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A Review of Research on the Impact of Air Pollution on Residents' Health and Labor Supply

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Abstract: Clarifying the degree of the negative effects of ambient air pollution on residents' health and labor participation and working time, and fully considering health loss caused by air pollution and human capital loss when formulating public policies are the prerequisites and key to controlling air pollution. At present, there are abundant research achievements in the fields of environmental pollution, residents' health, and labor supply in both domestic and foreign academic circles. This article systematically reviews and evaluates relevant research at home and abroad from the perspectives of the impact of air pollution on health and labor supply, aiming to outline the development of existing research and provide prospects for research directions in the field of environmental pollution, in order to lay a foundation for further research on the impact of air pollution on human capital.

Keywords: Air Pollution; Resident Health; Labor Supply; Literature Review.

1. Introduction

With the reform and opening up, China's industrialization and urbanization processes have accelerated. Blindly pursuing high-speed economic growth has led to serious damage to the ecological environment, among which the rapid deterioration of air quality has become the most prominent ecological environment problem. Clinical medicine has shown that cardiovascular and chronic respiratory diseases caused by air pollution can be accompanied by symptoms such as chronic cough, frequent chest tightness, shortness of breath, or difficulty in breathing [1]. Though long-term bed rest is not necessary, the resulting health loss can weaken the productivity of workers and prompt them to reduce their labor supply time. For manual laborers, healthy human capital is a key factor for them to earn rewards through physical labor in the labor market [2].

At present, there are abundant research achievements in the fields of environmental pollution, residents' health, and labor supply in both domestic and foreign academic circles. In terms of research on the impact of residents' health status, social science literature is mainly based on Grossman's health needs theory, taking the perspective of residents' socio-economic factors as the entry point, and deeply analyzing the mechanisms by which factors such as income, education, social capital, and medical insurance affect residents' health. In studying the issue of air pollution harming residents' health, recent research results published both domestically and internationally mainly use the implementation of a certain air pollution prevention and control policy or the occurrence of environmental pollution events as a "quasi natural experiment" to measure the health differences caused by changes in air quality before and after the "quasi natural experiment", in order to evaluate the health benefits brought by policy implementation or the health loss caused by the occurrence of environmental pollution events. Some literature is based on the analysis framework of epidemiology to measure the health loss of residents in areas with severe air pollution. The research on health and labor market performance mainly focuses on analyzing the impact of health shocks on people's labor supply behavior. When exploring the impact of ambient air pollution on labor participation and working time, the focus of the research is on examining the changes in labor productivity or working hours of practitioners in specific heavily polluted areas or industries after being affected by polluted air. This article follows the main line of exploring whether air pollution affects the health human capital of workers and measuring the degree of impact, systematically reviews and evaluates research literature in related fields, and attempts to outline the development of existing research. Based on this, it looks forward to the research direction in the field of environmental pollution.

2. Research on the Impact of Air Pollution on Health

Environmental pollution directly affects the human body and the negative impact on the health of residents in developing countries is much higher than that in developed countries or regions. Among the types of environmental pollution, air pollution has a wider range of hazards and the deepest degree of harm, receiving widespread attention. The academic community has achieved rich research results in the relationship between air pollution and residents' health.

In 1952, a severe smog event broke out in London, UK, resulting in the death of over 4000 people due to a large amount of toxic gases such as smoke, SO2, and CO. This event caused great panic among the local people, and the problem of air pollution received unprecedented attention. The detailed situation of the "London smog incident" proves that short-term high concentration smoke pollution can endanger the safety of residents' lives[3]. On the basis of existing research, some scholars have attempted to use time series and case cross analysis methods to study the impact of short-term high concentration fine particulate pollution on residents' mortality rates. For example, a survey was conducted on the correlation between the mortality rates of lung cancer and cardiovascular related diseases among 1.2 million adults and the fine particulate pollution incident happened in the United States in the year of 1982. It was found that long-term exposure to high concentration fine particulate pollution significantly increased residents'

mortality rates. For every 10ug/m3 increase in fine particulate content in the air, all-cause mortality, cardiovascular mortality, and lung cancer mortality rates increased by 4%, 4%, and 8%, respectively[4].

