

Article

How Does Air Pollution Impact Residence Intention of Rural Migrants? Empirical Evidence from the CMDS

Chuanwang Zhang  and Guangsheng Zhang *

Business School, Liaoning University, Shenyang 110136, China; 4022210067@smail.lnu.edu.cn

* Correspondence: gshzhang@lnu.edu.cn

Abstract: Based on data from the China Migrant Dynamic Survey project and urban statistics, this article examines the impact of air pollution on the residence intentions of rural migrants. The research findings indicate that: (1) Air pollution reduces the residence intentions of rural migrants. On average, for every one-unit increase in AQI, the residence intention of rural migrants will reduce by 1.51%. (2) Mechanism analysis shows that social networks and social integration have a negative moderating effect on the relationship between air pollution and the residence intention of rural migrants. (3) Heterogeneity analysis shows that in cities north of the Qinling Mountains-Huaihe River, cities with low precipitation, and cities with weak environmental regulations, the negative impact of air pollution on residence intention of rural migrants is more significant. Compared with high human capital levels, inter-provincial flow, and the new generation of rural migrants, the residence intention of low human capital levels, intra-provincial flow, and the old generation of rural migrants makes them more vulnerable to the negative impact of air pollution. This article reveals the inherent relationship between air pollution and the residence intention of rural migrants, which has certain practical enlightenment for cities to accelerate the process of citizenization of rural migrants through air pollution control and also provides important empirical evidence for cities to sustainably address air pollution.

Keywords: air pollution; rural migrants; residence intention; social networks; social integration



Citation: Zhang, C.; Zhang, G. How Does Air Pollution Impact Residence Intention of Rural Migrants? Empirical Evidence from the CMDS. *Sustainability* **2024**, *16*, 5784. <https://doi.org/10.3390/su16135784>

Academic Editor: Colin Michael Hall

Received: 21 May 2024

Revised: 4 July 2024

Accepted: 4 July 2024

Published: 7 July 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Advancing people-centered new urbanization is of great significance for promoting regional coordinated development and achieving socialist modernization. Since the reform and opening-up, many rural populations in China have poured into cities, forming a huge group of rural migrants. According to the “2022 Rural Migrants Monitoring Survey Report”, the total number of rural migrants in China in 2022 was 295 million, of whom 132 million lived in cities at the end of the year, accounting for about 45% of the total number of rural migrants. As the main force in the construction of new urbanization, the demographic dividend created by rural migrants has supported China’s economic growth in the past 40 years [1]. However, the existence of the urban-rural dual household registration system has made it difficult for a considerable number of rural migrants to truly integrate into cities, and they are forced to carry out seasonal migration between urban and rural regions, which not only seriously restricts the improvement of urbanization quality but also may produce a new dual structure of urban and rural [2] and even hinder the healthy development of China’s economy and society.

The report of the 20th National Congress of the Communist Party of China clearly stated that “Advancing people-centered new urbanization and accelerating citizenization of rural migrants”. Citizenization of rural migrants is not only a key measure to realize the new urbanization, but also a solid foundation to promote rural migrants to take root in the city and drive the healthy development of the economy and society. Therefore, how to improve the residence intentions of rural migrants and accelerate citizenization has

become the focus of academic attention. The existing literature generally believes that the household registration system is the primary factor impacting the residence intentions of rural migrants [3]. In the 1950s, to prevent excessive concentration of urban populations and ensure rational allocation of urban resources, China implemented a strict urban population management system. However, this system excluded the most vulnerable rural migrants in cities from the urban basic public service system [4], further widening the income gap between urban and rural regions, and household registration discrimination occurred from time to time. Over the years, China has further promoted the reform of the household registration system, the policy of household registration migration has been fully relaxed, and the restrictions on urban settlement have been basically lifted. As a result, the negative impact of this system on residence intention of rural migrants has gradually weakened.

In addition to the household registration system, the existing literature has also examined the impact of demographic characteristics (e.g., age and level of education) [5], family characteristics (e.g., family size and family migration) [6], and economic factors (e.g., residential costs and income) [7] on the residence intention of rural migrants. However, as China's new urbanization officially enters the "second half", the income and living standards of rural migrants are gradually improving, and the role of urban environmental factors in impacting the residence intentions of rural migrants is becoming more prominent. Relevant research shows that the higher the quality of the urban environment, the greater the attraction to rural migrants and the stronger the residence intention of rural migrants [8]. As an important component of environmental factors [9], air pollution may also have an important impact on the residence intentions of rural migrants.

In recent years, air pollution has become a global issue [10], seriously endangering the physical and mental health of the labor force. According to the "World Air Quality Report" released by the Swiss air quality platform IQAir, only 7 out of 134 countries and regions meet the PM_{2.5} standard in the World Health Organization (WHO) air quality guidelines. As one of the most significant environmental issues globally, air pollution has a profound impact on human health and productive activities. On the one hand, air pollution severely endangers people's physical and mental health and shortens their life expectancy. WHO points out that 99% of the global population breathes unhealthy air. Air pollution causes approximately 7 million premature deaths each year and leads to health damage for millions of people. Among them, the highest proportion of premature deaths due to air pollution occurs in low- and middle-income countries, accounting for 91%. Data from the WHO show that air pollutants inhaled by people can lead to damage to the lungs, heart, and brain, and increase the probability of cancer, stroke, and heart and brain diseases. On the other hand, air pollution can reduce people's labor time and productivity. Severe air pollution causes people to face higher health costs when they go out to work [11] and increases their anxiety, depression, and other negative emotions, resulting in self-selection behaviors such as reducing labor supply time or "not working hard" to avoid the health shocks caused by air pollution.

So, how does air pollution impact the residence intentions of rural migrants? Unfortunately, the academic community has paid relatively little attention to this issue. Although some research has shown that air pollution can reduce the residence intentions of migrants [12], due to the particularity of household registration and the behavior of rural migrants, the existing research conclusions on the impact of air pollution on the residence intention of migrants may not be extrapolated to rural migrants. In fact, for rural migrants, who make up more than 70% of total migrants, their health literacy is relatively low and their health awareness is generally poor [13], making them more vulnerable to the negative impact of air pollution. Therefore, how to improve the living environment of cities and enhance the residence intentions of rural migrants has become an important issue worth exploring. In summary, using data from the China Migrant Dynamic Survey project and urban statistics, this article takes rural migrants as the research object and systematically examines the impact of air pollution on the residence intentions of rural migrants.

The possible marginal contributions of this article are as follows. Firstly, this article promotes the discussion of air pollution in the field of population migration research. The existing literature mainly takes migrants as the research object and examines the impact of air pollution on the residence intentions of migrants [14]. This article mainly focuses on the group of rural migrants and explores how air pollution impacts the residence intentions of rural migrants, which not only enriches the relevant research on the citizenization of rural migrants but also strengthens the cognition of the causes of population migration. Secondly, this article reveals the internal mechanisms of air pollution impacting the residence intentions of rural migrants. Different from the research paradigm of air pollution–health–residence intention [15], this article finds that strong social networks and deep social integration can alleviate the adverse impact of air pollution on the residence intention of rural migrants, helping to deepen the understanding of the mechanism by which air pollution impacts the residence intention of rural migrants. Thirdly, based on differences in the characteristics of cities and rural migrants, this article analyzes the heterogeneity of urban geographical location, precipitation, environmental regulation, as well as the age, flow domain, and human capital levels of rural migrants, which provides references for cities to accelerate the process of citizenization of rural migrants through environmental governance.

Figure 1 shows the research path of this article. Based on Figure 1, the remaining sections of this article are organized as follows: Sections 2 and 3 provide the literature review and theoretical analysis, Section 4 introduces data processing and methodology, Section 5 discusses empirical results, and Section 6 summarizes the research conclusions and proposes policy suggestions.

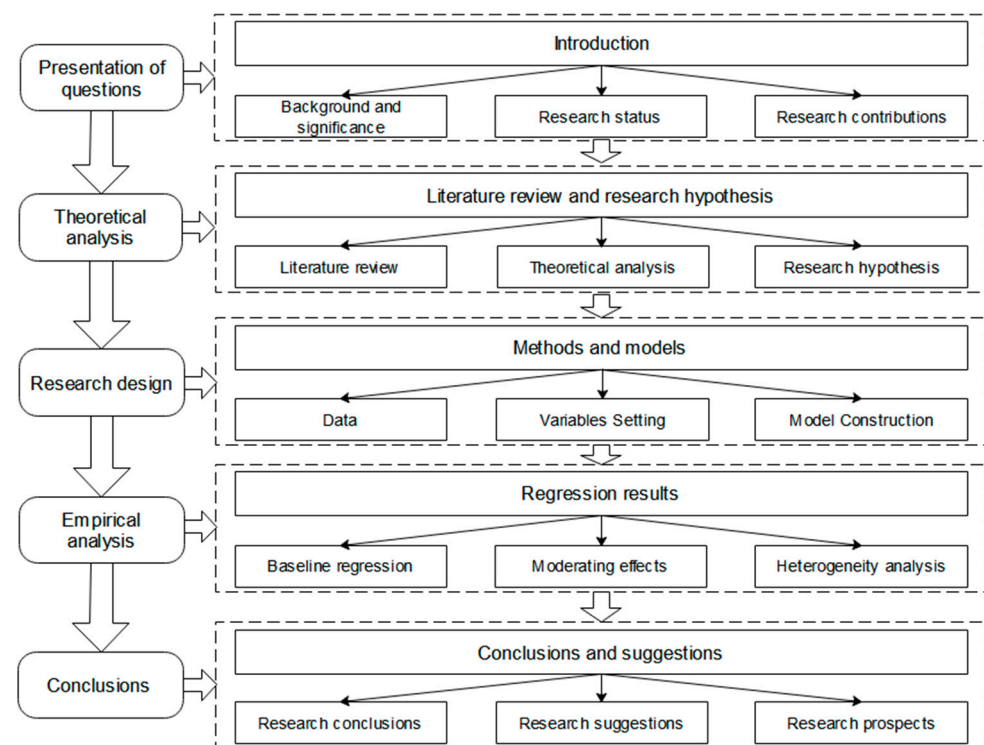


Figure 1. Research path.

