they have lived long. So in China, the reason for most migrations are working, as mentioned before. In the general thoughts, only when people want to get a better job or give their family a better economic condition, they will choose to move. But in reality, things are different because people are more and more likely to take the amenity to much consideration.

2. Literature review

Actually, there are so many researches about population mobility, most of them are about the relationship of economic and the migration, especially the migration's influence to the economic development. According to Lei and Jiao (2023)[1], the more a city's population gathers, the higher its development level will be. Meanwhile, a good economic performance will further aggravate the population gathering, that is, people will migrate from other places, resulting in an increasing population in developed cities. Due to this, we can infer that Chinese people prefer to migrating to east cities whose development is better.

In addition to the most intuitive factors of urban development, population mobility is also affected by other factors of urban development, such as policy factors. The research of Shen and Wang(2019)[2] focused on the impact of policy to population migrating. Focusing on the Beijing-Tianjin-Hebei region, they analyzed the impact of population flow scale and permanent population on the economic growth of the region from the perspective of the interaction between population flow and economic growth, and found that the population flow in the region was more affected by the hukou policy and the size of permanent population had an important impact on the benign development of regional economy. This also shows from another Angle that population flow will not only be affected by the level of local economic development, but also affect the level of economic development from other aspects.

As for researches about air quality, Grossman & Krueger (1994)[3] have pointed out that the main reason for urban air pollution is the population number and city's scale, and the emission of urban traffic waste gas and the combustion of fuels have a serious bad impact on the air quality. Huang and Wang(2008)[4] found that the environment can bring the economic growth of the tertiary industry, but also restrict its normal development, and environmental conditions become an important factor affecting economic development. Besides, the air pollution will effect not only the economic but people's mobility. According to Zhang et al.(2021)[5], the negative effects of air pollution can reduce people's favorable opinion of a city, which in turn affects their likelihood of moving to settle there. In addition, different groups have different responses to PM2.5 concentration. Through research, they found that for every 1 unit increase in PM2.5, people's willingness to migrate to the city will decrease by about 10%.

Apart from these, there are other reasons for people's migration, like seasonal changes[6], and this is the features of China. Due to various festivals, people often move between cities for a variety of reasons. However, although there have been a lot of studies on air pollution, population flow and economic development separately, there are few literatures that study them together. This is what I am interested in, aiming to explore whether the main reason affecting population flow in China is the city's environmental condition or the city's economic development level.

3. Data

In this paper, I collect 10 years' data from 2007 to 2016 of prefecture-level cities listed in CSMAR, including population, environmental data, GDP and other economic data. Before doing regression, I do some preprocessing using Excel. Because in some years, some cities' data are incomplete. For example, there is only one year's data for Haikou and Sanya. The situations like this are normal, so if there is some missing of years to a city's data, I will drop the city out. And finally I only reserve 284 cities whose data is complete from 2007 to 2016.

Additionally, it is so hard to get the 284 cities' AQI or some parallel index, it seems that as long as the data refers to environment, it will be difficult to get unless the professional researcher, let alone getting 284 cities' daily data. So I make some adjustment. On the one hand, I choose some related indexes

ISSN 2616-5902 Vol. 5, Issue 25: 28-32, DOI: 10.25236/AJBM.2023.052504

from CSMAR to measure the air quality, which are industrial waste gas and industrial waste smoke dust. Industrial pollution data they are, they do can measure a city's air quality. Because for the air pollution, the main polluter is industry. And some pollution indexes are very correlated to the data I choose. For example, PM2.5 is so close to industrial waste smoke dust, and both of can cause visibility reduction and respiratory disease.