Due to the long-term accumulation of harmful substances in the air causing damage to residents' bodies, observing short-term damage results may result in significant discrepancies between estimated results and actual situations due to other interfering factors. Some scholars have studied the health loss caused by long-term air pollution exposure based on long-term observational data. If we use data from 545 villages in the United States to study the relationship between the decrease in PM2.5 content in the atmosphere and residents' life expectancy from 2000 to 2007, the results show that for every 10 μ g/m3 decrease in PM2.5 concentration, the average life expectancy of residents increases by 0.35 years[5]. By evaluating the impact of the five major air pollutants on daily mortality rates in 20 major cities in the United States from 1987 to 1994, it was found that PM10 levels were significantly correlated with all-cause mortality, cardiovascular and respiratory system mortality. For every 100 μg/m3 increase in PM10 levels in the air, the mortality rate increased by 0.51%[6]. By studying the correlation between the number of visits, PM10 concentration, and steel plant operations at Utah Valley Hospital in the United States from 1985 to 1988, it was found that when the steel plant was in production during winter, the concentration of PM10 in the air was twice that of when it was not in production, and the visit rate for respiratory diseases in children increased by 1-2 times[7]. In the mid-1990s, scholars began to control smoking and other personal health risk factors, and demonstrated a significant statistical relationship between fine particulate pollution in the air and mortality rates[8]. Based on 16 years of observational data from 8111 adults in six cities in the United States, after adjusting for smoking and other factors that affect physical health, the study showed a significant correlation between mortality and air pollution. The mortality rate of residents in heavily polluted cities was 1.26 times higher than that in lightly polluted cities[9].

Since 1980, numerous air pollution regulation policies have been introduced, resulting in significant improvements in air quality. Some scholars use the implementation of a certain public policy as a "quasi natural experiment" to test the differences in the impact of air quality before and after policy implementation, in order to measure the degree of long-term air pollution exposure on resident mortality.[8]The "quasi natural experimental method" compares the different development results between the experimental group and the controlled group, and the experimental process may be influenced by policies, accidents, rules, or other factors beyond the control of the investigator[10]. The main difference between the "quasi experimental method" and observational research is that the "quasi natural experimental method" aims to identify omitted variables related to human health and the concentration of fine particles in the air, making the estimation results more accurate and closer to the real situation. Many scholars have used the implementation of air governance measures such as the Clean Air Act and the Acid Rain Plan as "quasi natural experiments" to study the correlation between air pollution and resident mortality rates before and after the implementation of the Act. For example, Using the implementation of the "Acid Rain Plan" as a "quasi natural experiment" to improve air quality and measure the impact of long-term exposure to polluted air on local adult mortality rates. The "Acid Rain Plan" has made clear regulations on the sulfur dioxide emission standards for thermal power plants in the United States. The author used the difference in differences (DID) method to compare the mortality rates of residents near and far from environmentally regulated factories and found that after the implementation of the "Acid Rain Plan", the mortality rate in the control group area significantly decreased, and the suspension of fine particles in the air was the main cause of resident mortality[11].

Some scholars have used the economic crisis in the United States from 1981 to 1982 as a "quasi natural experiment" to significantly improve air pollution levels, studying the effect of reducing suspended particulate pollution on infant mortality. The results show that for every 1% decrease in suspended particulate content in the air, the infant mortality rate at the county level will decrease by 0.35%, meaning that the decrease in suspended particulate content caused by the economic depression from 1980 to 1982 reduced the deaths of 2500 infants. Black infant mortality rates are more sensitive to air pollution[12].