2. Literature Review

From the existing literature, there is relatively little research examining the relationship between air pollution and residence intention, but the impact of air pollution can be indirectly explored from the perspective of population mobility. After the 19th century, extensive industrialization development and further acceleration of urbanization in industrially developed countries directly led to the concentrated outbreak of air pollution. The

typical events include the 1930 Mas Valley smog event in Belgium, the 1943 Los Angeles photochemical smog event in the United States, and the 1952 London smog event in the United Kingdom. As a result, environmental factors such as air pollution began to gradually become important factors impacting population mobility. Based on the push-pull theory, Wolpert (1966) [16] proposed a pressure threshold model to research the environmental factors that impact migration decisions and believed that harmful environmental factors would increase people's psychological pressure, thereby impacting migration behavior. Based on Wolpert (1966), Speare (1974) [17] constructed a pressure threshold-residential mobility model, which further emphasized the important role of environmental factors such as air pollution in migration decisions. Kahn (2000) [18] used ozone data from the suburbs of Los Angeles from 1980 to 1994 to show that good air quality can significantly stimulate people's migration tendencies, thereby promoting significant population growth. Similarly, Zhang and Guldmann (2010) [19] surveyed urban population changes in the Cincinnati metropolitan region from 1980 to 2000. Their research indicated that air quality is a determining factor in household location choices; the better the air quality in the region, the stronger the intention of people to migrate there.

In addition to research focused on the United States, research on the impact of air pollution on population mobility has also extended to other countries. Vuong et al. (2022) explored the impacting factors of urban residents' migration based on air pollution data from Hanoi, Vietnam. The results showed that residents' satisfaction with air quality is significantly negatively correlated with their intention to migrate to other cities [20]. Germani et al. (2023) conducted an empirical test using air pollution emission data from Italian provinces and found that air pollution negatively impacts the net migration rate of the population. This indicates that air pollution is an important factor causing population migration [21]. With the increasingly serious issue of air pollution, Chinese scholars have also gradually focused on how air pollution impacts population mobility. Relevant research is mainly carried out at the macro-urban level and the micro-individual level. At the macro-urban level, Cao et al. [22] found that air pollution can negatively impact the net migration rate of the urban population by using the urban panel data of 2000, 2005, 2010, and 2015. At the same time, this impact is becoming more and more obvious with the development of the social economy. At the micro-individual level, based on the 2013 China General Social Survey data, Zhang (2021) [23] indicated that air pollution increased the probability of labor force migration. This conclusion was also confirmed by Guo et al. (2022) [24]. Their results showed that if PM_{2.5} in the city increased by one unit, the probability of labor migration would increase by 1%.

In terms of the impact mechanism of air pollution on population mobility, most research has shown that the most direct impact mechanism is the damage to the health of the labor force. WHO announced ten major threats to global health in 2019, among which air pollution was considered the greatest health threat. Air pollution can directly impact the lungs and heart, leading to a significant increase in the prevalence of cardiovascular diseases, respiratory infections, lung infections, and other diseases [15]. In addition, air pollution can also impact sleep quality, which may lead to sleep disruption in severe cases. The research of Heyes and Zhu (2019) [25] showed that for every 1% increase in air pollution, the probability of insomnia will increase by 11.6%. Zanolibetti et al. (2010) [26] used PM₁₀ data from seven cities in the United States and found air pollution is significantly positively correlated with sleep apnea. With the deepening of research, scholars have found that the damage of air pollution to labor force health not only stays at the physiological level but also impacts the psychological level of the labor force. Relevant research confirms that air pollution reduces the life satisfaction of the labor force and increases their perception of mental health risks [27]. The decrease in life satisfaction and the perception of risk are likely to cause various chronic mental illnesses among labor force [28], and even elevate the risk of suicide, thereby increasing the probability of labor force migration.

The above literature mainly examined the adverse impact of air pollution on population mobility or labor force migration behavior. However, population mobility typi-

cally refers to short-term spatial changes, while residence intention, especially long-term residence intention, reflects whether people are willing to live permanently or semi-permanently in the destination. Compared with short-term mobility, the factors considered by people when choosing long-term settlements are more complex. In recent years, some scholars have attempted to examine the relationship between air pollution and residence intention. Liu and Yu (2020) [12] conducted an empirical test using the data from the 2016 China Labor Dynamics Survey. The results showed that air pollution significantly inhibited the residence intentions of migrants, and the elderly and less educated migrants were more sensitive to air pollution. Xu et al. (2022) [14] pointed out that air pollution reduced the job and life satisfaction of migrants, thereby exerting an adverse impact on residence intention.

Overall, although the existing literature has indicated that air pollution can impact migration decisions in the labor force and has also expanded the discussion on the consequences of air pollution, there are still the following shortcomings. Firstly, most existing research is based on the assumption of labor force homogeneity. The research object is only for migrants, and little research has explored how air pollution impacts the residence intentions of rural migrants. Secondly, the impact mechanism mostly focuses on the impact of labor force health and fails to clarify the specific complex mechanism of air pollution impacting the residence intentions of rural migrants from the perspective of social capital. This article focuses on the current research gap, takes rural migrants as the research object, and examines the potential impact of air pollution on the residence intentions of rural migrants, as well as the moderating effects of social networks and social integration. On the one hand, this article can compensate for the shortcomings of the existing literature and enrich the relevant research on the citizenization of rural migrants. On the other hand, this article provides practical significance for the continuous improvement of urban air quality and the treatment of the negative effects of air pollution.

3. Theoretical Analysis and Research Hypotheses

3.1. Direct Effects

Firstly, air pollution can aggravate the health risks for rural migrants and increase their health expenditures, thereby reducing their residence intentions. On the one hand, particulate pollutants in the air can enter the lungs, causing diseases such as asthma, pneumonia, and bronchitis. In addition, gases like ozone and nitrogen oxides in air pollution can stimulate the nervous system, leading to symptoms such as headaches and a lack of concentration. On the other hand, air pollution can have a more adverse impact on other family members of the labor force, such as infants, pregnant women, and the elderly. Pregnant women who are exposed to air pollution can increase the risk of miscarriage, depression, and abnormal birth weight in babies [29]. Air pollution can also accelerate osteoporosis and the onset of cognitive disorders such as Alzheimer's disease [30], seriously compromising the physical health of the elderly. The above diseases not only require medication or hospitalization but may also require long-term rehabilitation care, which increases the medical and healthcare expenditure of rural migrants. At the same time, severe air pollution forces rural migrants to purchase daily protective equipment such as anti-smog masks and air purifiers, further increasing their health costs.

Secondly, air pollution can reduce labor supply time for rural migrants, thereby reducing their residence intentions. On the one hand, the human capital theory suggests that the human capital stock of rural migrants is mainly composed of health, knowledge, and skills. Therefore, the health risks brought about by air pollution may damage the human capital stock of the labor force and decrease its work input, thereby reducing labor supply time for rural migrants. Fan and Grainger (2023) [31] indicated that for every $1 \mu\text{g}/\text{m}^3$ increase in air pollution, the weekly labor supply time of the labor force will decrease by 0.2 h. In contrast, Hanna and Oliva (2015) [32] found that closing a large oil refinery to improve air quality can increase the weekly work hours of the nearby labor force by 1.3 h. On the other hand, air pollution not only seriously damages the health of rural migrants themselves, but also increases the time they spend caring for the sick elderly and

children in the family [28], further reducing the labor supply time. For example, Kim et al. (2017) [33] used forest fires in Indonesia in the autumn of 1997 as a natural experiment and found that air pollution reduced the labor supply time of the labor force, and caring for children is one of the important influencing factors. Based on this, this article proposes a research hypothesis.

Hypothesis 1: *Air pollution can significantly reduce the residence intentions of rural migrants.*

3.2. Moderating Effects

3.2.1. Social Networks

Social networks refer to relatively stable social relationships formed by individuals through interactions within complex social systems. The establishment of social networks not only helps individuals increase social capital and access more material resources, but also helps individuals form a relationship system of mutual trust and mutual dependence within the networks [34], thereby impacting their social behaviors. For rural migrants, establishing strong social networks in the city can generate strong information effects and psychological support effects [35], thereby alleviating the adverse impact of air pollution on their residence intentions.

On the one hand, social networks can play an informational role, helping rural migrants access relevant information about urban air quality so that they can take timely protective measures to reduce the adverse impacts of air pollution on their health. At the same time, social networks can alleviate the information asymmetry in the job market, increase the employment development opportunities of rural migrants, and enhance their adaptability in the city, thereby enhancing their residence intention. On the other hand, social networks can have a psychological support effect, providing emotional support for rural migrants. Rural migrants may face marginalization in the city, resulting in a sense of loneliness and relative deprivation [36]. With the dual burden of increasingly serious air pollution and relatively low subjective social status, rural migrants may leave the city. In contrast, strong social networks are conducive for rural migrants to enhance their understanding of urban environmental quality, lifestyle, and cultural customs, which can effectively improve their subjective perception of urban life and enhance their accumulation of human capital in the city, thereby weakening the impact of air pollution on their residence intention. In summary, this article proposes a research hypothesis.

