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Air Pollution and Entrepreneurship

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ABSTRACT

We examine the causal effect of air pollution on an individual's propensity for entrepreneurship in China. Our preferred model, which employs an instrumental variable approach to address endogeneity arising from sorting into entrepreneurship and locational choices, suggests that exposure to higher intensity of air pollution lowers one's proclivity for entrepreneurship. We also find that industrial activity and self-efficacy mediate the relationship between air pollution and entrepreneurship. In addition, education and gender further moderate the relationship between air pollution and self-efficacy. In particular, air pollution negatively affects self-efficacy among the less-educated and females.

KEYWORDS

Air pollution; Entrepreneurship; China

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INTRODUCTION

Air pollution is an issue of global concern, with nine out of ten people worldwide are exposed to a high concentration of air pollutants (World Health Organization, 2018). Both outdoor (ambient) and indoor (household) air pollution are important environmental hazards for physical (Ghanem, 2018) and mental health[1] and cognition[2] (Zhang, Zhang, & Chen, 2017; Isen, Rossin-Slater, & Walker, 2017). Nevertheless, the negative impact of outdoor air pollution is the most challenging to address (Hu et al., 2019). Extensive epidemiological literature shows that outdoor air pollution exposure leads to adverse health consequences, while several recent studies in economics find that air pollution also affects productivity and human capital accumulation by impacting the functioning of the human body and brain. These effects, in turn, influence emotional status, memory, cognition, physical endurance, concentration, and absenteeism (Currie et al., 2009; Evans & Jacobs, 1981; Zivin & Neidell, 2013). The resulting loss in the human capital accumulated often manifests in a higher frequency of poor and biased decisions, as observed in the case of students and employees (Chang, Zivin, Gross, & Neidell, 2016, 2019; Zivin & Neidell, 2013).

It, however, remains unclear if air pollution negatively influences ongoing decision-making activities such as those regularly carried out by entrepreneurs as part of their work.[3] Yet this topic is important as entrepreneurs' decisions affect not only their companies'

[1] The older population has low levels of psychological symptoms (Segal, Hook, & Coolidge, 2001) and only those who feel energetic and healthy will engage in self-employment (Rietveld, van Kippersluis, & Thurik 2015). This suggests that proxies of general human capital, such as age and health, might be positively related to the decision-making of being an entrepreneur. Healthy old adults might be equipped with ability to cope with health issues and sustain their firms.

[2] For outdoor air pollution, the impact on cognition might be short-term (Ebenstein et al., 2016; Shier et al., 2019) or long-term (Stafford, 2015), and the long-term impact may have a cumulative and multiplier effect (Clark-Reyna et al., 2016). For instance, the impact of Air Pollution Index (API) readings in the past year is almost ten times larger than the impact of API in the past one day, and three times larger than the API effects in the past seven days (Chen, Oliva, & Zhang, 2022).

[3] We define entrepreneurs as those who work for themselves in non-agricultural sectors, as opposed to those who work for others in non-agricultural sectors or who work in agricultural sectors (Steinmetz & Wright, 1989). It includes Schumpeterian entrepreneurs and managerial business owners (Kirchhoff, 1994).

Schumpeterian entrepreneurs are innovative high-growth entrepreneurs. Schumpeterian entrepreneurship is an important pillar for economic development and might bring dramatic technological breakthroughs and revolutionize an entire industry (Block, Fisch, & van Praag, 2017).

success but also local employment, investment, trade and economic growth. As air pollution diminishes individual performance and productivity, it may also prevent the rise of entrepreneurship since this requires a sustained level of sound decision-making and performance. In addition, people with entrepreneurial aspirations but live in highly polluted areas may give up their preferred employment choice or migrate to less polluted to start their businesses. It is also worth investigating the mechanisms if air pollution does affect entrepreneurial activities.

We address these questions by using the data collected by the China Health and Retirement Longitudinal Study (CHARLS), combined with data on air pollution, thermal inversions and weather conditions sourced from the National Aeronautics and Space Administration (NASA) and city-level information from the *China City Statistical Yearbooks* and the *China Statistical Yearbooks*.

We find that those who experience more severe air pollution are less likely to start a business. In the correlation between air pollution and entrepreneurial decisions, we find that industrial activity in the local area plays a mediator role. In particular, self-efficacy acts as a suppressor, especially for women, consistently with the hypothesis that would-be entrepreneurs are doubtful about their personal abilities and entrepreneurial skills if they live in a highly polluted area. The results contribute evidence that air pollution is not only a health hazard but an economic problem, as it affects productivity and entrepreneurship.

The rest of the paper is organized as follows. In the next section, we begin by reviewing the relevant literature on air pollution and entrepreneurship to develop the framework and derive a set of testable hypotheses. We explain the methodology in Section 3 and report the empirical results in Section 4. In the last section, we discuss the main implications of our findings for research and policy.

THEORETICAL FRAMEWORK

Our analysis builds on established evidence that people exposed to air pollution tend to have low productivity, a higher probability of physical and mental health issues relative to people who are not (Chen, 2018), and a higher propensity to migrate to places with low air pollution if they are highly educated (Chen, Oliva, & Zhang, 2022; Qin & Zhu, 2018). Given such evidence, we advance the hypothesis that prospective entrepreneurs located in highly polluted areas make a conscious decision about whether and if so where to engage in entrepreneurial activities. Such decision, in turn, relies on their individual- and city-level characteristics (e.g., self-efficacy and subjective social status [4]). We hence posit that individuals with entrepreneurial aspirations are less willing to start a business if they live in a highly polluted area. We also posit that a person's level of education—representing their level of cognition before entering the labor market—may play a pivotal role in undertaking such choice, in that it affects self-efficacy and thereby influences the inclination to pursue entrepreneurship.

[4] Self-efficacy is people's belief in their ability to achieve something (Bandura, 1977). Individuals' human capital, such as their physical and mental abilities, are the seeds that could help enhance self-efficacy (Zuhir, Surin, & Rahim, 2019). Social learning theory also posits that people's physical health, mental health, and cognitive abilities underpin their level of self-esteem. These human capital factors are important determinants of entrepreneurial self-efficacy and entrepreneurship. Although life shocks on human-capital formation might lead some people to become entrepreneurs according to the underdog entrepreneur framework (Cheng, Guo, Hayward, Smyth, & Wang, 2021; Miller & Le Breton-Miller, 2017), the effects of air pollution on pollution-induced human capital might be different from general life adversity.

Specifically, as individuals' physical and psychological endurance decreases, their anxiety and depression will increase, and their learning ability will decline. Likewise, individuals who lack the ability to engage in social persuasion may have low self-efficacy.

Subjective social status is an individual's evaluation of personal position in the social hierarchy (Wang, 2017). It is an individual cognitive feature (is also an essential determinant of decision-making processes at the firm level) (Bhattacharya, 2012) and is based on objective status (e.g., education, income, and occupation) and social capital (i.e., high-class individuals might have high possibility to access to favorable resources embedded in social relationships; Kim & Lee, 2021).

Note that, due to data limitations, we focus on self-efficacy instead of entrepreneurial self-efficacy. Perceived self-efficacy could be viewed as people's beliefs in their ability to influence events that affect their lives, which is the foundation of human motivation, performance accomplishments, and emotional well-being (Bandura, 1977). Moreover, the role of self-efficacy is increasingly emphasized in entrepreneurship research. Self-efficacy can affect people's capabilities to mobilize motivation, resources, and behaviors (Wood & Bandura, 1989). Business founders have more self-efficacy in innovation and risk-taking than non-founders. Specifically, entrepreneurial self-efficacy could predict the likelihood of being entrepreneurs, and it is constructed by people's belief in their ability to perform marketing, innovation, management, risk-taking, and financial control (Chen, Greene, & Crick, 1998).

In addition to individual-level influences, high levels of air pollution may also affect the productivity of the labor supply available to a prospective entrepreneur. As a result, aspirational entrepreneurs might not choose to start new ventures in highly polluted areas fearing low levels of workers' productivity as well as a high propensity to migrate for skilled workers. As air pollution likely reflects a lax local environmental policy and the presence of large factories (Kwon, Heflin, & Ruef, 2013), entrepreneurship may still occur but predominantly for ventures in high-polluting industries.

Insert Figure 1 about here

Air Pollution and Productivity

Exposure to air pollution puts individuals at a disadvantage in terms of productivity. The relevant literature suggests that the productivity of manual workers such as fruit packers (Chang et al., 2016), those with white-collar jobs such as call-center workers (Chang et al., 2019), and workers with complex professional jobs such as investors and judges (Kahn & Li, 2019; Meyer & Pagel, 2017) are adversely affected by air pollution. The performance of people in high-pressure situations, such as athletes (Lichter et al., 2017), referees (Archsmith et al., 2018) and chess players (Künn et al., 2019), has also been found to be negatively impacted by air pollution. In the long run, one consequence of air pollution harming productivity is a reduction in local economic development. Our study is consistent with the literature that found exposures to air pollutants increase the risk of productivity loss. If air pollution negatively affects productivity, the entrepreneurial productivity of time devoted to businesses will decrease.[5] To the best of our knowledge, the studies have not directly assessed the outcomes of air pollution on entrepreneurial choices using detailed individual-level information. And we contribute to the substantive evidence of the socio-economic toll of air pollution by looking at the new insights regarding the correlation between air pollution and entrepreneurship. The preceding discussion leads us to hypothesize:

Hypothesis 1. In general, the more severe the air pollution experienced, the less likely that individuals will have entrepreneurship after controlling for individual and city-level characteristics and behaviors.