Previous research has mainly focused on developed countries, and the pollution level in developing countries is often higher than that in developed countries. The research results of developed countries are not suitable for promotion in developing countries.[11] With the rapid development of developing countries' economies, air pollution has become increasingly severe and has attracted high attention from scholars. For example, using China's winter heating policy (known as the "Huai River Policy") as a "quasi experiment", the distance to the Huai River is selected as the variable for breakpoint regression to identify the causal relationship between air pollution and residents' physical health[13]. The concentration of suspended particles north of the Huai River was found to be 184ug/m3 higher than that south of the Huai River. High concentration pollution caused cardiovascular and cerebrovascular diseases, resulting in a 5.5 year lower life expectancy for residents in the north compared to the south. Generally speaking, in a long-term living environment, for every 100ug/m3 increase in suspended particles in the air, the expected lifespan will decrease by 3 years. Furthermore, individual behaviors such as smoking that cause respiratory diseases were included, and other factors that harm individual health, such as income level, hospital quality, and water pollution, were controlled. The results showed that the "Huai River Policy" led to significant differences in air quality and residents' life expectancy on both sides of the Huai River. The "Huai River Policy" increased the annual average concentration of PM10 in northern cities by 41.7ug/m3 compared to southern cities, and shortened the average life expectancy by 3.1 years[13].

Scholars have also observed the health differences among residents caused by differences in air quality before and after a certain event. For example, using the major forest fires that occurred in Indonesia in 1997 as a quasi natural experiment to estimate the long-term impact of air pollution caused by forest fires on the health of local residents, it was found that long-term exposure to polluted air has a significant negative effect on human health, and the degree of impact varies significantly among different populations. Men and the elderly have a more severe impact, while children have a stronger ability to recover from early air pollution[14]. Based on the strict air emission regulations of the 2008 Beijing Olympic Games as a quasi experiment to measure the impact

of air pollution on the incidence of chronic cardiovascular disease, research has found that increasing air pollution levels will significantly increase the probability of thrombosis and cardiovascular and cerebrovascular health in healthy young people. This discovery has significant implications for clinical medicine[15].

The negative impact caused by air pollution not only affects physiology, but also significantly reduces people's cognitive level. Some scholars have explored the impact of long-term living in air polluted areas on individual cognitive abilities based on China Family Panel Studies (CFPS) data from 2010 and 2014, and found that long-term air pollution exposure significantly reduces the word test scores of respondents, and the impact on men is significantly greater than that on women. The decline in language scores is particularly evident among older and less educated men[16]. Some scholars attempt to explore whether there is a certain correlation between human cognitive level and air pollution by observing the academic performance of Israeli high school students over a long period of time. After controlling the fixed effects of cities, schools and students, they confirmed that PM2.5 and CO had a significant negative relationship with test scores. PM2.5 had a greater impact on groups with a higher incidence rate of asthma, and CO acted on the human nervous system[17]. Air pollution control not only promotes human health, but also helps improve the quality of human capital and make human resource allocation more efficient.

Unlike other types of pollution, air pollution has strong spillover and spreading characteristics. With the circulation of the atmosphere, air pollution in a certain area can quickly spread to neighboring areas, causing damage to the health of residents in surrounding cities. The existing research literature on air pollution and public health does not take spatial spillover effects and externalities of air pollution in the estimation scope, resulting in biased research results. If lung cancer mortality and respiratory disease mortality are selected as dependent variables, and industrial emissions of SO2 and coal smoke are used to indicate the degree of air pollution, the spatial Durbin model (SDM) is used to measure the negative effects of air pollution on public health and its spillover effects in 116 cities in China from 2006 to 2012[18]. Burning every 10000 tons of coal will cause the number of deaths from cancer and respiratory diseases increased by 0.35 ‰ and 0.3 ‰, respectively. In adjacent cities, lung cancer deaths and respiratory disease deaths will increase by 2.17 ‰ and 15.43 ‰, respectively. The above research results consistently indicate a direct correlation between air pollution and the probability of residents falling ill..