Hypothesis 2: *Social networks negatively moderate the relationship between air pollution and residence intention of rural migrants.*

3.2.2. Social Integration

In a narrow sense, social integration refers to the degree of integration at the social level, involving the individual's living environment and work experience at the destination, which is a relatively complex and dynamic process. In a broad sense, social integration is a comprehensive concept that includes economic, psychological, and cultural integration. Among them, psychological integration is not only an important manifestation of social integration but also an important guarantee for the realization of citizenization of rural migrants. According to the new labor migration economics and push-pull theory, the migration decisions of rural migrants are determined by both push factors and pull factors. Among them, push factors usually include urban air quality deterioration and concerns about their health [37]. While pull factors mainly include higher employment income and urban identity. The existing literature shows that, compared with employment income, urban identity can further weaken the push effect of air quality deterioration, thereby exerting an important impact on the migration decisions of rural migrants [38].

The above reasons are as follows. Firstly, the improvement of urban identity can narrow the psychological distance between rural migrants and the locals, change the

marginalized status of rural migrants in urban life, and enhance rural migrants' trust in the city and urban culture, thereby promoting the comprehensive integration of rural migrants into urban society. Secondly, the higher the urban identity of rural migrants, the stronger their sense of social participation, they are also more likely to participate in urban environmental governance activities such as "urban air action plans" and "establishing environmentally friendly city". By providing suggestions for improving urban air quality, rural migrants can not only indirectly improve urban air pollution, but also directly enhance their sense of ownership, thereby increasing their residence intention. Therefore, this article proposes a research hypothesis.

Hypothesis 3: *Social Integration negatively moderates the relationship between air pollution and residence intention of rural migrants.*

4. Methods and Models

4.1. Data

The air pollution data in this article come from real-time national air quality monitoring data released by the Ministry of Ecology and Environment of China. The urban statistical data and meteorological data are sourced from the "China Urban Statistical Yearbook" and the MERRA-2 dataset released by NASA. Among them, the "China Urban Statistical Yearbook" is a dataset that can comprehensively reflect the development of Chinese cities, including relevant statistical data such as urban social and economic development and urban construction. MERRA-2 is a dataset used for analyzing long-term time series. It covers various meteorological data such as temperature, precipitation, wind speed, air pressure, and so on.

The relevant data on rural migrants mainly comes from the data of the 2017 China Migrant Dynamic Survey project (CMDs). The CMDs is a sample survey of migrants carried out by China in May every year. The CMDs examines the individual characteristics, family characteristics, basic public services employment, and expenditure of migrants. The survey participants of the CMDs are migrants who are over 15 years old, have resided at the destination for more than one month, and have no destination household registration. Since the research object of this article is rural migrants, this article only retains samples with a household registration nature of "Agriculture", and the reasons for migration are "Work", "Business", and "Family relocation".

4.2. Variables Setting

4.2.1. Dependent Variable

Residence intention (Intent). Drawing on most of the existing literature [39], this article uses the expected residence time of rural migrants in the destination to measure residence intention. The longer the expected residence time, the stronger the residence intention of rural migrants. Specifically, this article measures residence intention based on the responses of survey participants in the 2017 CMDs to questions Q314 "Do you plan to continue to reside at the destination for some time to come?" and Q315 "If you plan to reside at the destination, how long do you expect to reside?". If survey participants choose "Yes" in Q314 and choose "6–10 years", "More than 10 years", or "Settling down" in Q315, this article considers that they have residence intention and assigns a value of 1. If survey participants choose "No" or "Not sure" in Q314 or choose "1–2 years", "3–5 years", or "Not sure", this article considers that they have no residence intention and assigns a value of 0. In addition, to reduce the measurement error of the variable and ensure the robustness of the research results, this article re-measures residence intention based on whether survey participants choose to settle at the destination for the robustness test.

4.2.2. Independent Variable

Air pollution (AQI). Most existing research mainly uses PM_{2.5}, PM₁₀, and other suspended particles, industrial sulfur dioxide emissions, and soot emissions to measure

air pollution. A little research uses the air pollution index (API) as a proxy variable for air pollution. However, API only contains SO_2 , NO_2 , CO , O_3 , and other pollutants, and does not include the major pollutant $\text{PM}_{2.5}$ in the air. In addition, the single indicator makes it difficult to fully reflect the degree of air pollution in cities due to a lack of comprehensiveness. Based on this, this article refers to the research of Xu et al. (2022) [14] and Heyes and Zhu (2019) [25] and uses the air quality index (AQI) from the Ministry of Ecology and Environment of China to measure air pollution in cities. AQI is primarily composed of six atmospheric pollutants: $\text{PM}_{2.5}$, PM_{10} , SO_2 , NO_2 , CO , and O_3 . It is not only the most direct air quality indicator, apart from subjective perception, but also a scientific basis for measuring urban air quality. China's Ambient Air Quality Standards classify AQI into six levels: Excellent (0–50), good (51–100), light pollution (101–150), moderate pollution (151–200), heavy pollution (201–300), and severe pollution (above 300). The higher the AQI, the worse the air quality of cities and the more severe the impact on health. Since the AQI released by the Ministry of Ecology and Environment of China is daily data, this article uses the arithmetic average method to calculate the annual average air quality index of each city as a proxy variable for air pollution.

From Figure 2, it can be seen that there are obvious differences in air quality among cities. Air quality in northern cities, especially in North China, is relatively worse, while air quality in southern cities, particularly in the southwest areas, is comparatively better. The possible reasons for the above are that air quality in North China is not only limited by the natural conditions of low surface wind speed, high relative humidity, and poor atmospheric diffusion conditions, but also closely related to the industrialization process in North China. On the one hand, as an important industrial base in China, a large number of industrial pollution sources and coal combustion in North China have aggravated air pollution. On the other hand, the population distribution in North China is relatively dense, while population agglomeration is often an important reason for serious air pollution. In contrast, the climate conditions in the southwest areas are favorable, with a sparser population and fewer heavy industrial enterprises. Therefore, air quality in the southwest areas is generally better.

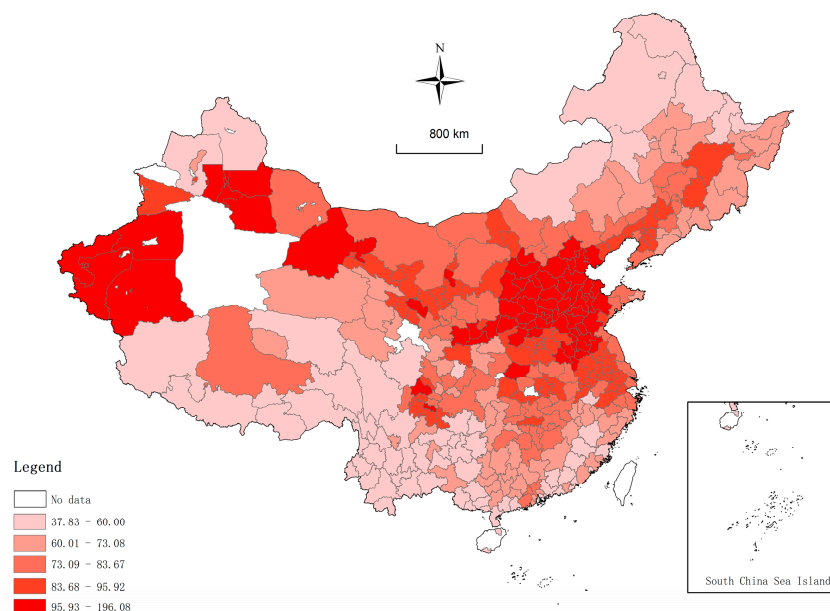


Figure 2. Spatial distribution of AQI in China in 2017.

4.2.3. Instrumental Variable

Accurately estimating the impact of air pollution on the residence intentions of rural migrants requires considering two important issues. The first issue is reverse causality. Air pollution can have an adverse impact on the health status and labor supply of rural

migrants, thereby reducing their residence intentions. Meanwhile, the increase in residence intentions of rural migrants may lead to a large-scale agglomeration of urban populations, exacerbating issues such as urban traffic congestion and industrial emissions, consequently leading to air pollution. The second problem is the omitted variables. Although this article controls the impact of relevant characteristics of rural migrants and urban characteristics in the model, it may still face endogenous issues due to unobservable omitted variables. To alleviate the above potential endogenous issues, this article draws on the ideas of Hering and Poncet (2014) [40] and Fishman and Svensson (2007) [41] and selects the air circulation coefficient (ACC) and the average value of air pollution in other cities in the same province (Demean) as the instrumental variables.

The air circulation coefficient is defined as the product of wind speed and mixing height. Wind speed determines the horizontal diffusion of pollution, and mixing height determines the height of pollutant diffusion in the atmosphere [40]. Therefore, the construction of the air circulation coefficient in this article is as follows:

$$ACC_c = WS_c \times MH_c \quad (1)$$

where c represents cities, ACC represents the air circulation coefficient, WS represents wind speed at the height of 10 m in the city, and MH represents mixing height. The greater the air circulation coefficient, the stronger the air flow, making it difficult for air pollutants to accumulate, thereby improving air quality. Therefore, the air circulation coefficient is related to urban air pollution, which meets the correlation requirement of the instrumental variable. At the same time, the air circulation coefficient is calculated based on wind speed and mixing height. Both wind speed and mixing height depend on complex meteorological systems and geographical conditions and generally cannot directly impact the economic activities of cities or the individual behavior of rural migrants. This meets the exogenous requirements of the instrumental variables.