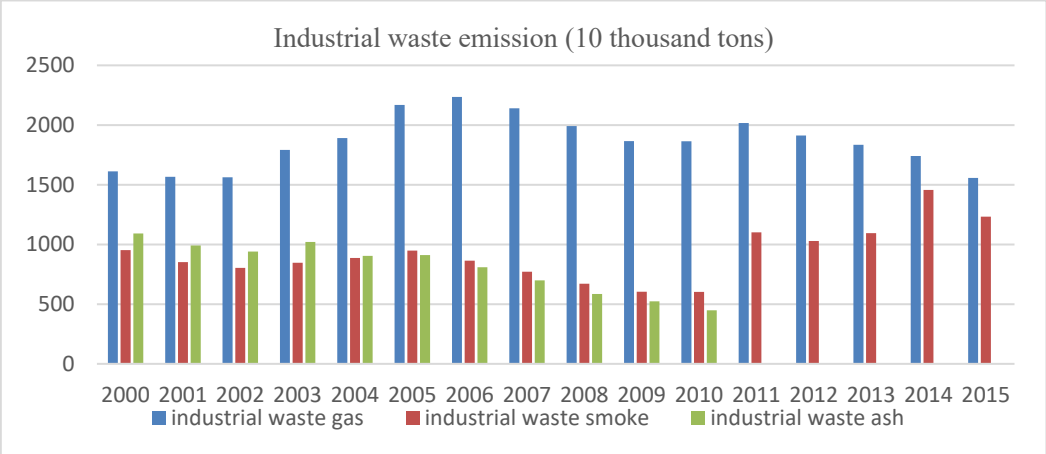


Figure 2: Industrial waste emission (10 thousand tons).

On the other hand, the reason why these data are reasonable is because people who are considering migration will must consider a city's industrial pollution, it is even a common knowledge that industry is the main murder of pleasant air quality. And from figure 2 we can see that the industrial waste emission

4. Model

4.1 Variables

In this paper, I will focus on the population mobility, namely the migration rate of a city. The mobility data is not directly collected, it is calculated by a city's population at the end of a year, the population at the end of last year and the natural population growth rate of last year. The formula is:

$$\boldsymbol{R_{i,t}} = \frac{\boldsymbol{P_{i,t} - P_{i,t-1} - P_{i,t-1} \times r_{i,t-1}}}{\boldsymbol{P_{i,t}}} \times \mathbf{100}\% \quad (1)$$

$\boldsymbol{R}$ denotes the population mobility rate, $\boldsymbol{P}$ denotes the population at the end of one year, $\boldsymbol{r}$ denotes the natural population growth rate of one year, $\boldsymbol{i}$ denotes one of the 284 cities and $\boldsymbol{t}$ denotes the one year between 2007 and 2016. When calculating the population mobility rate of 2007, it needs data from 2006. And after calculation, we get the mobility rate, and it is the explained variable.

The main explaining variables are divided two parts, one is about the air quality and another is the economic development level. For the air quality data, I make some adjustments which have been mentioned in the last section. In order to measure the change, I take the natural logarithm to both waste gas and waste smoke dust. As for the economic development index, I choose each years' GDP as the measurement. Considering the different size of cities, I use GDP divided by population to get the GDP per capital. Similarly, for observing the change effect to population mobility, I take natural logarithm for it.

Also I choose 3 control variables. The first is the proportion of the tertiary industry in GDP. The higher the level of service industry in GDP, the more job opportunities and better services can be provided. The second is the number of employees working in cities and towns. More employees means a better chance of finding a job. The third is the average salary of employees. The higher the average salary, the better the living conditions of residents. The corresponding data has been logarithmically processed

4.2 Regression model

The main model is as following:

$$\boldsymbol{R_{i,t} = \beta_0 + \beta_1 Gas_{i,t} + \beta_2 Smoke_{i,t} + \beta_3 GDP_{i,t} + \beta_4 Ter_{i,t} + \beta_5 Sta_{i,t} + \beta_6 Wage_{i,t} + \varepsilon} \quad (2)$$

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The meaning of each variable has been talked about in the last part, before doing the regression in STATA, the panel data needs to be unit root tested, for avoiding using unstable data. Hence, I test all the 7 variables with LLV method (Levin-Lin-Chu), and the testing results show as Figure 3.

Variables	*Unadjusted t*	*Adjusted t**	*p-value*
$R_{i,t}$	-51.1252	-24.1321	0.0000
$Gas_{i,t}$	-37.4246	-13.1238	0.0000
$Smoke_{i,t}$	-50.2543	-21.9577	0.0000
$GDP_{i,t}$	-15.2944	-4.1657	0.0000
$Ter_{i,t}$	-40.0392	-28.2716	0.0000
$Sta_{i,t}$	-27.4709	-19.7626	0.0000
$Wage_{i,t}$	-31.1234	-15.3402	0.0000

Figure 3: LLV unit root test.

We notice that under this kind of circumstance every variable's p is smaller than 0.01, which shows that the variables are very stable. Therefore, all the data are useable to run the regression.