Compared with foreign scholars who measure the negative effects of air pollution on human health from large-scale population random sampling, domestic scholars mainly focus on measuring the negative effects of air pollution on human health in some heavily polluted areas, and empirically test the negative effects of air pollution on human health. The main research areas are Beijing-Tianjin-Hebei region, Guangzhou, Beijing, Shanghai and other economically developed and heavily polluted areas[19]. If a semi parametric generalized additive model of time series is used to study the effects of SO2 and NO2 concentrations in the atmosphere of Shanghai on the daily mortality rate of residents, the results show that for every 10ug/m3 increase in SO2 and NO2 concentrations, there is a varying degree of increase in daily total mortality caused by cardiovascular disease and respiratory disease in Shanghai[20]; Based on time series analysis, it has been proven that an increase of one unit in the concentration of major air pollutants in Beijing will lead to increase of the mortality rate of cardiovascular and cerebrovascular diseases among residents in the short term[21]; Based on the birth data of newborns in a district of Shanghai in 2013, using epidemiological principles and controlling for other premature birth factors, it was confirmed that maternal exposure to air pollutants (SO2, NO2, PM10) during pregnancy increases the probability of premature birth in infants[22].

However, due to the presence of solid and gaseous pollutants in air pollutants, they may have a certain interactive effect on the human body. When measuring the effect, it is difficult to determine whether the physical damage is caused by solid pollutants, gaseous pollutants, or a combination of both. From this, it can be seen that there are omitted variables that are not controlled and act together with the main independent variable on the explained variable, resulting in multicollinearity and overestimating the influence of a certain pollutant.

To strip away the interference of other pollutants, some scholars attempt to focus on the pollutants in the air that cause the strongest harm to the body and have the widest range of pollution. According to epidemiological research results, inhalable particles pose the greatest threat to human health among common air pollutants, especially fine particulate matter represented by PM2.5 (the main component of haze)[23]. Fine particulate matter (PM2.5) with a diameter of less than or equal to 2.5 microns can not only enter the respiratory system directly through human respiration, but also carry a large amount of toxic substances such as viruses, heavy metals, polycyclic aromatic hydrocarbons, etc., which directly affect the human body and cause serious diseases[24]. In addition, air pollution has a more severe impact on the respiratory system than other parts of the body in terms of health loss[25].

The large-scale haze pollution incident that erupted in Beijing in January 2013 has caused concern among scholars, and future research will focus on the negative impact of inhalable particulate matter on respiratory diseases. The author used Poisson regression model for empirical testing on the damage and loss caused by short-term high concentration PM2.5 in Beijing from January 10 to 15, 2013. The results showed that short-term high concentration The increase in PM2.5 concentration has had significant adverse effects on the cardiovascular and respiratory health of Beijing residents, further significantly increasing the incidence of premature death, respiratory diseases, cardiovascular diseases, bronchitis, and other diseases[26].

However, the observation time is too short, and only the health terminal data at the regional level is observed, ignoring cases that were not treated in a timely manner, resulting in underestimation of the results. Some scholars began to pay attention to the adverse impact of extended polluted air exposure on public health. Taking PM2.5 and PM10 as proxy variables, it was proved that the problem of air pollution will prominently raise the incidence rate of asthma and the rate of medical outpatient services among urban residents living in the Pearl River Delta region from 2001 to 2014, and the results also show that the negative impact of air pollution has significant spatial spillover effects[27]. With the deepening of research, some scholars have extended their observation period and expanded their research scope to the whole country. By using provincial balanced panel data from 2000 to 2015,

empirical analysis has been conducted to prove that atmospheric particulate pollution caused by industrial smoke and dust emissions poses significant harm to national health. Scholars have also predicted the health loss caused by future air pollution[28], and based on the exposure effect relationship, calculated the respiratory system cases and premature deaths caused by air pollution with high concentration of PM2.5 in the beijing-tianjin-hebei region in the year of 2020[29]. The above research results unanimously indicate that air pollution will have significant health impacts on individuals.