The average value of air pollution in other cities in the same province: this means calculating the arithmetic average of air pollution in all other cities in the same province, excluding the local city. On the one hand, the geographical location of cities in the same province is relatively close, and the degree of air pollution in other cities will inevitably impact the air pollution of the local city, meeting the endogenous hypothesis of the instrumental variables. On the other hand, there is no evidence to suggest that air pollution in other cities can impact the residence intentions of rural migrants in the local city, meeting the exogenous hypothesis of the instrumental variables.

4.2.4. Control Variables

Taking into account the potential impact of other factors on the robustness of the empirical results, this article introduces a series of control variables, including individual and family characteristics of rural migrants as well as urban characteristics. Individual characteristics of rural migrants include age (Age), gender (Gen), nation (Nat), marital status (Mar), education levels (Edu), political affiliation (Pol), and health status (Hea). Family characteristics of rural migrants include the number of family members (Fam) and the total monthly family income (Inc). Urban characteristics include economic development levels (Pgdp) and temperature inversion days (Tem).

According to Table 1, 46.25% of rural migrants in the sample of this article have residence intention, indicating that their residence intention in cities is relatively low. The average age of rural migrants is about 36 years old, males accounted for 53.61%, Han Chinese accounted for 92.26%, and married people accounted for 82.73%. The average education level of rural migrants is generally low, with the majority having a junior high school or lower education, and the average monthly family income is 5986 yuan. The mean AQI is 84.0925, with a standard deviation of 18.8678, further indicating significant differences in air pollution levels between cities. In addition, there is also a significant difference in economic development levels and temperature inversion days between cities.

Table 1. Descriptive statistical results.

Variables	Meaning	Mean	Std. Dev.	Min	Max
Intent	Residence intention	0.4625	0.4986	0.0000	1.0000
AQI	Air quality index	84.0925	18.8678	37.8333	133.9167
ACC	88,424	7.1096	0.3849	5.7235	8.1137
Age	Age	35.9120	10.1422	15.0000	96.0000
Gen	Gender	0.5361	0.4987	0.0000	1.0000
Nat	Nation	0.9226	0.2672	0.0000	1.0000
Mar	Marital status	0.8273	0.3780	0.0000	1.0000
Edu	Education levels	3.3153	1.0285	1.0000	7.0000
Pol	Political affiliation	0.0936	0.2913	0.0000	1.0000
Hea	Health status	0.9786	0.1447	0.0000	1.0000
Fam	Number of family members	3.1843	1.1259	1.0000	10.0000
Inc	the total monthly family income	8.6972	0.5734	3.9120	12.2061
Pgdp	Economic development levels	11.2047	0.8698	7.7757	12.2234
Tem	Temperature inversion days	180.6856	72.6392	9.0000	327.0000

4.3. Model Construction

4.3.1. Baseline Model

The research content of this article is the impact of air pollution on the residence intentions of rural migrants. Since residence intention is a binary discrete variable, using OLS regression may lead to the estimated coefficient being biased. Therefore, this article refers to the research of Guo et al. (2024) [42] and Xu et al. (2022) [14] and chooses the Probit model for regression analysis. The Probit model is more suitable for analyzing binary classification issues. It establishes a regression model where the random variable follows the standard normal distribution to predict the values of a binary discrete variable. In recent years, the Probit model has gained high recognition in the academic community and has been widely applied in research in economics, social sciences, and other fields. The baseline model set in this article is as follows:

$$Intent_i = \alpha_0 + \alpha_1 AQI_c + \alpha_2 Controls + \gamma_c + \varepsilon_i \quad (2)$$

where i represents rural migrants, c represents cities, $Intent$ represents the residence intention of rural migrants, AQI represents the urban air quality index, $Controls$ represent the set of all control variables, γ represents regional fixed effects, ε represents the random disturbance term. α_1 is the regression coefficient of primary concern in this article.

4.3.2. Moderating Effect Model

To investigate the moderating effects of social networks and social integration, this article draws on the research of Subramaniam et al. (2023) [43] and constructs the following moderating effect model:

$$Intent_i = \beta_0 + \beta_1 AQI_c + \beta_2 AQI \times M_i + M_i + \beta_3 Controls + \gamma_c + \varepsilon_i \quad (3)$$

where M_i is the moderating variables, which represent social networks (Net) and social integration (Int), respectively, and the meaning of the remaining variables is consistent with the Model (2).

5. Empirical Analysis

5.1. Baseline Results

Table 2 shows the impact of air pollution on the residence intentions of rural migrants. Column (1) only controls the regional fixed effect. Columns (2) to (4) are the regression

results of sequentially adding control variables, including relevant characteristics of rural migrants, as well as urban characteristics. The above results show that no matter whether the control variables are added or the fixed effect is controlled, the regression coefficient of air pollution is significantly positive at the level of 1%, indicating that air pollution can significantly reduce the residence intention of rural migrants. According to Column (4), the regression coefficient of AQI is -0.0151 , which is significant at the level of 1%. On average, for every 1% increase in AQI, the residence intention of rural migrants will significantly decrease by 1.51%. For example, we assume that the AQI of a city is 84, but due to the increase in existing industrial pollution emissions, its AQI rises to 101, which is in the range of mild pollution. According to the regression results of this article, the residence intention of rural migrants in this city will reduce by 25.67%. In addition, we further compare the research results of this article with other literature that researches the impacting factors of rural migrants' residence intention. Zhu (2023) [13] indicated that for every 1% increase in urban public services, the residence intention of rural migrants will increase by 0.51%. Liu et al. [44] found that the implementation of free compulsory education can increase rural migrants' residence intention by 0.24%. It can be seen that, compared with other factors that impact the residence intention of rural migrants, air pollution has a more severe impact on residence intention.

Table 2. Baseline regression results.

Variables	(1)	(2)	(3)	(4)
AQI	-0.0124^{***} (-3.5336)	-0.0129^{***} (-3.6265)	-0.0142^{***} (-3.9955)	-0.0151^{***} (-4.1961)
Age		0.0099^{***} (18.8430)	0.0118^{***} (22.1552)	0.0118^{***} (22.1553)
Gen		-0.0256^{***} (-2.8695)	-0.0345^{***} (-3.8537)	-0.0346^{***} (-3.8540)
Nat		-0.0525^{***} (-2.9436)	-0.0728^{***} (-4.0622)	-0.0728^{***} (-4.0629)
Mar		0.4070^{***} (30.7079)	0.2783^{***} (20.1174)	0.2783^{***} (20.1175)
Edu		0.2053^{***} (40.5800)	0.1789^{***} (34.7992)	0.1789^{***} (34.7985)
Pol		0.0295^{*} (1.7956)	0.0381^{**} (2.3101)	0.0381^{**} (2.3099)
Hea		-0.1696^{***} (-5.4455)	-0.2478^{***} (-7.9355)	-0.2478^{***} (-7.9356)
Fam			-0.0018 (-0.4075)	-0.0017 (-0.3985)
Inc			0.2999^{***} (33.9556)	0.2999^{***} (33.9557)
Pgdp				-0.0018 (-0.2100)
Tem				-0.0057^{***} (-11.0763)
Cons	1.1946^{***} (3.3505)	0.0271 (0.0750)	-2.2632^{***} (-6.1235)	-0.6637 (-1.4248)
FE	Yes	Yes	Yes	Yes
Obs	88,424	88,424	88,424	88,424
R ²	0.0559	0.0798	0.0893	0.0893

Note: *, **, *** are significant at the 10%, 5%, and 1% levels, respectively, and the robust standard error values are in parentheses.

In control variables, age, marital status, education levels, and total monthly family income of rural migrants remain consistent with the existing literature, which are also important factors in impacting the residence intention of rural migrants. With the increase in age and residence time, rural migrants gradually adapted to the urban lifestyle, and their sense of dependence on the city gradually increased. Meanwhile, the establishment

of the family significantly enhances the sense of family responsibility of rural migrants. To create a stable and comfortable living environment for their families, rural migrants are more willing to reside in the city. The improvement of education levels can enhance the employment ability of rural migrants, which is conducive to rural migrants obtaining broad employment opportunities and stable working income, thereby enhancing their residence intention. To some extent, family income represents the total resources available for distribution within the family [45]. A higher family income can cover the various costs of living for rural migrants in the city, reduce related pressures of surviving in the city, and consequently promote residence intention of rural migrants.

5.2. Robustness Test

5.2.1. Endogenous Treatment

To alleviate the potential endogenous issues such as reverse causality and omitted variables, this article uses the air circulation coefficient and the average value of air pollution in other cities in the same province as the instrumental variables for air pollution. The first-stage regression model for the instrumental variables is constructed as follows:

$$AQI_c = \lambda_0 + \lambda_1 IV_c + \lambda_2 controls + \gamma_c + \varepsilon_i \quad (4)$$

where IV_c is the instrumental variable, which represents the air circulation coefficient and the average value of air pollution in other cities in the same province, respectively. The meaning of the remaining variables is the same as the Model (2). Columns (1) and (2) of Table 3 present the test results using the air circulation coefficient as an instrumental variable. In the first stage, the Wald F-statistic is 6034.70, which is much higher than the critical value of 16.38 at the 10% level, indicating that there is no weak instrumental variable issue. The Anderson LM test results show that there is no unidentified issue with the instrumental variable. These results indicate that the selection of the instrumental variable is effective. From the regression results of the first stage, it can be found that the regression coefficient of the air circulation coefficient is -0.0086 and is significant at the level of 1%, indicating that the stronger the air circulation, the better the air quality. This is consistent with the expectations of this article. The results of the second stage show that the regression coefficient of AQI is -0.0079 , which is also highly significant at the level of 1%, further demonstrating that air pollution can significantly reduce the residence intention of rural migrants.