And, in the next section, I will both use random effect and fixed effect to see the regression result, for the further discussion, I will talk about it in the last part.

5. Results analysis

After putting all the data into STATA, I get the results in Figure 4.

Variables	*re*	*fe*
$Gas_{i,t}$	0.1063 (0.116)	-2.001* (0.054)
$Smoke_{i,t}$	-0.1300** (0.043)	0.0338 (0.711)
$GDP_{i,t}$	0.2223** (0.024)	-1.9805*** (0.000)
$Ter_{i,t}$	-0.0429 (0.858)	-2.3838*** (0.000)
$Sta_{i,t}$	0.2251*** (0.007)	1.0836*** (0.000)
$Wage_{i,t}$	-0.6416*** (0.000)	0.7116** (0.027)
$\_cons$	0.9364 (0.301)	11.4145*** (0.000)

*Figure 4: Regression result. *** means the coefficient is significant at 1% level, ** means the coefficient is significant at 5% level and * means the coefficient is significant at 10% level.*

We can see that under different effect, the coefficients are different and the significances are also different. The influence of most items to the population mobility are totally reverse, like GDP per capital, number of staffs and the average wage.

If we considering random effect of the variables, the waste smoke, GDP per capital, number staffs and average wage have significant influence to the population mobility, while the waste gas and the proportion of tertiary industry don't have significant effect to the migration. Take the waste smoke for example, -0.13 means that if the city's industrial waste smoke discharge increase 1 percent, then the city's population mobility decrease 0.13 percent, namely for individuals, the willing for them to come to this city will reduce 0.13. Actually, the influence of the waste smoke is much smaller than the economic items. And this can explain why although Beijing's air quality is not better than Kunming, there are still so many people, especially those who are eager to find a good job and those who graduate from the college for a short time, pouring into Beijing instead of Kunming. Only in big cities can they have large possibility to achieve their goals, the cost is burdening the bad air quality, whose effect can be offset by the convenience bringing by better economic. Moreover, the effect of the average wage is negative, which means the higher wage of a city has, the less willing people have to come. It's hard to explain because in our normal thinking, people are willing to go to cities whose wages are high. One reason I guess is that higher average wage means higher price level, but for those who move to a new city, the higher price

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level can totally be troublesome, because they may not find a high wage job at once. Then they may take the average wage, more detailed, the price level, into consideration.

When we take a look at the fixed effect of these variables, things become different. In general, the effect of all the variables increase, and the effect of some variables are totally different from the effect under random effect circumstance. For example, the GDP per capital's effect is negative to population mobility. And noticing that the effect of average wage is negative under random effect circumstance, which is hard to explain, but for fix effect, its effect is positive. If we take a look at the economic indicators together, we can see that people will choose a development city if there is a high wage job for them. And people will consider much careful about the air quality. Because they will consider the gas instead of smoke, namely they even consider their breath instead of the pollution which they can see like haze. The reason why this result occurs might be the choice of cities, namely I don't get all the cities' data of China, only those cities listed on CSMAR. Theas cities are in prefecture-level instead of top level, and many of them are so obscure that nearly no one would choose to move in. So when I take my sample as a whole to identify all the China to verify the fixed effect, there must be some unreasonable results.

6. Conclusion

In this paper, I choose 284 cities to see the effect of air quality and economic development level to the population mobility. I run the regression under 2 kinds of effect, random effect and fixed effect. Results show that no matter under what circumstance, both air quality and economic development level have impact on the migration rate. But connecting with the real word, I think the fixed effect can't reflect what the true correlation is.

With random effect, the regression result shows that the impacts of waste gas and GDP proportion of the tertiary industry are not significant. The remaining variables' impacts are significant. For more pollution to the air, the fewer people would come; better integral economy a city has, more people would come. But the average wage's impact is negative, I think this can be explained that the higher average wage, the higher price level. People who arrives in a city may not find a job with high wage, under this condition, high price level does be a burden which should be considered seriously.

In a nutshell, both air quality and economy of a city will influence residents' willing to migrate. From the coefficients of the regression results, economic impact is stronger than the air quality, it means that people's damaged amenity causing by bad air quality can be compensated with convenient transportation, complete infrastructure and potential promotion, namely high economic development level.

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