Air Pollution and Entrepreneurship: The Mediating Role of Personal Characteristics

Air pollution and physical health. Air pollution is one of the crucial factors that lead to diseases. For example, nitrogen dioxide and carbon monoxide are closely linked to pneumonia, chronic obstructive pulmonary infections, asthma and metabolic disorders (Fang et al., 2012; Gehring et al., 2013; Vella et al., 2015). Air pollution also cause deaths. According to global estimates, total pollution's impact is on par with that of smoking and more significant than that of war, terrorism, drugs and alcohol (Fuller et al., 2022).[6]

Air pollution and entrepreneurship: the mediating role of physical health. Good health condition might be an important determinant of productivity and decision-making, especially for people who bear almost all of the risks and make most of the business decisions (Chao, Szrek, Pereira, & Pauly, 2010). Individuals in good health may have much time to think about complex entrepreneurship issues and believe they have enough energy to prepare for businesses and deal with challenges in entrepreneurship development.[7] Because of these

[5] Individual preferences dictate the time that we devote to leisure, improving innate ability through education and training, and working as an employee or employer. Similarly, entrepreneurs also need to allocate time to activities related to innovation, management and production (Ferrante, 2005).

[6] In 2019, air pollution remained responsible for 6.7 million deaths, accounting for approximately 74.4% of the total number of deaths caused by pollution worldwide (Fuller et al., 2022).

[7] Specifically, an increase in illness duration will reduce people's time to prepare for their business, and it may make people doubt whether they will be able to spend enough time building up their companies.
Although the self-employed can use time more flexibly, they tend to have longer effective work hours and are often under greater time pressure than paid employees (Hyytinen & Ruuskanen, 2007). And they need to learn skills and perform tasks to make sure their businesses do not fail (Lechmann & Schnabel, 2014).

reasons, individuals with poor physical health will be unlikely to have enough physical ability, focus and time to start a business. The reduction in physical ability caused by poor physical health might negatively correlate with entrepreneurship. The lack of time to prepare for creating a new venture and self-directed suspicion (i.e., doubt about one's physical ability) lead to low self-evaluations and weak entrepreneurial orientation.

Air pollution and subjective perception factors. Subjective perception factors include self-efficacy and self-rated social status. According to investor sentiment theory, air pollution leads to negative emotions and expectations, and these cause people to make cognitive errors, auditors to make inaccurate professional judgments and investors to change trading behaviors (Ailshire, Karraker, & Clarke, 2017; Song & Song, 2018; Wu, Chen, Guo, & Gao, 2018).[8]

Air pollution and entrepreneurship: the mediating role of subjective perception factors. Entrepreneurs might have a strong internal locus of control and a high level of entrepreneurial self-efficacy (Chen et al., 1998). And self-efficacy might be related to entrepreneurial self-efficacy. Personal performance is a basis of self-efficacy. It will shape and estimate self-efficacy. The sense of self-efficacy will also predict performance. People with high self-efficacy will have a high intrinsic interest in tasks and tend to expand the effort and show persistence in front of obstacles. Recent studies also point out that self-efficacy enables people to have high self-motivation, positive expectations, low perceived discrepancy

[8] The existence of investor sentiment is an assumption of the alternative standard finance model in behavioral finance. It results in investors not having justified beliefs about future cash flows or investment risks based on the facts at hand (Baker & Wurgler, 2007; De Long, Shleifer, Summers, & Waldmann, 1990). So, it is clear that betting against sentimental investors is costly and risky (Baker & Wurgler, 2007; Shleifer & Vishny, 1997).
For example, air pollution can affect mood, in turn impacting decision-making and risk-taking behaviors (i.e., suggesting that prevailing retail investors will invest less in firms), ultimately resulting in lower stock returns (Ding, Guo, & Yang, 2021).
Moreover, air pollution may reduce individuals' self-efficacy by damaging cognitive performance. People with prolonged exposure to air pollution tend to exhibit low school test scores and weak working memory (Ebenstein, Lavy, & Roth, 2016; Shier, Nicosia, Shih, & Datar, 2019; Vahedi, 2020). Taking the correlation between cognitive ability and learning efficacy into account (Burgoyne et al., 2016), weak cognition among potential entrepreneurs may lead to poor learning performance when preparing for entrepreneurship. For potential entrepreneurs, insufficient accumulation of relevant skills and experiences before starting businesses may reduce their perceived self-efficacy in starting a business, as experiences are generally the critical components for successful companies.

and increased effort allocation, which will help people to enact entrepreneurial intentions (Gielnik, Bledow, & Stark, 2020). And people who have low self-efficacy caused by domestic violence are not likely to create businesses (Shahriar & Shepherd, 2019).[9]

Moreover, some researchers argue that social status is an essential socioeconomic factor in creating entrepreneurs (Khan, Alam, & Khan, 2005). Individuals' social capital, such as personal networks, could promote entrepreneurship (Kwon et al., 2013). This might play a mediating role between family socioeconomic status and self-efficacy (Han, Chu, Song, & Li, 2014). In the Chinese context, many studies have shown the positive impact of social networks (i.e., individuals' social capital) on entrepreneurship, as social networks can help potential entrepreneurs obtain financing (Barnett, Hu, & Wang, 2019).[10]

Although studies in entrepreneurship focus on the individual-level determinants of becoming entrepreneurs, they do not look at the environmental circumstances of these individuals. By exploring the impact of air pollution on entrepreneurship through personal characteristics, we could understand how human behaviors change in response to the environment. Based on the above reasoning, we state the following hypotheses:

Hypothesis 2a. Higher air pollution is associated with worse physical health.

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[9] In addition, ambient air pollutants are commonly viewed as a cause of attention-deficit hyperactivity disorder (ADHD) in children and neurodegenerative diseases in adults (e.g., dementia, Parkinson's disease, and multiple sclerosis; Peden, 2018). A survey of young Chinese adults showed that air pollution is negatively associated with psychopathological symptoms, such as interpersonal sensitivity (other symptoms include distress, obsessive-compulsive disorder, depression, and psychoticism) (Chen, Mitchell, Brigham, Howell, & Steinbauer, 2018). Thus, while it is unlikely that severe air pollution correlates with ADHD in adults, it may cause them to be sensitive to their emotions. Although sensitive feelings may increase entrepreneurial actions, air pollution's adverse effects on emotions, raising the likelihood of misjudgment and inattention, may increase the probability of making mistakes that outweigh the positive effects. Then, people's resilience and confidence in coping with challenges when they are preparing to start businesses will be diminished. Another survey of Chinese youngsters suggested that individual traits of prospective entrepreneurs, such as overconfidence (i.e., perceiving less risk), are associated with decision-making errors and contemptuous view of the challenges during the preparation of starting a business. And once the environmental conditions change, the entrepreneurship may fail and will lead to failure to start businesses (Zhao & Xie, 2020). Considering the above evidence, in terms of mental health, air pollution's negative impact on entrepreneurship may be more significant than its positive effects, such that entrepreneurial activities are likely obstructed.

[10] Although some of these factors may relate closely to the likelihood of business success, the literature denotes the impact of these factors on business creation. Moreover, we found that the expectation of business success or failure will, respectively, positively or negatively affect entrepreneurial intentions (Ha & Jung, 2011), and we assume that expectations about business success might influence subjective perception factors.

Hypothesis 2b. Worse physical health is related to lower entrepreneurship and mediate the negative relationship between air pollution and entrepreneurship conditions to a certain extent.
Hypothesis 2c. Higher air pollution is associated with worse subjective perception factors (i.e., self-efficacy and self-rated social status).
Hypothesis 2d. Worse subjective perception factors (i.e., self-efficacy and self-rated social status) are related to lower entrepreneurship and mediate the negative relationship between air pollution and entrepreneurship conditions to a certain extent.