Column (3) and Column (4) of Table 3 are the estimation results of the average value of air pollution in other cities in the same province as an instrumental variable. The Wald F-statistic in the first stage is still much higher than the critical value of the 10% level, and the Anderson LM statistic is significant at the level of 1%, confirming the effectiveness of the instrumental variable selection. The regression coefficient of the instrumental variable is significantly positive at the level of 1%, indicating that air pollution in other cities in the same province can indeed impact the local city. At the same time, the regression coefficient of AQI in the second stage is also significantly positive. The above results indicate that after introducing the instrumental variables to alleviate endogenous issues, the research conclusion of this article is still valid.

Table 3. Endogenous treatment.

Variables	(1) First Stage	(2) Second Stage	(3) First Stage	(4) Second Stage
AQI		−0.0079 *** (−18.5909)		−0.0028 *** (−13.2173)
ACC	− 0.0086 *** (−77.6833)			
Demean			0.7293 *** (170.2100)	
Cons	44.1399 *** (40.6123)	−0.1214 *** (−2.9572)	26.3261 *** (26.8192)	−0.3591 *** (−9.8805)
Controls	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes
Wald F Statistic	6034.70		28971.46	
Anderson canon.corr. LM statistic	369.89 ***		176.49 ***	
N	88,424	88,424	88,424	88,424
R ²		0.4563		0.4857

Note: *** is significant at the 1% levels and the robust standard error values are in parentheses.

5.2.2. Replace Independent Variable

Since CMDS is a sample survey organized by China in May each year, this article adopts the approach of Liu and Yu (2020) [12] and replaces the annual average of AQI with the monthly average of AQI in April to ensure that rural migrants have experienced the air quality environment for at least one month at the destination. According to Column (1) of Table 4, the regression coefficient of AQI has not changed substantially compared with the baseline regression results. In addition, the AQI is a comprehensive index that includes six pollutants, such as PM2.5, PM10, etc. Using AQI to measure urban air pollution may not fully reflect the impact of different pollutants on the residence intentions of rural migrants. Therefore, this article replaces AQI with six pollutants, including PM2.5 and PM10, and substitutes them into Model (2) for re-estimation. The specific results are shown in columns (2) to (7) of Table 4. It can be seen that, except for SO₂, the regression coefficients of other pollutants are significantly negative at the level of 1%, which once again confirms the robustness of the baseline regression results.

Table 4. Robustness test results of replacing independent variable.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
AQI	−0.0136 *** (−4.1961)						
PM2.5		−0.0206 *** (−4.1961)					
PM10			−0.0322 *** (−4.1961)				
CO				−23.3854 *** (−4.1961)			
NO ₂					−0.0207 *** (−4.1961)		
O ₃						−0.1429 *** (−4.1961)	
SO ₂							0.6020 *** (4.1961)
Cons	−2.4182 *** (−15.3590)	−0.6435 (−1.3680)	1.8730 * (1.7752)	47.7633 *** (3.9866)	−1.3382 *** (−4.1952)	2.3567 ** (2.0156)	−15.9579 *** (−4.9718)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4. Cont.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	88,424	88,424	88,424	88,424	88,424	88,424	88,424
R ²	0.0893	0.0893	0.0893	0.0893	0.0893	0.0893	0.0893

Note: *, **, *** are significant at the 10%, 5%, and 1% levels, respectively, and the robust standard error values are in parentheses.

5.2.3. Replace Dependent Variable

In terms of the measurement of the dependent variable, this article considers rural migrants who are expected to reside at the destination for more than 5 years as having residence intention, which may have measurement errors. Therefore, this article further measures residence intention based on whether rural migrants choose to settle at the destination. If they choose to settle, they are considered to have a residence intention and assigned a value of 1; if they choose otherwise, they are considered to have no residence intention and assigned a value of 0. Column (1) of Table 5 shows the robustness test results for replacing the dependent variable. The regression coefficient of AQI is -0.0195 and is significant at the level of 1%. This result is highly consistent with the baseline regression results, indicating that after replacing the measurement method of the dependent variable, the baseline regression results remain robust.

Table 5. Robustness test results of replacing independent variable and replacing regression model.

Variables	(1) Replace Dependent Variable	(3) Logic	(4) OLS
AQI	-0.0195^{***} (-5.4560)	-0.0247^{***} (-4.2045)	-0.0058^{***} (-4.3357)
Cons	0.1716 (0.3682)	-1.1271 (-1.4852)	0.3261 * (1.8827)
Controls	Yes	Yes	Yes
FE	Yes	Yes	Yes
Obs	88,394	88,424	88,424
R ²	0.1082	0.0894	0.1154

Note: *, ***, are significant at the 10% and 1% levels, respectively, and the robust standard error values are in parentheses.

5.2.4. Replace Regression Model

Since the residence intention of rural migrants in this article is a binary variable, the Logit model is also applicable to binary discrete variables. Therefore, this article further uses the Logit model to re-regression Model (2). The results in Column (2) of Table 5 show that the regression coefficient of AQI is -0.0247 , which is highly significant at the level of 1%. Meanwhile, this article also replaces the Probit model with the OLS model commonly used in most research. The regression results in Column (3) of Table 5 indicate that, compared with the baseline regression results, the regression coefficient of AQI has not changed significantly and remains significant at the level of 1%. These results further confirm the robustness of the inhibitory effect of air pollution on residence intention.

5.3. Moderating Effects Analysis

5.3.1. Social Networks

Social networks are relatively stable social relationships formed among individual members through social interaction. Social interaction is the foundation for the stability and continuity of social networks and can impact individual social behavior. Therefore, to test the moderating effect of social networks, this article refers to the research of Guo et al. (2023) [34] and uses the response to question Q309 “Who do you interact with the

most in your spare time at the destination (excluding customers and relatives)?” in the CMDS survey to measure the strength of social networks among rural migrants. If rural migrants choose any of the following options, they are considered to have strong social networks and assigned a value of 1. These options include: “Fellow townsmen (whose household registration has moved to the destination)”, “Fellow townsmen (whose household registration remains in the original region or has moved to other regions besides the destination)”, “The locals (whose household registration has always been at the destination and has not changed)”, or “The outsiders (whose household registration has not moved to the destination)”. If rural migrants choose the option “Rarely interact with others”, they are considered to have weak social networks and assigned a value of 0.

Column (1) of Table 6 shows the test results of social networks as a moderating variable. We can find that the coefficient of $AQI \times Net$ is 0.0033, which is significantly positive at the level of 1%. This result shows that social networks can significantly mitigate the negative impact of air pollution on the residence intentions of rural migrants; namely, the stronger the social network of rural migrants, the weaker the negative impact of air pollution on their residence intentions. The possible reason is that strong social networks can help rural migrants obtain information about urban environmental conditions and take timely protective measures. It can also alleviate information asymmetry in the job market and increase employment opportunities for rural migrants, thereby helping to alleviate the adverse impact of air pollution on their residence intentions.

Table 6. Regression results of moderating effects.

Variables	(1)	(2)
AQI	−0.0175 *** (−4.8572)	−0.0152 *** (−4.1081)
$AQI \times Net$	0.0033 *** (18.6318)	
Net	0.0519 *** (12.7989)	
$AQI \times Int$		0.0020 ** (1.9805)
Int		−0.1480 (−1.6153)
Cons	−0.7404 (−1.5879)	−0.7393 (−1.5451)
Controls	Yes	Yes
FE	Yes	Yes
Obs	88424	88424
R ²	0.0922	0.0894

Note: **, *** are significant at the 5% and 1% levels, respectively, and the robust standard error values are in parentheses.

5.3.2. Social Integration

Social integration broadly includes economic, psychological, cultural, and educational integration. Psychological integration is not only an important part of social integration, but also a crucial guarantee for rural migrants to settle in cities. Therefore, to test the moderating effect of social integration, this article uses question Q503 “Do you agree with the following statements?” in the CMDS survey to measure the social integration index of rural migrants. These statements include “I would like to be a part of the locals”, “I am concerned about the changes in the destination where I currently reside”, and “My hygiene habits are not significantly different from those of the locals”. Based on the responses of rural migrants, the assignment is as follows: “Strongly disagree” is assigned a value of 1, “Disagree” is assigned a value of 2, “Basically agree” is assigned a value of 3, and “Strongly agree” is assigned a value of 4. At the same time, this paper uses the entropy weight method to determine the weight coefficients of each statement in social integration and calculates the final social integration index of rural migrants. Compared with other

methods, the entropy weight method uses information entropy to measure the degree of each indicator change, avoids the impact of individual subjective factors, and makes the determination of weight more objective and scientific [46].

Column (2) of Table 6 reports the test results of social integration as a moderating variable. The coefficient of $AQI*Int$ is also significantly positive, indicating that social integration can alleviate the adverse impact of air pollution on the residence intentions of rural migrants. In other words, the deeper the social integration of rural migrants, the weaker the negative impact of air pollution on their residence intentions. The possible reason for this result is that deep social integration can improve the marginalized status of rural migrants and enhance their sense of belonging and identity. At the same time, it can also help rural migrants better adapt to urban culture and environments and increase their sense of social participation, thereby strengthening their sense of ownership and reducing the negative impact of air pollution.