3. Research on the Impact of Air Pollution on Labor Supply

In recent years, the impact of air pollution on people's work efficiency has received widespread attention from international scholars. Existing researches have fully proved that air pollution prominently reduces the productivity of manual laborers. Research has shown that every 10 ppb increase in ozone concentration in the air will significantly reduce the labor productivity of agricultural workers by 5.5%, while increasing labor costs by approximately $700 million[30]. However, due to the relatively low proportion of value created by the agricultural industry in national income, studying the impact of air pollution on the labor market in the agricultural sector alone is difficult to comprehensively reflect the impact of air pollution on the labor market, and there are certain limitations for policy reference.[31] Therefore, some scholars have focused on whether air pollution affects the production efficiency of secondary industry practitioners, proving that every 10 units increase in PM2.5 concentration will reduce the productivity of pear packaging workers by 6%[31]. In addition, some scholars have proposed that with the increase of PM2.5 concentration, the production efficiency and product quality of manufacturing workers in industrial cities have decreased[32]. Due to the fact that the majority of economic output comes from knowledge and technology intensive industries rather than labor-intensive ones. The latest research shows that an increase in air pollution index will significantly reduce the work efficiency of technical employees in large call centers in China[31]. In addition, there is a linear relationship between production capacity loss and air quality deterioration, and the number of misjudgments by professional baseball umpires increases with the increase of CO concentration[33].

A large amount of literature has verified a significant causal relationship between air pollution and labor market distortions. Some literature has proven that air quality is closely related to employee absenteeism and student absenteeism. By controlling for urban fixed effects, it was found that an increase of 1 standard deviation in suspended particulate matter concentration in the air would lead to a 10% increase in absenteeism rate. On the contrary, a decrease in the concentration of suspended particulate matter in the air will effectively reduce the probability of work absenteeism. For every 10% decrease in suspended particulate matter (TSP) concentration, the daily loss decreases by 4.4%. It is worrying that this problem may be more severe among school-age children, as they have weaker resistance and a higher probability of contracting air pollution related diseases, leading to an increased likelihood of missing classes. Studies have shown that high concentrations of carbon monoxide or ozone in the air can cause a substantial increase in the amount of children missing classes.

With the deepening of research, the latest research results provide new evidence for studying the impact of air pollution on working hours, which can more accurately reflect the influence of ambient air pollution on individual labor time. The article uses the closure of a large oil refinery in Mexico City as a quasi natural experiment to estimate the negative impact of air quality changes on the total labor time of workers before and after the change. [34]. The results indicate that closing the refinery helps reduce SO2 emissions by 19.7% and increases workers' weekly working hours by 1.3 hours. On the basis of previous research results, other scholars have discovered the mechanism by which air pollution affects people's labor supply. That is, weaker members of the family (elderly and children) are more sensitive to the impact of air contamination, leading to diseases. Members who participate in labor choose to reduce their working time to take care of sick family members. The research objectives of existing literature all demonstrate that improving air quality to reduce labor supply will yield significant economic benefits[35]. By constructing a local equilibrium model based on the perspective of healthy human capital, it was found that air pollution affects the health level of workers, which in turn has a negative impact on labor supply[36].

Some domestic researches have also started to follow with interest in the influence of air pollution on rural residents' labor participation and working time. For example, by sorting out the internal mechanism of the impact of air pollution on agricultural production and operation, constructing the "Air Pollution Agricultural Production" model, research has found that air pollution has a "deprivation effect" on agricultural production and operation, that is, air pollution is not conducive to agricultural production and operation activities[37]. Secondly, air pollution has a significant "inhibitory effect" on agricultural labor supply, that is, air pollution will reduce agricultural labor supply.