Air Pollution and Entrepreneurship: The Mediating Role of City Characteristics

Air pollution and industrial activity. Air pollution could be harmful to the local economy and might influence industrial activity (i.e., the number of the city's industrial firms).[11] The economic losses come from the negative impacts on health, informal sectors and environmental damage (Fuller et al., 2022). Moreover, if air pollution harms productivity continuously, it will negatively affect the output of individuals and local economic development and, ultimately, make it unlikely to provide a favorable business environment. And the local economic status could be reflected in variations in the distribution of resource allocation and industrial structure transformation. Compared to firms in the agriculture and service sectors, manufacturing firms might experience less negative impact from air pollution. According to pollution haven hypothesis, industrial firms might increase due to the possible less stringent environmental regulations in high polluted areas.[12]

Air pollution and entrepreneurship: the mediating role of city industrial activity. We know that China's economic reform in 1978 (i.e., the introduction of Reform and Opening-Up policies) by removing or lowering institutional barriers to market entry could largely contribute to booming entrepreneurship. In alternative words, economic development could bring benefits to performance of enterprises (He, Lu, & Qian, 2019). If a local labor force's average productivity declines, the economy will also be negatively affected. And highly

[11] The 2017 Lancet Commission on pollution and health reported that air pollution was responsible for a 6.2% reduction in global economic output in 2015.
[12] Although part of the working population migrates to other cities to avoid exposure to severe air pollution, industrial firms might adopt machines to replace workers in production.

polluted areas have high migration rates (Chen, Oliva, & Zhang, 2022; Qin & Zhu, 2018). Moreover, community environment, regional economic development and relevant policies will have impacts on entrepreneurial activities (Kwon, Heflin, & Ruef, 2013). Although the number of industrial firms might increase, the reduction in the numbers of firms in agricultural and service sectors as well as the increase in the migration of the working population caused by high levels of air pollution will lead to low levels of average entrepreneurial activities. In recent studies, only scarce attempts have been made to provide evidence on how city-level attributes impact individual-level outcomes under exposure to air pollution. And we contribute to the understudied macro-level perspective on the determinants of entrepreneurial choices. Therefore, we propose the following hypotheses:

Hypothesis 2e. Higher air pollution is related to less number of industrial firms per ten thousand people.

Hypothesis 2f. Less number of industrial firms per ten thousand people is related to lower entrepreneurship and mediates the negative relationship between air pollution and entrepreneurship conditions to a certain extent.

Impact of Air Pollution on Entrepreneurship through Subjective Perception Factors: The Moderating Role of Education

Considering that high education level may represent advantages in the labor market such as high cognition, family background and opportunities, education level could act as a moderator of the correlation between air pollution and subjective perception factors. First, education is an input in the human capital production function and an essential element for overall skills (e.g., managerial, decision-making and new specialized knowledge) accumulation in the future. Individuals with lower education levels may be less efficient in skills development and problem-solving than people with higher education levels (Gustavsson, 2006). Second, the higher the initial level of cognition, the higher the sense of efficacy and self-esteem, which may increase individuals' perception of opportunities and ability to assess their business success in a certain sector. Thirdly, high education levels might signal high general capability. The possibility of entrepreneurship for more capable individuals may be higher than for their less-educated counterparts (Robinson & Sexton, 1994). Considering education level might impact self-perceived factors, and the exploration of the mediated moderation role of education might be helpful in examining how people respond to air pollution differently, we hypothesize as follows:

> *Hypothesis 3. Education level moderates the correlation between air pollution and subjective perception factors (i.e., self-efficacy and self-rated social status). Individuals with high school or above education experience weaker adverse effects of air pollution than do individuals with below high school education.*

METHOD

Data Analysis

We adopt the linear probability model to test the impact of air pollution on entrepreneurial choices (Hypothesis 1). And we use a causal mediation analysis framework in instrumental-variable regressions to assess the effects of air pollution on entrepreneurship, mediated by personal and city characteristics (Hypothesis 2a–2f). We group respondents by education level to test for heterogeneity (Hypothesis 3). Our mediation approach is based on estimations of three regressions of the same sample (Baron & Kenny, 1987). First, we regress the mediator on air pollution. Second, we regress the entrepreneurship on air pollution. And finally, we regress the entrepreneurship on both mediator and air pollution. There is an indirect effect of air pollution on entrepreneurship if the results of the first and second regressions are significant and the result of the mediator is significant in the third regression. Furthermore, there is a partial mediation (i.e., complementary mediation) if the coefficient of air pollution in the third regression is less than the second regression and significant. There is a full mediation (i.e., indirect-only mediation) if the air pollution in the third regression is not significant. And there is a suppressor effect (i.e., competitive mediation) if the coefficient of air pollution in the third regression is equal to or larger than the second regression and significant.

In the regressions, we include city fixed effects and year fixed effects to control for the time-invariant factors of city and year, respectively. Robust standard errors are clustered at the city-level to adjust for heteroskedasticity and accommodate within-city autocorrelation over time.

Finally, we address the endogeneity problem in the model by using an instrumental variable. In this study, endogeneity mainly occurs because entrepreneurship and pollution-related factors cannot be fully controlled. For example, compared to other places, large cities might have lower levels of entrepreneurship (due to severe air pollution) or higher levels (due to higher development, more entrepreneurial talent, and more measures to protect against air pollution, such as the promotion of electric vehicles and the installation of air purifiers in public places).

We follow the recent studies on air pollution to construct an instrumental variable using thermal inversions (He et al., 2019; Liu & Salvo, 2018; Qin et al., 2019). Thermal inversions can only affect air pollution when the pollutants exist, and thermal-inversion-induced air pollution will affect entrepreneurship through the original air pollution. Thus, we use values for temperature inversions in the atmosphere, wind speed, wind direction, and the number of stagnation days (i.e., days with positive thermal inversion values) in the regression predicting PM2.5. Moreover, we adopt the fitted value of PM2.5 in the first-stage regression in our analysis. Considering that the relationship between thermal inversions and air pollution might be non-linear, we use their squared terms in robustness checks. The instrumental variable is exogenous as the temperature inversions, wind speed, and wind direction in the atmosphere are natural phenomena and may exacerbate the level of air pollution.

Limitations and Suggestions for Future Analysis

First, we focus only on the impact of air pollution on the decision to become an entrepreneur, yet the measures taken by established companies to deal with air pollution and the subsequent consequences might also be valuable topics for further study. Following the existing literature, air pollution and corporate measures may also have a causal relationship. Specifically, when the level of air pollution increases, companies may adopt environmentally friendly techniques to improve their environmental management under the influence of corporate responsibility or government policies, and these actions may decrease the concentrations of air pollutants.

Second, although we adopt PM2.5 as an independent variable, other environmental factors may also impact entrepreneurship, and their effects are unclear. As other environmental factors may have different impacts on productivity, we assume that they may also have different effects on entrepreneurship. For example, temperature and productivity have an inverted U-shaped relationship (i.e., the extreme temperature will have a significant adverse impact on human-capital accumulation) (Zivin & Neidell, 2014), and this might be due to the adaptation effects of humans (Monn, 2001).

Third, we investigate that air pollution might negatively affect people's proclivity to become entrepreneurs through several channels. Future research could focus on the mediating roles of other social factors (e.g., childhood adversity, domestic violence and inequality) and provide a comprehensive view of the impact of air pollution on general entrepreneurship.

Fourth, researchers could try to identify further long-term effects of air pollution on entrepreneurship. Future work could distinguish between the cumulative effects of air pollution and the human body's habituation effects on air pollutants. By looking at multiple lags of air pollution and the impacts of early-stage exposure on different phases of the life cycle, we could understand how to mitigate air pollution's harmful impacts in the long run.

Finally, both firm formation rates and firm dissolution rates could represent entrepreneurship; future research could address our study's limitations by using firm-level data and measuring the impact of air pollution on business failures.

Sample

Participants in the study were urban Chinese included in the CHARLS. The CHARLS dataset we utilize was initiated by Peking University in China in 2011. The CHARLS was conducted in 2011, 2013, 2015 and 2018 and included 28 provinces in the sample. Moreover, the researchers of the CHARLS utilized systematic probability proportional to size sampling with implicit stratification by administrative boundary and socioeconomic status. Then, they obtained a multi-stage probability sample. Finally, the CHARLS's baseline survey contains 10,257 households in 150 counties and consists of information on adults, families and communities. The CHARLS datasets provide city-level geographical information.

Compared with other surveys, the CHARLS have more detailed geographic information, a longer follow-up period, a larger sample size, and more variables that reflect middle-aged individuals and the elders' characteristics[13]. We use CHARLS data from 2011, 2013, 2015 and 2018 to create a city-level dataset, adopting cross-sectional data so that all interviewees were surveyed at least once.[14] Our working sample contains 10,362 adults, with a total of 19,089 data points.

We obtained air pollution data from the NASA Socioeconomic Data and Applications Center at Columbia University.[15] This satellite-derived data is used to measure the annual global surface concentrations of ground-level PM2.5 (μg/m^3). The dataset has a high grid cell resolution of 0.01 degrees (latitude) × 0.01 degrees (longitude) (Van Donkelaar et al., 2016, 2018). And the data confirm the significant variations of PM2.5 concentrations across cities in our dataset: the mean and standard deviation of the PM2.5 concentrations in the sample are 53.264 μg/m^3 and 21.233 μg/m^3, respectively.

Measures

[13] For example, for the self-efficacy variable in the CFPS, we need to eliminate the error due to scale mismatch and increase comparability across years.
[14] We also use panel data to test the hypotheses, and the results are robust.
[15] The data can be found at: https://beta.sedac.ciesin.columbia.edu/data/set/sdei-global-annual-gwr-pm2-5-modis-misr-seawifs-aod-v4-gl-03.

All the measures in the survey were constructed in Chinese, and CHARLS provides official English versions of the questionnaires and datasets on its website. The data from the Yearbooks are also provided in the original Chinese and official English versions. To assure the accuracy and consistency of the air pollution and weather condition data, we adopted data only from NASA in the United States, which provides data in English.