5.4. Heterogeneity Analysis

5.4.1. Geographical Location

The Qinling Mountains-Huaihe River divides China into southern and northern cities. Among them, northern cities began to implement the central heating policy in the 1950s, while southern cities did not implement central heating. In recent years, although a few northern cities have gradually implemented measures such as “coal-to-electricity” and “coal-to-gas” to replace coal combustion for heating during the winter heating period, most northern cities still mainly rely on coal combustion for centralized heating. However, incomplete combustion of coal releases a large amount of air pollutants [15], resulting in a significant deterioration of air quality in northern cities. In addition, northern cities have relatively low average temperatures and relatively dry climates, which hinder the dispersion of pollutants and further aggravate air pollution.

Therefore, to accurately grasp the different impacts of air pollution in different cities on the residence intentions of rural migrants, this article takes the Qinling Mountains-Huaihe River boundary as the geographical division standard and divides the sample into southern and northern cities. Figure 3a presents the grouping regression results for geographical location. In the figure of heterogeneity analysis results, the solid line represents the confidence interval, and the solid circle on the solid line represents the size of the regression coefficient of AQI. If the solid line is completely located on the left or right side of the dashed line, it indicates that the regression coefficient is significantly negative or significantly positive. If the solid line crosses the dashed line, it indicates that the regression coefficient is not significant. According to Figure 3a, it can be seen that air pollution significantly reduces the residence intentions of rural migrants in northern cities but has no significant impact on southern cities. The above results show that rural migrants in northern cities will reduce their residence intentions due to serious air pollution.

5.4.2. Precipitation

Urban precipitation can also impact the diffusion of pollutants, resulting in a significant gap in air quality between cities. In general, the more precipitation in the city, the more water vapor in the air. More water vapor helps to adsorb particulate materials, thereby reducing pollutant concentrations and improving air quality [47]. Therefore, this article divides the samples into a high precipitation group and a low precipitation group according to the median of urban precipitation.

The results of Figure 3b show that the regression coefficient of AQI in cities with low precipitation is significantly negative, while the regression coefficient of AQI in cities with high precipitation is significantly positive. This indicates that in cities with low precipitation, rural migrants will significantly reduce their residence intention due to air pollution, while in cities with high precipitation, rural migrants will not reduce their residence intention due to air pollution. On the contrary, the possibility of rural migrants choosing long-term residence may increase.

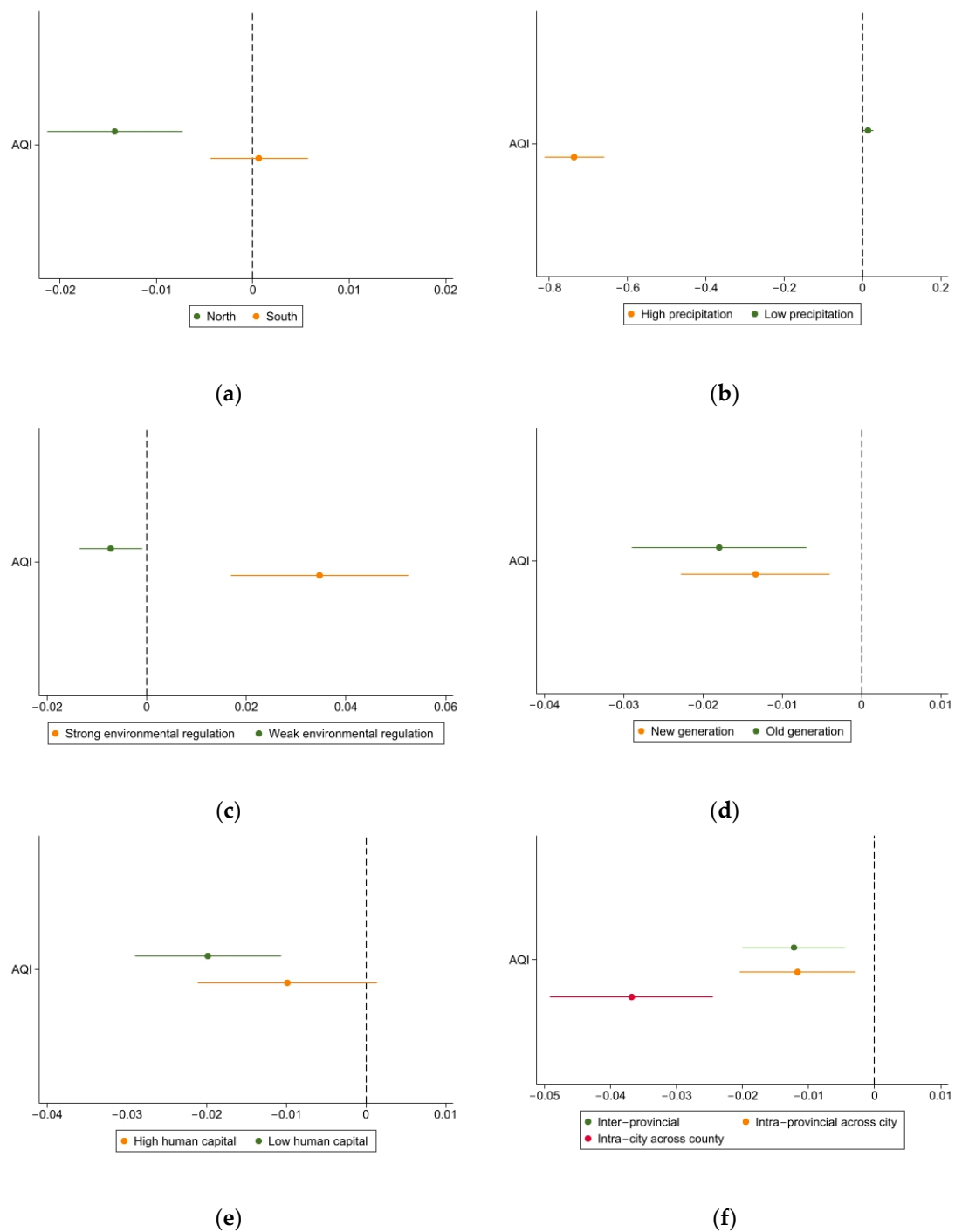


Figure 3. Heterogeneity analysis. (a) Geographical location; (b) Precipitation; (c) Environmental regulation; (d) Age; (e) Human capital level; (f) Flow domain.

5.4.3. Environmental Regulation

Environmental regulation is a process in which the government supervises environmental protection and resource utilization through laws and regulations. Its purpose is to protect the natural environment and promote sustainable development by implementing environmental protection standards and other measures. In recent years, the academic community has conducted a lot of research on the impact of environmental regulation on air pollution, but research conclusions are not consistent. Some research has shown that strong environmental regulation can reduce pollutant emissions, promote air quality

improvement, and ensure public health and safety [48]. Other research suggests that strict environmental regulation policies not only make it difficult to improve air quality but also increase pollution control costs and reduce production efficiency [49].

Therefore, to examine the role of environmental regulation in the impact of air pollution on the residence intentions of rural migrants, this article uses Python software version 3.9.0 to count the frequency of environmental regulation words such as “blue sky”, “green space”, “environmental protection”, and “clean energy” in the regional government work report. According to the median frequency of regional environmental regulation words, the samples are divided into a strong environmental regulation group and a weak environmental regulation group. Figure 3c illustrates the specific grouping regression test results. The regression coefficient of AQI is significantly negative in cities with weak environmental regulation, but significantly positive in cities with strong environmental regulation. The above results further confirm that strong environmental regulation can improve air quality, thereby enhancing the residence intentions of rural migrants.

5.4.4. Age

With the change in population structure, the migration choices of rural migrants show significant intergenerational differences. Based on the definition of the new generation of rural migrants by the All-China Federation of Trade Unions, this article divides rural migrants born after the 1980s into the new generation of rural migrants, while others are divided into the older generation of rural migrants, thereby examining the age heterogeneity of air pollution impacting the residence intention of rural migrants.

Figure 3d shows the age heterogeneity of air pollution impacting residence intention. Compared with the new generation of rural migrants, the older generation of rural migrants' residence intention makes them more vulnerable to air pollution. The reasons for the above result are that the new generation of rural migrants may place greater emphasis on economic factors such as employment opportunities and employment income, and environmental factors such as air pollution do not play a decisive role in residence intention. As age increases, the health status of the older generation of rural migrants gradually declines, and they are more sensitive to air pollution that impacts health. At the same time, the social networks and urban identity of the older generation of rural migrants are relatively weak, making them more vulnerable to external environmental factors such as air pollution, resulting in a significant decrease in their residence intention.

5.4.5. Human Capital Levels

Human capital levels of rural migrants can also impact the relationship between air pollution and residence intention. The reasons are that rural migrants with low human capital levels are more likely to engage in jobs such as couriers, deliverymen, and construction workers. These jobs require long-term exposure to outdoor environments and have irregular working hours, which not only damage their health but also reduce their working hours. Rural migrants with high human capital levels generally work in better indoor environments or formal work departments, and their working hours are relatively fixed. Therefore, their tolerance for air pollution is relatively high.

In summary, this article chooses education levels as the grouping variable for the human capital levels of rural migrants and divides the high school, technical secondary school, and above into the high human capital group, and the junior high school and below into the low human capital group. Data from the 2017 CMDS survey show that in the low human capital group, the residence intention of rural migrants is 42.55%, significantly lower than 53.37% in high human capital group, which preliminarily confirms the above speculation. The specific grouping regression results for human capital levels are shown in Figure 3e. The regression coefficient of AQI in the low human capital group is significantly negative, while it is negative but not significant in the high human capital group, indicating that rural migrants with lower levels of human capital are more likely to reduce their residence intention due to severe air pollution.