4. Literature Review and Research Prospects

At present, there are abundant research achievements in the fields of environmental pollution, residents' health, and labor supply in both domestic and foreign academic circles. Nevertheless, there is still room for supplementation and improvement in the research field of the impact of air pollution on residents' health and labor supply. The specific analysis is as follows:

(1) At present, literature on the impact of air pollution on health status and labor supply mainly focuses on urban residents, while the internal relationship between rural air pollution, rural residents' health, and agricultural labor supply has not yet been clearly determined. Compared to cities, rural areas are in a clearly disadvantaged position in terms of environmental regulation intensity, enterprise cost accounting, and differences in neighborhood resistance. Urban pollution sources continue to shift to rural areas, posing a serious threat to the rural environment[38]. In addition, due to the extensive production activities of rural residents, the problem of air pollution in rural areas cannot be ignored. However, most of the existing studies focus on specific urban areas with heavy pollution and high economic development, such as Beijing Tianjin Hebei, the Yangtze River Delta and the Pearl River Delta, while few focus on underdeveloped rural areas. Relevant literature and statistical data indicate that the degree

of air contamination in China's countryside has worsened, and the risk of chronic diseases among rural residents is higher than that of urban residents. This will lead to the loss of rural health human capital, which is not conducive to the sustainable and stable development of the agricultural industry and rural economy. Therefore, evaluating the impact of air pollution on the health and labor supply of rural residents is of great significance for rural environmental governance and the accumulation of rural human capital.

(2) At present, study on the influence of air contamination on agricultural labor supply is still insufficient, with health loss as a mediating variable. Research on the role of air quality in agricultural labor supply inevitably requires using health as a medium. At present, the interrelationships and underlying logic between air pollution, health loss, and labor supply time are not yet clear, and there are studies have explored the negative effects of worker health loss on the process of air pollution affecting labor supply. On the basis of previous research, this article explores the inherent logical relationship and action mechanism among air contamination, health shocks, and labor supply decisions and behaviors at the theoretical level based on pathological principles, human capital theory, and Grossman's health needs theory, filling the gaps in previous studies in this area.

(3) Current research mainly focuses on the correlation between air quality in specific economically developed regions and the overall health or employment status of the area. However, there is currently no consensus on the impact of air pollution in rural areas on the health of rural residents and labor supply issues. Macro level research cannot observe the behavioral choices of different micro individuals under air pollution conditions. This article takes a micro perspective as the starting point, focusing on the health of farmers and the supply of agricultural labor, which helps to improve the depth and accuracy of research. Some existing literature mainly explores the impact of urban air pollution on the overall incidence of cardiovascular and cerebrovascular diseases, lung cancer, and mortality in the local area from a macro perspective, but it is difficult to capture relevant information on the health status and labor participation behavior of individuals exposed to polluted air at the micro level. Individual differences in information will be easily overlooked. This article innovatively measures the impact of PM2.5 concentration in areas with different levels of air quality and frequency of air pollution on the risk of chronic respiratory and cardiovascular diseases among respondents, and thus measuring the reduction in labor supply caused by health impairment in micro individuals from a microeconomic perspective. At the same time, in order to explore the hidden effects of air pollution on health, this article further analyzes the impact of air pollution on the blood pressure and pulse of respondents, and exploring the potential health hazards of air pollution more systematically.

Looking back at the past, while China's economy has grown rapidly, it has also caused serious environmental damage, and the cost of labor and other factors has continued to rise. The current Chinese economy has shifted from a stage of high-speed growth to a stage of high-quality development. The people's demand for a good ecological environment is becoming increasingly strong, and the transformation of labor from a quantity dividend to a quality advantage is the key to high-quality economic development. The research on air pollution, residents' health, and labor supply provides important theoretical and practical basis for the formation of harmonious development between humans and nature, the improvement of human capital level, and the promotion of high-quality development of health care. Given the availability of relevant data, further analysis of logical relationship and internal mechanism of air pollution affecting residents' health and labor supply is a topic that should be studied in the next stage.

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