The survey questions changed slightly from year to year. We match the variables according to their original meaning or response options. If the answer options have different ranges or scales, we indicate this in the item descriptions below.

Entrepreneurship. We focus on people who are employed or self-employed. They have different skills and experiences and work in various sectors and industries. They might be, for example, physical laborers, salespersons, equipment or machinery operators, doctors, or leaders of enterprises. Although these people have divergent skills and experiences, most of them could invest in businesses if they had entrepreneurial intentions.[16] This is because individuals with enough financial or social capital can make decisions to enter or exit the market in many industries under the permission of relevant regulations. We attempt to reduce the bias in the estimations by excluding people who worked in agriculture (i.e., casual agricultural workers and those who do agricultural work for their families or other families). Although agrarian workers might also be affected by air pollution, the reasons for and conditions of their entrepreneurial decisions might differ from those in the non-agricultural labor force. Thus, our study focuses on non-agricultural individuals.[17]

[16] However, the population density of entrepreneurs is much lower in China (Hall, 2002).
[17] Air pollution could cause a reduction in the yield and attributes of agriculture, and the impact of air pollution on crop loss is severe in the developing world (Bell, Power, Jarraud, Agrawal, & Davies, 2011; Spash, 1997). Thus, people who live in polluted areas might not want to start (or continue) working in an agricultural job. Additionally, air pollution is less severe in rural areas than in urban areas in China, so people who live in the countryside may have reasons unrelated to air pollution for working as an employee or becoming self-employed.

We measured individuals' entrepreneurial actions using the adults' primary job type reported in the surveys.[18] After excluding agricultural workers, we created a dichotomous variable representing an individual's entrepreneurial behavior; the variable is coded as one if the individual started a new venture and as zero if the individual worked at a company owned by someone else.

Air pollution. We used PM2.5 to measure air quality and matched it at the city-level with the CHARLS data. This is a reasonable measure of air pollutants because the fine particulate matter of 2.5 micrometers or smaller is more harmful to people's physical health than larger and more extensive particulate matter.

Thermal-inversion-induced air pollution. Following previous studies on air pollution, we use atmospheric thermal inversions to adjust the measurement error and solve the endogenous problem of air pollution arising from sorting, avoidance behaviors and the relationship between air pollution and economic activities. Specifically, air pollutants are not randomly assigned. Individuals may try to avoid exposure to air pollution. And areas with high economic growth tend to have high levels of air pollution. Yet, they will provide a favorable living environment, mitigating the negative impact of air pollution on human beings (Chen, Paulina, & Zhang, 2018; Deschenes, Wang, Wang, & Zhang, 2020; Jans, Johansson, & Nilsson, 2014).[19]

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[18] Job types include entrepreneurship, waged jobs, and agriculture work..

[19] Thermal inversions occur in three ways. They are generated on clear nights when the ground and the air touching the ground are cooled faster than the higher air layers. This is because the Earth's infrared emissions warm the higher layers of the atmosphere (radiation inversions). Vertical air movement causes a cold air layer to descend through a hot air layer (subsidence inversions). Moreover, when layers of air at different temperatures move horizontally, a layer of cold air develops below a layer of hot air (advection inversions; Hicks, Marsh, & Oliva, 2016; Jacobson, 2002).
Air stagnation is delineated as conditions under which: sea-level geostrophic wind speed is less than 8 ms^{-1}, surface (anemometer-level) wind speed is less than about 4 ms^{-1}, or wind speed at 10 m is less than approximately 3.2 ms^{-1} (Brunt, 1941; Godske, Bergeron, Bjerknes, & Bundgaard, 1957; Wang & Angell, 1999). Temperature inversions could create the clearing index (Ransom & Arden, 2013). On days with measurable precipitation or a cold front, the clearing index is assigned a value of more than 1,000. During poor atmospheric ventilation, the air becomes stagnant, and the clearing index might fall below 200 (Zhao & Yuan, 2020).

We calculate the temperature differences from 1,000 to 850 hPa and adopt the predicted PM2.5 based on temperature differences as an instrumental variable for air pollution in the analysis. The first-stage specifications are as follows:

$$PM_{2.5_{t,j}} = PM\_fit_{2.5_{t,j}} + X_{t,j} + \varepsilon_{t,j}, \tag{1}$$

$$PM\_fit_{2.5_t} = \sum_0^t \sum_0^l \gamma_{1_{t,l}} InverValue_{t,\mathrm{j}} + \sum_0^t \sum_0^j \sum_0^l \gamma_{2_{t,\mathrm{j},l}} WS_{t,\mathrm{j},l} + \sum_0^t \sum_0^j \sum_0^l \gamma_{3_{t,\mathrm{j},l}} WD_{t,\mathrm{j},l} + \sum_0^t \sum_0^j \sum_0^l \gamma_{4_{t,\mathrm{j},l}} InverDay_{t,\mathrm{j},l} + \varepsilon_{t,j}, \tag{2}$$

In Equation (1) and Equation (2), where $PM\_fit_{2.5t}$ represents the fitted value of PM2.5 at time t in city j. In Equation (1), $PM_{2.5t}$ is PM2.5 at time t in city j, and X_t is the set of control variables. As for Equation (2), $InverValue_{t,j}$ is the value of thermal inversions at time t in city j; $WS_{t,\mathrm{j},l}$, $WD_{t,\mathrm{j},l}$, and $InverDay_{t,\mathrm{j},l}$ denote wind speed, wind direction, and the number of occurrences of temperature inversions at time t in city j at layer l, respectively.

The data source is the Modern-Era Retrospective Analysis for Research and Applications version 2 project, which provides historical atmospheric climate records.[20] And we aggregate the 6-hourly data to yearly mean data. Moreover, in the robustness checks, we add the squared and cubic terms of temperature differences and wind speed.[21]

Mediators. We utilize a dichotomous variable, whether the respondents visited the hospital last month to reflect their physical health status. And we adopt individuals' self-

Notably, the impact might be non-linear (Hicks et al., 2016), and pollution might heat the ground-level air layer, thus reducing the occurrence of inversions (Jans et al., 2014). Other weather conditions might also impact thermal inversions, such as extreme temperature (Arceo, Hanna, & Oliva, 2016).

[20] The data can be accessed at https://disc.sci.gsfc.nasa.gov/datasets/M2I6NPANA_5.12.4/summary?keywords= M2I6NPANA.
Also, some researchers use thermal inversions data from National Oceanic and Atmospheric Administration (NOAA) (He et al., 2019; Liu & Salvo, 2018; Qin, Wu, & Yan, 2019), which are slightly different from the data we use. The NOAA atmospheric temperature at standard pressure points (e.g., 1,000 hPa) or other detailed pressure points (e.g., 999 hPa) is easily accessed. However, the NASA data we obtained only directly show the average temperature in standard pressure points, while the data at other pressure points need to be further calculated. Considering that the previous literature mainly focuses on the differences between layers of standard pressure points, we do not pay attention to other pressure points in this study.

[21] Wind can transport air pollution. Researchers have found that the variation of meteorological parameters, such as wind speed and direction, can cause pollutant dispersion (Verma & Desai, 2008). Studies have also confirmed that PM2.5 and other pollutants can traverse considerable distances (Deryugina, Heutel, Miller, Molitor, & Reif, 2019).

efficacy and self-rated social status as mechanisms through which air pollution affects entrepreneurship. The survey interviewers asked adults how frequently they had felt bothered by things that don't usually bother them during the past week.[22] We converted the scales of the variable and constructed a dummy variable represents adults' self-efficacy (low self-efficacy = 0, high self-efficacy = 1). Moreover, the interviewers asked adults, "Overall, how would you rate your own standard of living? Is it very high, relatively high, average, relatively poor or poor?" After converting the scales of answers, constructed responses ranged from 1 (poor) to 5 (very high), with higher values as a proxy of higher social status. Furthermore, we calculate the city's industrial activity by using the number of industrial firms per ten thousand people from the *China City Statistical Yearbook.*

Controls. The survey includes many questions on individuals' characteristics that could be covariates. Including these variables could eliminate bias in the estimation because they may impact ambient air pollution and entrepreneurial decisions, but they cannot be influenced by air pollution and entrepreneurship. The control variables at the individual-level are age, age squared, sex (female = 0, male = 1), education level (below high school = 0, equal to or above high school = 1), whether the individual migrated to other provinces (non-migrant = 0, migrant = 1), hukou status (rural = 0, urban = 1), marital status (never married = 1, separated, divorced, widowed = 2, married with spouse present, or married but not living with spouse temporarily for reasons such as work = 3), number of people living in this household, financial status compared to the average family in the same area before the age of 17 years old, health condition compared to other children of same age before the age of 16 years old, whether covered by public medical insurance and non-entrepreneurial status

[22] In entrepreneurship studies, people may use single-item or multiple-item measures to operationalize people's feelings about whether they have the knowledge and skills to start businesses (Shahriar & Shepherd, 2019).

(entrepreneurial = 0, non-entrepreneurial = 1).[23] City attributes include the real gross domestic product (GDP) per capita (1978 = 100) and population density, as reported in the *China City Statistical Yearbook*.[24] Furthermore, in the heterogeneity test, we use education level. Considering that weather could significantly affect individual performance, we collected weather information from NASA.[25] The weather control variable is surface-level temperature, precipitation and wind speed.[26] We also control for a dummy variable to measure if there are large variations among the counties within the same city (no = 0, yes = 1).