5.4.6. Flow Domain

According to the “Seventh National Census Bulletin of China”, the total number of migrants in China was about 376 million in 2020. Among them, intra-provincial migrants accounted for about 251 million, making up 66.78% of the total migrants, which is much higher than that of the inter-provincial migrants. The above data show that the closest migration is still the main form of population mobility [44]. Compared with intra-provincial migrants, inter-provincial migrants need a longer time to adapt to the new living environment and lifestyle due to the great differences in cultural customs and living habits. This increases the psychological costs of migration and ultimately impacts migration decisions [7].

Therefore, this article speculates that the impact of air pollution on residence intention is more significant for intra-provincial rural migrants. The research conclusions of Liu and Yu also support the above speculation [12]. To verify this speculation, based on the CMDS survey data, this article divides the flow domain of rural migrants into three categories: inter-provincial, intra-provincial across the city, and intra-city across the county. Figure 3f shows the specific regression results. We can find that the regression coefficients of AQI are significantly negative in all samples. However, compared with inter-provincial flow, the absolute value of the regression coefficient of AQI is larger in the intra-provincial flow sample. The above results indicate that as the flow domain narrows, the negative impact of air pollution on the residence intentions of rural migrants is gradually increasing.

6. Conclusions and Suggestions

In recent years, the reasons for the migration decisions of rural migrants have changed significantly. The household registration system and economic factors are no longer the only driving forces behind their migration decisions. The role of urban environmental factors in migration decisions is beginning to be highlighted. Therefore, in the context of increasing environmental awareness among rural migrants, exploring how air quality impacts their residence intention is of significant importance for accelerating citizenization of rural migrants and advancing people-centered new urbanization. Using data from the 2017 China Migrant Dynamic Survey project and urban statistics, this article examines the impact of air pollution on the residence intentions of rural migrants. The conclusions are as follows: Firstly, air pollution reduces the residence intentions of rural migrants. For every one-unit increase in air pollution, residence intention of rural migrants will reduce by 1.51%. Secondly, mechanism analysis shows that social networks and social integration have a negative moderating effect on the relationship between air pollution and the residence intentions of rural migrants; namely, the stronger social networks or the deeper the degree of social integration, the weaker the negative impact of air pollution on the residence intention of rural migrants. Thirdly, heterogeneity analysis finds that air pollution mainly reduces residence intention of rural migrants in cities north of the Qinling Mountains-Huaihe River, cities with low precipitation, and cities with weak environmental regulations. At the same time, compared with high human capital levels, inter-provincial flow, and the new generation of rural migrants, air pollution has a more significant negative impact on the residence intention of low human capital levels, intra-provincial flow, and the older generation of rural migrants. Based on the above conclusions, this article proposes the following suggestions.

- (1) The relevant subjects must adhere to the new development philosophy and continuously improve air quality. Local governments need to understand that air pollution not only damages the health of rural migrants but also runs counter to accelerating the process of new urbanization. Therefore, local governments should abandon the extensive economic development model at the expense of the environment and strive to achieve an effective balance between economic development and environmental protection. Firstly, local governments should improve environmental protection laws and regulations, such as standardizing carbon emissions trading and restricting the exploration of ecologically sensitive areas, to control air pollution comprehensively.

In addition, local governments should strengthen the construction of environmental management institutions, increase supervision and penalties for heavily polluting enterprises, and enhance the implementation capacity of environmental protection policies. Secondly, local governments need to adopt production restriction measures for high-energy consumption and high-pollution industries at the policy level, support and guide the vigorous development of green and low-carbon industries such as new energy and energy conservation and emission reduction industries, and build bridges for economic development and environmental protection. Thirdly, local governments should strengthen the publicity of environmental protection, broaden the publicity channels of environmental protection, utilize television, newspapers, social media, and other platforms to popularize environmental protection knowledge and enhance public awareness of environmental protection.

- (2) Enterprises should face up to the negative impact of air pollution on rural migrants and accelerate the green-oriented transition. Firstly, enterprises should fulfill their primary responsibility for environmental protection, vigorously support the implementation of environmental policies, and actively participate in the pilot construction of national carbon emissions trading. Secondly, enterprises should integrate the concept of green and sustainable development throughout their production processes, adopt clean production methods, use clean energy, and improve energy efficiency, thereby reducing air pollutant emissions and improving the working environment for rural migrants. Thirdly, enterprises should leverage digital technologies such as big data, cloud computing, and artificial intelligence to drive green innovation, further strengthen the adjustment and optimization of their energy structure, and increase their green and low-carbon production levels. Rural migrants need to raise their environmental awareness, actively participate in environmental protection actions, and try to choose low-carbon lifestyles such as green travel and garbage sorting to reduce energy waste and the use of pollution sources. At the same time, rural migrants should practice the concept of green consumption and give preference to green products, thereby contributing their efforts to the continuous improvement of air quality.
- (3) Since the inhibitory effect of air pollution on the residence intentions of rural migrants is more significant in cities north of the Qinling Mountains-Huaihe River, cities with low precipitation, and cities with weak environmental regulations, cities should implement differentiated environmental governance policies and carry out air pollution control actions according to local conditions. Cities north of the Qinling Mountains-Huaihe River should reduce coal burning for heating and increase the proportion of clean energy for heating. At the same time, it is necessary to gradually improve the flexible heating mechanism in winter and adjust the heating time according to the weather conditions to reduce the waste of funds and energy and lower the emission of polluting gases. Cities with low precipitation should accelerate ecological civilization construction and improve the air purification capacity by afforestation and increasing green space. In addition, these regions should strengthen dust control on major transport roads and pay attention to dust management at construction sites, thereby achieving full coverage of dust area supervision. Cities with weak environmental regulation should strengthen air quality monitoring and control and guide enterprises to adopt environmental protection measures to reduce pollutant emissions. In contrast, cities with strong environmental regulation should adopt appropriate regulatory measures based on local development conditions to avoid adverse impacts on production activities caused by a “one-size-fits-all” approach. In addition, rural migrants who are easily impacted by air pollution, especially those with low human capital levels, should actively participate in employment skills training to enhance their human capital levels.
- (4) The results of this article indicate that strong social networks and deep social integration can alleviate the negative impact of air pollution on the residence intentions

of rural migrants. On the one hand, local governments should broaden the social participation channels of rural migrants, encourage rural migrants to join labor unions or other social organizations, and deepen the connection between rural migrants and other urban groups, thereby enhancing the sense of value and belonging of rural migrants in urban life. On the other hand, local governments need to continue deepening the reform of the household registration system, accelerating the development of urban-rural integration, establishing a comprehensive social security system, and achieving the equalization of basic public services. This will allow rural migrants to share the fruits of urban development and promote their genuine integration into urban life.

This article examines the impact of air pollution on the residence intentions of rural migrants. While it has achieved certain results in both theoretical and practical aspects, there are still some limitations. On the one hand, due to the accuracy and availability of data, this article only uses cross-sectional data for empirical analysis and cannot observe the changing trend of individual behavior. Therefore, in future research, it is necessary to find traceable panel data to expand the time range and further verify the conclusions of this article. On the other hand, although different from the existing research, this article finds that social networks and social integration have a negative moderating effect on the relationship between air pollution and residence intention of rural migrants, other potential impacting mechanisms may still exist. Therefore, future research should focus on exploring other mechanisms of air pollution impacting the residence intentions of rural migrants to enrich and improve the research framework on air pollution impacting the residence intentions of rural migrants. This will provide new ideas for cities to sustainably deal with air pollution and enhance the residence intentions of rural migrants.

Author Contributions: Conceptualization, C.Z. and G.Z.; Methodology, C.Z. and G.Z.; Formal analysis, C.Z. and G.Z.; Data curation, C.Z.; Software, C.Z.; Writing—original draft, C.Z. and G.Z.; Writing—review and editing: C.Z. and G.Z.; Funding acquisition, C.Z.; Investigation, C.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This article was funded by the Academic Graduate Research Innovation Program at the Business School of Liaoning University (No. 22GIP002).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this article are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Cai, F. *Understanding Chinese Economics*; China CITIC Press: Beijing, China, 2017.
2. Liu, X.; Han, L.M.; Yuan, B. Does the conversion of household registration actually improve the happiness of migrant workers in China? *Int. J. Environ. Res. Public Health* **2020**, *17*, 2661. [[CrossRef](#)] [[PubMed](#)]
3. Li, P.L.; Wu, Y.F.; Ouyang, H. Effect of hukou Accessibility on Migrants' Long Term Settlement Intention in Destination. *Sustainability* **2022**, *14*, 7209. [[CrossRef](#)]
4. Xie, S.H.; Wang, J.X.; Chen, J.; Ritakallio, V.M. The effect of health on urban-settlement intention of rural-urban migrants in China. *Health Place* **2017**, *47*, 1–11. [[CrossRef](#)] [[PubMed](#)]
5. Li, L.N.; Liu, Y.S. Understanding the gap between de facto and de jure urbanization in China: A perspective from rural migrants' settlement intention. *Popul. Res. Policy Rev.* **2020**, *39*, 311–338. [[CrossRef](#)]
6. Tian, M.; Xu, Q.W. Process and determinisms of settlement intention among China's migrant workers. *Acta Geogr. Sin.* **2023**, *78*, 1376–1391.
7. Shi, Q.H.; Zhou, Y.X. Regional differences and influencing factors of mobile population's long-term settlement. *J. South China Agric. Univ.* **2022**, *21*, 69–84.
8. Liang, X.X.; Li, Q.Y.; Zuo, W.; Wu, R. How does mobility and urban environment affect the migrants' settlement intention? A perspective from the intergenerational differences. *Front. Public Health* **2024**, *12*, 1344400. [[CrossRef](#)] [[PubMed](#)]