RESULTS

The descriptive statistics for the variables of all samples, educated individuals and less-educated individuals are presented in Table 1.[27] In the data from all samples, about 23.0% of participants are entrepreneurs, and most of them are less educated. 15.1% of individuals went to the hospital last month. The average self-efficacy for adults is 0.605 (SD = 0.489), and the average self-rated social status is 2.439 (SD = 0.779); both means are similar to the median values. The average number of industrial firms per ten thousand people is 3.150. Of the

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[23] To explore the impact of air pollution on general entrepreneurship, we view the people who have no employees in firms as non-entrepreneurs in the analysis. We would downward bias the results if including this group of people. Due to data limitations, we do not contain other types of non-entrepreneurial people. Non-entrepreneurial people might be those who work in government, computer science or finance, entrepreneurs with simple physical work, and individuals with many years of schooling. First, people who work in government might prefer a stable job and have a lower tolerance for risk than other types of workers. People who work in computer science or finance may find it easier to get a professional, high-paying job. Thus, they are less likely to be self-employed and avoid the adverse impact of the uncertainty of entrepreneurialism (Bernard & Dubard Barbosa, 2016; Cai & Winters, 2017). Second, we perceive those entrepreneurs with simple physical work might be street vendors who choose to be self-employed because they may be unable to get regular jobs and have no other options. Some of them are illegal (i.e., operating illegally without the permission of the government) and have a hard time getting by. Street vending might be perceived not as entrepreneurship but as a problem for urban governance (Bhowmik & Saha, 2013). Finally, people whose schooling is too many years are likely to pursue a Ph.D. and have more intention to become researchers than entrepreneurs, even if they have the skills, experiences, or resources to start their own business.

[24] The GDP deflator was calculated by nominal and real GDP, which are sourced from the *China Statistical Yearbook*.

[25] For surface-level temperature, the spatial grid is 0.25 degrees (latitude) × 0.25 degrees (longitude), and the data frequency is every three hours. The data were gathered from the NASA Global Land Data Assimilation System: https://disc.sci.gsfc.nasa.gov/datasets/GLDAS_NOAH025_3H_2.1/summary?keywords=GLDAS_NOAH025_3H.2.1.

[26] Weather data were gathered via http://daac.gsfc.nasa.gov/. Note that precipitation might reduce the occurrences of thermal inversions and closely correlates with relative humidity.

[27] The analysis was conducted using STATA (version 16.0 MP).

interviewees, 67.0% are male, 20.0% attended high school or above, 8.8% migrated from other provinces, 27.3% have non-agricultural hukou and 5.6% are coded as non-entrepreneurial. Moreover, the data indicate that the levels of air pollution vary greatly across cities, and the average annual mean PM2.5, 53.264 μgm^{-3}, is largely higher than the primary annual mean National Ambient Air Quality Standard of 12 μgm^{-3} set by the United States Environmental Protection Agency.[28]

Insert Table 1 about here

To compare the impact of air pollution on entrepreneurial actions by education level, we report the summary statistics after grouping respondents by their level of education. We also conducted a univariate test, again segregating interviewees by education level, to identify any differences between the two groups. The results show that the group differences are significant ($t_{Entrepreneurship}$ = 11.768, $p < 0.01$; $t_{PM2.5}$ = -5.992, $p < 0.01$). Table 1 indicates that the distributions of entrepreneurship and air pollution across education levels are very similar to the distributions in all samples. Yet, considering that descriptive statistics do not fully capture the relationship between air pollution and entrepreneurial behaviors, and the relationship might change when including the micro-level and macro-level controls, we explore our research questions through further empirical analysis.

Insert Table 2 about here

Table 2 (Hypothesis 1) reveals the results of the estimation using a linear probability model and a two-stage least squares regression. Column (1) in Table 2 presents the results of

[28] We could find the air quality standard on the website: https://www.epa.gov/criteria-air-pollutants/naaqs-table.

the linear probability model. The findings indicate that the impact of air pollution on entrepreneurship is not significant. However, based on the above discussion, we suspect that the estimation of the linear probability model is biased, so we use an instrumental variable to construct a two-stage least squares regression. As reported in column (2), the results indicate that an increase in the growth rate of PM2.5 corresponds to a decrease in entrepreneurship (β = -0.010, $p < .05$). Furthermore, the instrument's t-statistic is larger than the threshold of 3.43 (Lee, Moreira, McCrary, & Porter, 2020), indicating that there are no weak instrument variable problems and our usage of the two-stage least squares regression is reasonable. Thus, the results fully support Hypothesis 1—that air pollution hinders the emergence of entrepreneurship.

Insert Table 3 about here

As we assume that there are channels through which air pollution affects entrepreneurship, we regress entrepreneurship on PM2.5 with physical health, self-efficacy, self-rated social status and the number of the city's industrial firms and present the results of the mediated models in Table 3 (Hypothesis 2a–2f). The results in Panel B and Panel D of Table 3 show that air pollution is significantly negatively related to self-efficacy (β =-0.13, $p< .05$) and significantly positively related to the number of the city's industrial firms (β =0.028, $p< .01$), whereas the results in Panel A and Panel C of Table 3 represent the impact of air pollution on physical health and self-rated social status are not significant. Also, after controlling for air pollution, the indirect effects of self-efficacy ($\beta_{Indirect\ effect}$ = -0.032, $p < .01$) and the number of the city's industrial firms ($\beta_{Indirect\ effect}$ = -0.038, $p < .01$) are significant and negative. The indirect effects of self-efficacy and the number of the city's industrial firms show the impact of air pollution on entrepreneurship is partly mediated by the number of the city's industrial firms and is partly suppressed by self-efficacy. The possible reason for the slightly suppressive effect of self-efficacy is that higher self-efficacy might lead to lower performance of entrepreneurs. Although people believe in their own ability to perform specific tasks, they might not expect to achieve positive outcomes. And those with high self-efficacy might be overconfident and experienced environmental dynamism (i.e., a high rate of unpredicted change occurring in a specific industry), which makes individuals ambiguous and have errors in judgment and decision-making (Hmieleski & Baron, 2008).[29] The Kleibergen-Paap *F*-statistic[30] for the excluded instruments in the first-stage regression of air

[29] Hofstede's and Bird's landmark study proposed a transmission mechanism: entrepreneurial beliefs include a preference for personal actions, preparation for taking risks (i.e., entrepreneurs need to be aware of the timing of business events and recognize patterns), cherishing time (i.e., due to complex tasks, entrepreneurs experience temporal tension and live in present), goal directed (i.e., set specific goals to achieve entrepreneurial success), "entrepreneurial zoom lens" (i.e., have characteristics such as flexibility, field independence and cognitive complexity, and could focus on detailed operations or strategy/vision when needed), efficient communication, networking skills and learning ability (Hofstede, 1980; Bird, 1988; McGrath, MacMillan, & Scheinberg, 1992; Drnovšek, Wincent, & Cardon, 2010). These factors are positively related to self-efficacy.
Mentally healthy individuals may be confident, willing to take personal actions and ready to take risks, which increases the probability of entrepreneurial entry. Self-efficacy will also have positive effects on the performance of the venture after it is started (McGee & Peterson, 2019). Individuals with good cognition may also believe they can learn new techniques and increase experience efficiently due to their high study ability. The low level of self-efficacy caused by low cognition hinders entrepreneurship.
For example, individuals with low self-efficacy caused by weak cognitive abilities may have biases in their perceptions about the business environment, make wrong judgments in investment, and exhibit negative leadership behaviors such as failing to set correct arrangements, goals and expectations and behaving in innovative ways. Since risk perception (Dubard Barbosa et al., 2019), the objective existence of resources (e.g., financial capability, specialized knowledge and innovation outputs) (Alvarez & Busenitz, 2001), the perception of resource availability (Krueger, Reilly, & Carsrud, 2000; de Sousa-Filho, Matos, da Silva Trajano, & de Souza Lessa, 2020) and leadership (Viinikainen, Heineck, Böckerman, Hintsanen, Raitakari, & Pehkonen, 2017) are vitally important to perceived desirability, perceived feasibility and propensity to take actions, the lack of these characteristics reduces the potential for new entrepreneurship.
Yet, the performance, judgement and behaviors caused by air pollution may be radical or conservative. Thus, in the literature on mental health and entrepreneurship, the impact of mental barriers on entrepreneurship is uncertain. For example, mental health issues, such as inattention (Wiklund et al., 2017), counterfactual thinking, and negative emotional states (Baron, 2000), are negatively related to entrepreneurship, but overactive (Wiklund et al., 2017) and sensory processing sensitivity (Harms, Hatak, & Chang, 2019) have positive impacts on it.
Note that inattention or counterfactual thinking is a class of neurodevelopmental disorders. Some researchers view hyperactivity or inattention as mental health issues, and they may also view cognitive impairment as a mental health problem (Sonuga-Barke et al., 2017). Relatedly, people might reconstruct past events to engage in counterfactual thinking, a form of mental stimulation in which a person imagines how some factual outcome might easily have turned out differently (Kahneman & Tversky, 1982).
In addition, overconfidence may not lead to the entry of entrepreneurs. Some scholars explain that overconfidence is measured by indicators that may not directly relate to enterprise creation (Simon, Houghton, & Aquino, 2000). Moreover, other scholars point out that the "psycho-physics" of risk-taking could aid entrepreneurship (Dubard Barbosa, Fayolle, & Smith, 2019).
[30] We obtain Kleibergen-Paap *F*-statistic to test for the weak-instruments problem. The null hypothesis is that the independent variable is weakly identified because it is subject to unacceptably large bias. And the rule of thumb is that if it exceeds 10, we could say that the instruments are not weak, and the correlations between the

pollution on entrepreneurship as well as for air pollution and the self-efficacy and the number of the city's industrial firms is above 10, which proves there are no weak instrument issues. Overall, the results fully support Hypothesis 2e and 2f, partly supporting Hypothesis 2c and 2d, but do not support 2a and 2b—that air pollution affects entrepreneurship through the number of the city's industrial firms and there is a suppressive mediation effect of self-efficacy.

Insert Table 4 about here

Air pollution may have different effects on entrepreneurs with different backgrounds. Considering that education level may affect people's ways of thinking and work performance, and that subjective perception factors may also play mediated roles in these relationships, we conducted a moderated mediation analysis. We focus on self-efficacy rather than self-rated social status since it significantly impacts the relationship between air pollution and entrepreneurship. We report only the results for the critical variables due to space limitations. All columns include the controls for the individual and city attributes and include city and year fixed effects. In column (1) of Table 4 (Hypothesis 3), we find that the impact of air pollution on self-efficacy is harmful and significant for less-educated individuals ($\beta_{Interaction}$= 0.003, p < .1). Hence, the heterogeneity effects provide partly support for Hypothesis 3. In the regression, we exclude those who have aged above or equal to 55 years old to eliminate the bias caused by legal retirement age (i.e., 60 years old for males, 55 years old for female civil servants and 50 years old for other female workers). In addition, we found the effect is significant for females below 55 years old whereas not significant for males below 60 years

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independent variable and instruments are not small. In addition, it is valid in non-independent and identically distributed (non-i.i.d.) cases (we could use robust standard errors to address non-i.i.d errors) (Kleibergen & Paap, 2006).

old, which shows that females' self-efficacy is negatively influenced by air pollution and they are more vulnerable if experiencing severe air pollution than males. Yet, according to the results in Table 4, we cannot conclude that education might be helpful for the generation of entrepreneurship for the middle-aged and elderly prospective entrepreneurs.[31]

[31] Entrepreneurial human capital, such as relative skills and knowledge learned from schools, is a crucial ingredient in the emergence of growing productive firms, which also affects the initial level and growth rates of entrepreneurial productivity (Queiro, 2021). High academic attainment might be the outcome of high parental investments of time and money in a student's development (it will also benefit individuals' generalized self-efficacy and social skills in childhood) (Haveman & Wolfe, 1994). Likewise, parental socioeconomic backgrounds are significantly associated with competence in early adulthood and might be an essential predictor of career development—more so than individuals' experiences (Schoon & Duckworth, 2012). Therefore, educated prospective entrepreneurs with good performance in adulthood, confidence in being entrepreneurs and high parental socioeconomic status tend to become entrepreneurs in developing countries such as China (Jia, Lan, & Padró i Miquel, 2021; Xiao & Wu, 2021) and Nigeria (Salami, 2019). According to a study in Atlanta Metropolitan Area in the United States in the 1970s, entrepreneurs who founding high-technology firms tend to have more formal education compared to the general population. In this metropolitan area, with the rising educational level of the general population, the number of entrepreneurs with a college degree also has been historically increasing (Douglass, 1976). Additionally, many literature suggest that there is a significant positive effect of schooling on the entrepreneurial performance such as survival chances and earnings (Van Der Sluis et al., 2008). Yet, it is worthwhile to note that recent studies provide mixed results on the relationship between schooling and selection into entrepreneurship. For instance, some literature does not find a significant positive impact of schooling on entrepreneurship. The possible reasons caused this nonsignificant effect include: on the one hand, education would enhance the managerial ability and outside options, which positively influence the propensity to be entrepreneurs; on the other hand, high levels of education may bring many occupation options such as lucrative wage employment with decent working conditions.

In previous discussion, we hypothesize that people in developing countries might experience different effects. Researchers found moderation effect of education in the relationship between entrepreneurial characteristics and entrepreneurship entry. Education is positively associated with a risk-taking propensity, which increases people's entrepreneurial intentions. And the positive environment in developing countries will also push people to establish a business for a decent living (İlhan Ertuna & Gurel, 2011). In China, although education might have a negative or not significant effect on entrepreneurship for relatively young males and college graduates (i.e., entrepreneurship may not be a preferred choice for these people in the absence of related policy) (Huang, Tani, & Zhu, 2021; Zhou, Li, & Shahzad, 2021), it may have a positive effect on middle-aged and elderly people or other groups of the population. For example, researchers found that education may help to create entrepreneurship for rural-urban migrants (Cheng & Smyth, 2021) and boss-type entrepreneurs (i.e., entrepreneurs such as small or large business owners who generally require high capacity in managing complex business activities compared to self-employed people or own-account workers) (Chu & Wen, 2019). In the Chinese context, the proportion of entrepreneurs with a high-school education is about 30%, and the number of entrepreneurs with a college degree is also increasing due to higher education reforms and changes in the labor market since 1999 (Fan & Lü, 2019). And a study found that high school or above education rather than university or above education might be positively related to entrepreneurship (Huang, Tani, & Zhu, 2021). From this, we advance that high education levels will mitigate the negative impact of air pollution on subjective perception factors.

One possible reason causes this result is that the majority of middle-aged or older adults in China do not receive a graduate education. Graduate education restarted in 1978 after the Cultural Revolution and the implementation of "Opinions on the Arrangement of Postgraduate Enrollment Work in Colleges and Universities in 1978". And enrollments in graduate education boomed in the first decade of the 21st century. During 2006 and 2014, the total enrolment ratio of tertiary education increased from 21% to 39% (Organization for Economic Co-operation and Development, 2016). And there is a golden era of entrepreneurship development in China. The removal and reduction in institutional barriers to market entry and development of private business led to unleashing of entrepreneurship in China. The Chinese government also implemented new national economic development strategies to devote tremendous financial and non-financial resources to startups (e.g., reduction of corporate

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Insert Table 5 about here

In Table 5 of robustness checks, we report the results of the long-term impact of air pollution on entrepreneurship. We found that the average air pollution in previous years is positively correlated with entrepreneurship. The possible reason for the increase in entrepreneurship might be the individuals' adaptation to the long-term air pollution and the encouragement of entrepreneurial behavior of the government.

Insert Table 6 about here

Indoor air pollution harms cognitive abilities (Vahedi, 2020), and it has various adverse effects on different cognitive functions (Burgoyne, Sala, Gobet, Macnamara, Campitelli, & Hambrick, 2016). It also harms work performance (Satish et al., 2012), which is evident in underdeveloped areas (Soppelsa, Lozano-Gracia, & Xu, 2021). Considering indoor air pollution might affect entrepreneurship, we conduct robustness checks to check if the impact of outdoor air pollution will change after controlling for indoor air pollution. The results in Table 6 confirm the consistency of the findings in Table 2.

Insert Table 7 about here

We conduct sub-group analysis to measure the impact of air pollution in cities with different economic performances. The results in Table 7 represent that the negative impact is

income taxes for firms in western areas from China's Western Regional Development Strategy after 2000, establishment of a platform where startups could list shares from National Equities Exchange and Quotations in 2013, streamlined administration, innovation promotion and fair supervision from "mass entrepreneurship and innovation" since 2015) (He, Lu, & Qian, 2019).

not significant in the cities with top or bottom 10% economic status, whereas significant in the cities after excluding these cities. The cities with the top 10% economic status might have comprehensive protection actions to help people escape from the negative impact of air pollution, which might lead to the nonsignificant effect of air pollution on entrepreneurship. For example, schools and firms in large metropolitan areas might be likely to provide air purifiers in indoor spaces. And the cities with the bottom 10% economic status are not likely to have a favorable business environment; thus, the level of air pollution and entrepreneurship might not change over the years.

Insert Table 8 about here

We divide the sample into urban and rural areas since the types of activities, development opportunities and business environment might be different for urban entrepreneurs and their rural counterparts. The results are presented in Table 8 and show a negative and significant impact on entrepreneurs living in urban areas, which suggests that the urban population might experience more negative effects from air pollution than rural residents.

Insert Table 9 about here

We use an alternative measure of air pollution, distance weighted PM2.5, to estimate the impact of air pollution on entrepreneurship in Table 9. The results are negative and significant, which confirms the robustness of our results.