9. Zhao, Z.H.; Lao, X.; Gu, H.Y.; Yu, H.C.; Lei, P. How does air pollution affect urban settlement of the floating population in China? New evidence from a push-pull migration analysis. *BMC Public Health* **2021**, *21*, 1–15. [\[CrossRef\]](#)
10. Giannakis, E.; Kushta, J.; Violaris, A.; Paisi, N.; Lelieveld, J. Inter-industry linkages, air pollution and human health in the European Union towards 2030. *Environ. Dev. Sustain.* **2024**. [\[CrossRef\]](#)
11. Zivin, J.G.; Neidell, M. The impact of pollution on worker productivity. *Am. Econ. Rev.* **2012**, *102*, 3652–3673. [\[CrossRef\]](#)
12. Liu, Z.M.; Yu, L. Stay or leave? The role of air pollution in urban migration choices. *Ecol. Econ.* **2020**, *117*, 106780. [\[CrossRef\]](#)
13. Zhu, Z.K. Public health services and migrant workers' willingness to settle in cities: Evidence from China migrants dynamic survey. *China Rural. Econ.* **2021**, *10*, 125–144.
14. Xu, F.; Xie, Y.J.; Zhou, D. Air pollution's impact on the settlement intention of domestic migrants: Evidence from China. *Environ. Impact Assess. Rev.* **2022**, *9*, 1067615. [\[CrossRef\]](#)
15. Li, W.B.; Zhang, K.X. The effects of air pollution on enterprises' productivity: Evidence from Chinese industrial enterprises. *Manag. World* **2019**, *35*, 95–112+119. [\[CrossRef\]](#)
16. Wolpert, J. Migration as an adjustment to environmental stress. *J. Soc. Issues* **1966**, *22*, 92–102. [\[CrossRef\]](#)
17. Speare, A. Residential satisfaction as an intervening variable in residential mobility. *Demography* **1974**, *11*, 173–188. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Kahn, M.E. Smog reduction's impact on California county growth. *J. Reg. Sci.* **2020**, *40*, 565–582. [\[CrossRef\]](#)
19. Zhang, S.M.; Guldmann, J.M. Accessibility, diversity, environmental quality and the dynamics of intra-urban population and employment location. *Growth Chang.* **2010**, *41*, 85–114. [\[CrossRef\]](#)
20. Vuong, Q.H.; Le, T.T.; Khuc, Q.V.; Nguyen, Q.L.; Nguyen, M.H. Escaping from air pollution: Exploring the psychological mechanism behind the emergence of internal migration intention among urban residents. *Int. J. Environ. Res. Public Health* **2022**, *19*, 12233. [\[CrossRef\]](#)
21. Germani, A.R.; Scaramozzino, P.; Castaldo, A. Does air pollution influence internal migration? An empirical investigation on Italian provinces. *Environ. Sci. Policy* **2021**, *120*, 11–20. [\[CrossRef\]](#)
22. Cao, G.Z.; Liu, J.J.; Liu, T. Examining the role of air quality in shaping the landscape of China's internal migration: Phase characteristics, push and pull effects. *Geogr. Res.* **2021**, *40*, 199–212.
23. Zhang, Y. The role of air pollution risk perception in labor migration: The perspective of healthy human capital investment. *Popul. Dev.* **2021**, *27*, 51–64.
24. Guo, Q.B.; Wang, Y.; Zhang, Y. Environmental migration effects of air pollution: Micro-level evidence from China. *Environ. Pollut.* **2022**, *292*, 118263. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Heyes, A.; Zhu, M.Y. Air pollution as a cause of sleeplessness: Social media evidence from a panel of Chinese cities. *J. Environ. Econ. Manag.* **2019**, *98*, 102247. [\[CrossRef\]](#)
26. Zanobetti, A.; Redline, S.; Schwartz, J.; Rosen, D.; Patel, S.; O'Connor, G.T.; Lebowitz, M.; Coull, B.A.; Gold, D.R. Associations of PM10 with sleep and sleep-disordered breathing in adults from Seven US Urban Areas. *Am. J. Respir. Crit. Care Med.* **2010**, *182*, 819–825. [\[CrossRef\]](#) [\[PubMed\]](#)
27. Lu, H.; Yue, A.L.; Chen, H.; Long, R.Y. Could smog pollution lead to the migration of local skilled workers? Evidence from the Jing-Jin-Ji region in China. *Resour. Conserv. Recycl.* **2018**, *130*, 177–187. [\[CrossRef\]](#)
28. Zhao, H.J.; Liu, X.M.; Tao, X.J. The spatial and temporal effect on labor supply time--empirical evidence from China labor force dynamics survey. *Econ. Perspect.* **2021**, *11*, 76–90.
29. Lakshmi, P.V.M.; Viridi, N.K.; Sharma, A.; Tripathy, J.P.; Smith, K.R.; Bates, M.N.; Kumar, R. Household air pollution and stillbirths in India: Analysis of the DLHS-II national survey. *Environ. Res.* **2013**, *121*, 17–22. [\[CrossRef\]](#)
30. Bishop, K.C.; Ketcham, J.D.; Kuminoff, N.V. Hazed and confused: The effect of air pollution on dementia. *Rev. Econ. Stud.* **2022**, *90*, 2188–2214. [\[CrossRef\]](#)
31. Fan, M.X.; Grainger, C. The impact of air pollution on labor supply in China. *Sustainability* **2023**, *15*, 13082. [\[CrossRef\]](#)
32. Hanna, R.; Oliva, P. The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City. *J. Public Econ.* **2015**, *122*, 68–79. [\[CrossRef\]](#)
33. Kim, Y.; Manley, J.; Radoias, V. Medium and long-term consequences of pollution on labor supply: Evidence from Indonesia. *J. Labor. Econ.* **2017**, *6*, 1–15. [\[CrossRef\]](#)
34. Guo, X.X.; Zhou, S.H.; Li, Z.J. Determinants of rural migrants' urbanization: Evidence from the perspective of social network. *Chin. J. Popul. Sci.* **2023**, *37*, 51–66.
35. Xu, M.Y. Human capital, social capital and the urbanization willingness of migrant workers. *J. South China Agric. Univ.* **2018**, *17*, 53–63.
36. Xu, Y.H.; Shi, M. Research on migrant workers' social status and their settlement intention. *J. Soc. Sci. Hunan Norm. Univ.* **2018**, *47*, 83–90. [\[CrossRef\]](#)
37. Lu, H.Y.; Guo, X.L.; Li, C.Z.; Qian, W.R. Social ties and urban settlement intention of rural-to-urban migrants in China: The mediating role of place attachment and the moderating role of spatial pattern. *Cities* **2024**, *145*, 104725. [\[CrossRef\]](#)
38. Liu, Y.Q.; Liu, Y.; Li, Z.G. Settlement intention of new migrants in China's large cities: Patterns and determinants. *Sci. Geogr. Sin.* **2014**, *34*, 780–787. [\[CrossRef\]](#)
39. Wang, Z.; Li, T.C. Impact of accessibility of compulsory education on migrant workers' residency intention. *J. South China Agric. Univ.* **2024**, *23*, 48–62.

40. Hering, L.; Poncet, S. Environmental policy and exports: Evidence from Chinese cities. *J. Environ. Econ. Manag.* **2014**, *68*, 296–318. [[CrossRef](#)]
41. Fisman, R.; Svensson, J. Are corruption and taxation really harmful to growth? Firm level evidence. *J. Dev. Econ.* **2007**, *83*, 63–75. [[CrossRef](#)]
42. Guo, X.X.; Zhong, S.H.; Qiu, Z.Y. Wealth or health? Haze pollution, intergenerational migration experience and settlement intentions of rural migrant workers. *J. Rural Stud.* **2024**, *107*, 103244. [[CrossRef](#)]
43. Subramaniam, Y.; Loganathan, N.; Subramaniam, T. Moderating effect of governance on healthcare and environmental emissions. *J. Environ. Manag.* **2023**, *351*, 119646. [[CrossRef](#)] [[PubMed](#)]
44. Liu, J.F.; Liu, R.M.; Shi, Y. From Semi-urbanization to urbanization: The education promotion mechanism of citizenization of migrant workers in China. *J. Quant. Tech. Econ.* **2023**, *40*, 138–156.
45. Han, J.Q.; Yuan, C.Y. The study of rural floating population's gender preference for their accompanying children. *Youth Stud.* **2023**, *3*, 37–49+95.
46. Li, S.; Ying, Z.X.; Zhang, H.; Ge, G.; Liu, Q.J. Comprehensive assessment of urbanization coordination: A case study of Jiangxi Province, China. *Chin. Geogr. Sci.* **2019**, *29*, 488–502. [[CrossRef](#)]
47. Li, H.B.; Zheng, Q.B.; Li, Z. Industrial intelligence and urban air pollution control in China: Empirical evidence from the application of industrial robots. *Manag. Rev.* **2023**, *35*, 300–311. [[CrossRef](#)]
48. Song, Y.; Yang, T.T.; Li, Z.R.; Zhang, X.; Zhang, M. Research on the direct and indirect effects of environmental regulation on environmental pollution: Empirical evidence from 253 prefecture-level cities in China. *J. Clean. Prod.* **2020**, *269*, 122425. [[CrossRef](#)]
49. Wang, Y.; Shen, N. Environmental regulation and environmental productivity: The case of China. *Renew. Sustain. Energy Rev.* **2016**, *62*, 758–766. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.