Insert Table 10 about here

Increasing literature suggests that air pollution might affect human beings in a number of ways. First, high air pollution is associated with high crime rates since it will increase mental health problems such as aggression, impulsivity and anxiety. Types of criminal activities include cybercrimes, violent and unpremeditated crimes (Herrnstadt, Heyes, Muehlegger, & Saberian, 2021; Kuo & Putra, 2021; Sarmiento, 2020). Moreover, high air pollution is associated with a large number of economic activities or limited environmental regulations in the short run, which might attract outside investment (especially in high pollution industries). In Chinese context, the increase in air pollution in the short term might generate a production effect (i.e., imply production expansion) (Liu, Zheng, & Wang, 2020). And the pollution haven hypothesis suggests air pollution is associated with an increase in the number of manufacturing firms from foreign countries. This hypothesis is confirmed in recent Chinese studies that pollution-intensive industries tend to relocate to places with less stringent environmental regulations, especially for industries with strong mobility (i.e., relocate across regions at a low cost and in a short time) (Dou & Han, 2019; Zheng & Shi, 2017). These social factors might reduce the willingness to become entrepreneurs and mediate the correlation between air pollution and entrepreneurship. We use the number of people arrested for violent crimes by the procuratorate per ten thousand people calculated from the data in People's Procuratorate work reports[32] and outside investment scores from components of the Index of Regional Innovation and Entrepreneurship[33] in China to represent criminal activities and outside investment, respectively. The results in Table 10 prove that air pollution might impact personal entrepreneurial intention through outside investment.

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[32] Many cities in our sample does not provide criminal activities data in official websites.
[33] This data is calculated by Center for Enterprise Research of Peking University. The website is https://doi.org/10.18170/DVN/NJIVQB.

Insert Table 11 about here

Since the non-entrepreneurial population might have less willingness to start businesses, we test whether the results remain the same if we exclude the non-entrepreneurial population in Table 11. The results suggest the negative effect of air pollution on entrepreneurship still exists.

Insert Table 12 about here

Considering migrants might experience mixed effects from air pollution (i.e., on the one hand, compared to their life in origin, migrants might experience a lower level of air pollution, have higher productivity and obtain better opportunities in the destinations they moved to; on the other hand, in the destination areas, they might have fewer financial and nonfinancial resources for starting businesses), we measure the impact of air pollution and entrepreneurship after excluding migrants from the sample. The negative and statistically significant coefficient in Table 12 also empirically supports our Hypothesis 1.

Insert Table 13 about here

To test whether our results are sensitive to alternative samples, we estimate the main regression by using alternative samples. First, we exclude 2018 in our sample, considering air quality becomes better after a series of environmental regulations and it may influence our results. Results in Table 13 suggest that our previous findings are consistent and environmental policy might underestimate the negative impact of air pollution slightly. Second, we adopt the sample of the same age group of China Family Panel Studies (CFPS) and the results are not significant. The possible reason is that the target sample of the survey is the general population, not only middle-aged and elderly people in China. The lack of observations for this group of people might lead to biased results. Also, due to data limitations, we cannot control for similar financial and health status in childhood by utilizing CFPS data.

Insert Table 14 about here

We further check the personal income of people pre- and post-choice of becoming an entrepreneur. We present the summary statistics on income after excluding people with the same job status in the survey and zero income. We also exclude people who are entrepreneurs before they are workers to eliminate the effect of business failures and the possibility of side work. The results in Table 14 report that those who are entrepreneurs tend to have a relatively higher income than workers, which suggests that being an entrepreneur might be helpful in improving individuals' well-being.

Insert Figure 2 about here

We attempt to plot the trends in entrepreneurship and air pollution and see if they are negatively correlated without the control of other confounders. As shown in Figure 2, the yearly average entrepreneurial probability increases after 2011 but decreases after 2013. And the trend in air pollution decreases steadily between 2011 and 2018, with a reduction of nearly 21.494 μg/m^3. The trends of entrepreneurial probability and air pollution show a positive correlation between these variables after 2013. The findings mitigate the concern that the correlation between air pollution and entrepreneurship is negative and might give biased relationships.

DISCUSSION

Theoretical Implications

Our study makes a number of contributions to the environment and human-capital literature. First, the research on human resilience might suggest that air pollution will have some positive impact. Most people are inherently resilient and have the capacity to become resilient. These abilities will contribute to adaptation or recovery responses when people face extreme stressors or traumatic life events (Abramson et al., 2015). Specifically, in some Chinese cities with high pollution industries, air pollution might be similar to environmental disasters, or they can be correlated; when people are exposed to severe air pollution, they may want to start businesses to alleviate the loss and help others reduce the harm (i.e., they feel a sense of social responsibility). However, we find that the harmful impact caused by air pollution on general entrepreneurship is more significant than its positive effects on green entrepreneurship. The impact of toxic airborne particles may differ from that of general environmental adversity, such as earthquakes and tsunamis.[34]

Second, while many studies have shown that air pollution negatively impacts the performance or productivity of workers, we know very little about air pollution's effects on entrepreneurs. Therefore, our research supplements the literature on the impact of air pollution on human behaviors.

[34] First, air pollution might have a negative impact on entrepreneurship. Although individuals feel the harm caused by air pollution, they may not want to become entrepreneurs since entrepreneurial decision-making is affected by many factors. Also, they may suffer trauma due to air pollution, which might decrease their productivity. Second, we know that the resilience process is complex. For individuals confronted with traumatic events, success in business start-up projects may depend on receiving help from a resilience mentor, a commitment to action and initiative, interim victories, and self-esteem reconstruction (Bernard & Dubard Barbosa, 2016). Finally, the pollution-related impact might be cumulative or sustained throughout a person's life (He et al., 2019). Furthermore, considering the relatively weak enforcement of government environmental policies in some areas of China, and the air pollutants carried by the wind to nearby regions, air pollution might significantly and negatively impact entrepreneurship in general. The estimation results are statistically and economically significant, at least in the Chinese context.

Third, our results on how air pollution influences self-efficacy and city attributes are consistent with existing research on air pollution issues, contributing to this literature.

Finally, we provide evidence that policymakers need to be alerted to the important role of education in the negative impact of air pollution and self-efficacy. People with low education levels might experience more air pollution’s adverse effects since they might have lower levels of cognition or social support and thus they will have lower self-efficacy compared to their high-educated counterparts. Low self-efficacy constitutes an individual’s low cognitive estimate of capabilities when performing job tasks, although it might not be related to being an entrepreneur; thus, some favorable jobs will no longer become an attractive career option for them. And having skills related to an individual’s work might be helpful for personal success. The government could help less-educated people to counteract the negative impact by encouraging them to attend classes, training and apply for support from the government. All jobs are equally important in society. And we care about whether people can live equally without paying an extra price for clean air. These practices will help them to master experiences, improve social connections, enhance self-belief and, ultimately, help them to realize their full potential and greatest possibilities vocationally.

Practical Implications

Our study has several policy implications. First, the significant negative impact of air pollution on individuals’ entrepreneurial decisions should be considered when encouraging entrepreneurship and providing support to people who live in highly polluted areas. To reduce large health costs and productivity loss caused by air pollution, governments need to control air pollutant emissions, especially in cities with high air pollution levels. For instance, governments could install air quality monitors and use mobile technologies to increase environmental awareness. And policy makers need to be alerted to weather factors in relation to air pollution, such as thermal inversions, wind speed, and wind direction. The results on the mediating role of subjective perception factors suggest that, air pollution may take a heavier toll on self-efficacy. In addition to addressing air pollution issues, policy makers might need to figure out how to enhance people's psychological capital. Feasible measures include developing mental health care services in clinics and hospitals, establishing community psychological consultation rooms nationwide (i.e., places to provide convenient private consultation services about mental issues) and ensuring the provision of high-quality education (Chen et al., 2018; Lu, Yue, & Liu, 2020). These practices could be helpful for the improvement and construction of self-confidence. Second, although the Chinese government has already been focusing for decades on environmental protection and sustainability, there may be differences in enforcement across prosperous urbanized areas and impoverished inland areas (van Rooij, Zhu, Li, Wang, & Zhang, 2017). Some cities in China might need to address air pollution issues in an efficient manner, as our findings highlight the potential continuous impact of air pollution. Finally, the results of our moderation analysis further prove the importance of education. According to our findings, the nine-year compulsory education policy benefits the Chinese urban population. Although the negative impact of air pollution on self-efficacy might decrease for the new generations of China, we cannot ignore the broad negative outcomes of air pollution.

Conclusion

This study suggests that air pollution adversely affects the creation of businesses by increasing the city's industrial firms[35]. And self-efficacy might be a suppressor variable in the correlation between air pollution and entrepreneurship. After grouping respondents, we show that in terms of self-efficacy, less-educated individuals are more vulnerable to air pollution than their more-educated counterparts. The significant effects of air pollution on entrepreneurship are consistent with this strand in the productivity literature. Prior studies

[35] There might be a mutual relationship between air pollution and the number of the city's industrial firms. In our results, we found air pollution might increase the number of the city's industrial firms. From the existing literature, potential channels might be production effects of air pollution in the short run and less stringent environmental regulations.

have investigated the productivity outcomes of individuals in responding to both concurrent and prolonged severe air pollution (He et al., 2019). As these studies emphasize that demographic variables are essential information (Qin et al., 2019), we considered heterogeneity and uncovered the adverse effects of air pollution on self-efficacy of people with low levels of education. Furthermore, from a managerial perspective, potential entrepreneurs need to pay attention to air pollution issues and individual-level characteristics and city-level attributes resulting from air pollution. And less-educated people might need to seek additional help or resources such as training classes to overcome the negative impact of air pollution. We should find methods to tackle air pollution issues due to negative externalities of air pollution. Our results will convince policy makers of these externalities and the costs of air pollution in different dimensions of productivity and life course choices. Supporting policies are needed in reducing air pollution and encouraging education and the publicity of these information (i.e., let people understand what they were doing and what they need to do next).

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TABLE 1

Descriptive Statistics

	All adults		Less educated		More Educated		Welch's t-statistic
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Entrepreneurship (yes = 1)	0.230	0.421	0.246	0.431	0.165	0.371	11.768***
PM2.5 (μg/m^3)	53.264	21.233	52.793	20.972	55.167	22.142	-5.992***
Thermal-inversion-induced fitted PM2.5 (μg/m^3)	53.496	9.705	53.394	9.628	53.907	10.001	-2.860***
Physical health	0.151	0.358	0.153	0.360	0.146	0.353	1.025*
Self-efficacy	0.605	0.489	0.601	0.490	0.624	0.485	-2.613***
Self-rated social status	2.439	0.779	2.416	0.788	2.515	0.741	-4.522***
City's industrial activity	3.150	3.112	3.216	3.219	2.883	2.615	6.592***
Age	54.161	6.858	54.450	7.174	53.011	5.271	13.908***
Male (yes = 1)	0.670	0.470	0.657	0.475	0.720	0.449	-7.691***
High school or above (yes = 1)	0.200	0.400	0.000	0.000	1.000	0.000	n.a.
Migrated to other provinces (yes = 1)	0.088	0.283	0.086	0.280	0.096	0.294	-1.838**
Non-agricultural hukou (yes = 1)	0.273	0.445	0.181	0.385	0.606	0.489	-49.292***
Marital status	2.982	0.133	2.983	0.130	2.979	0.145	1.637*
Household size	3.315	1.485	3.347	1.508	3.186	1.381	6.318***
Financial status in childhood	2.538	0.963	2.477	0.960	2.817	0.928	-17.469***
Health status in childhood	3.403	0.993	3.394	1.000	3.445	0.956	-2.543**
Have public medical insurance (yes=1)	0.944	0.230	0.943	0.232	0.949	0.221	-1.352*
Non-entrepreneurial (yes = 1)	0.056	0.229	0.060	0.238	0.036	0.187	6.683***
Real gross domestic product per capita (thousand yuan)	8.385	5.349	8.330	5.326	8.602	5.434	-2.776***
Population density (per km^2)	512.521	319.370	520.037	314.171	482.603	337.720	6.211***
Ground-level temperature (°C)	15.547	4.854	15.807	4.680	14.514	5.370	13.643***
Ground-level rainfall (10^6 kg/m^2*s)	34.414	16.638	35.073	16.672	31.776	16.238	11.165***
Ground-level wind speed (m/s)	3.376	2.263	3.340	2.283	3.520	2.175	-4.539***
High variance of PM2.5 within city (yes=1)	0.110	0.313	0.101	0.301	0.146	0.354	-7.331***

Notes: SD = standard deviation. The sample only includes entrepreneurs and workers. We assume that our unpaired data do not have equal variances, and we present Welch's *t*-statistic (less educated−educated). Physical health denotes at least one hospital visit last month (yes = 1) and the city's industrial activity indicates the number of industrial firms per ten thousand people.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 2

The Impact of Air Pollution on Entrepreneurship: Direct Effect

Dependent variable	**(1) Entrepreneurship**		**(2) Entrepreneurship**	
PM2.5 (μg/m^3)	-0.001	(0.001)	-0.010**	(0.005)
Age	-0.035***	(0.009)	-0.034***	(0.009)
Age squared	0.000***	(0.000)	0.000***	(0.000)
Male (yes = 1)	-0.031***	(0.008)	-0.031***	(0.008)
High school of above (yes = 1)	-0.054***	(0.012)	-0.051***	(0.012)
Migrated to other provinces (yes = 1)	-0.009	(0.019)	-0.007	(0.019)
Non-agricultural hukou (yes = 1)	0.006	(0.014)	0.007	(0.014)
Marital status	0.025	(0.031)	0.029	(0.032)
Household size	0.002	(0.003)	0.002	(0.003)
Financial status in childhood	0.008*	(0.005)	0.008*	(0.005)
Health status in childhood	0.001	(0.004)	0.001	(0.004)
Have public medical insurance (yes=1)	-0.045**	(0.019)	-0.046**	(0.019)
Non-entrepreneurial (yes = 1)	0.945***	(0.007)	0.947***	(0.007)
Real gross domestic product per capita (thousand yuan)	0.001	(0.002)	-0.003	(0.002)
Population density (per km^2)	0.000	(0.000)	0.000	(0.000)
Ground-level temperature (°C)	0.016**	(0.006)	0.021***	(0.007)
Ground-level rainfall (10^3 kg/m^2*s)	0.113	(0.713)	0.141	(0.724)
Ground-level wind speed (m/s)	-0.018**	(0.008)	-0.017**	(0.008)
High variance of PM2.5 within city (yes=1)	0.045***	(0.016)	0.116***	(0.040)
Constants	0.918***	(0.289)		
City fixed effects	YES		YES	
Month fixed effects	YES		YES	
Year fixed effects	YES		YES	
Observations	12946		12946	
Clusters	5074		5074	
Methodology	LPM		2SLS	
t-statistic (instrument)	n.a.		13.95	
Kleibergen-Paap rk Wald F-statistic (instrument)	n.a.		194.630	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

** $p < .05$
*** $p < .01$

TABLE 3

The Impact of Air Pollution on Entrepreneurship: Mediation Effects of Personal and City Characteristics

Panel A. Physical health

	(1)		(2)		(3)	
Dependent variable	**Physical health**		**Entrepreneurship**		**Entrepreneurship**	
PM2.5 (μg/m^3)	0.006	(0.005)	-0.010**	(0.005)	-0.010**	(0.005)
Physical health					0.006	(0.010)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	12946		12946		12946	
Clusters	5074		5074		5074	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	13.95		13.95		13.94	
Kleibergen-Paap rk Wald F-statistic (instrument)	194.630		194.630		194.392	

Panel B. Self-efficacy

	(1)		(2)		(3)	
Dependent variable	**Self-efficacy**		**Entrepreneurship**		**Entrepreneurship**	
PM2.5 (μg/m^3)	-0.013**	(0.006)	-0.009624**	(0.005)	-0.010035**	(0.005)
Self-efficacy					-0.032***	(0.007)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	12946		12946		12946	
Clusters	5074		5074		5074	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	13.95		13.95		13.98	
Kleibergen-Paap rk Wald F-statistic (instrument)	194.630		194.630		195.349	

Panel C. Self-rated social status

Dependent variable	(1) Self-rated social status		(2) Entrepreneurship		(3) Entrepreneurship	
PM2.5 (μg/m^3)	-0.219	(0.516)	0.140	(0.286)	0.144	(0.277)
Self-rated social status					0.021	(0.063)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	5172		5172		5172	
Clusters	3101		3101		3101	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	0.70		0.70		0.73	
Kleibergen-Paap rk Wald F-statistic (instrument)	0.489		0.489		0.533	

Panel D. City's industrial activity

Dependent variable	(1) City's industrial activity		(2) Entrepreneurship		(3) Entrepreneurship	
PM2.5 (μg/m^3)	0.028***	(0.003)	-0.012**	(0.005)	-0.011**	(0.005)
City's industrial activity					-0.038***	(0.009)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	12571		12571		12571	
Clusters	4898		4898		4898	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	13.43		13.43		13.37	
Kleibergen-Paap rk Wald F-statistic (instrument)	180.363		180.363		178.860	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 4

The Impact of Air Pollution on Entrepreneurship: Moderated Mediation Effect of Education

	(1)		(2)		(3)	
Dependent variable	**Self-efficacy**		**Self-efficacy**		**Self-efficacy**	
PM2.5 (μg/m^3)	-0.017**	(0.008)	-0.018	(0.013)	-0.015*	(0.008)
PM2.5 * Education level	0.003*	(0.001)	0.006**	(0.003)	-0.001	(0.001)
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	7018		2625		6563	
Clusters	2967		1583		3273	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	10.67		7.51		11.90	
Kleibergen-Paap rk Wald F-statistic (instrument)	60.958		31.129		71.742	
Sample	Age<55		Female, age<55		Male, age<60	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 5

Robustness Checks: The Long-term Impact of Air Pollution on Entrepreneurship

Dependent variable	**(1) Entrepreneurship**		**(2) Entrepreneurship**		**(3) Entrepreneurship**		**(4) Entrepreneurship**		**(5) Entrepreneurship**	
Average PM2.5 (μg/m^3) in previous years	0.001*	(0.001)	0.002*	(0.001)	0.002**	(0.001)	0.004**	(0.001)	0.005**	(0.002)
Control variables	YES		YES		YES		YES		YES	
City fixed effects	YES		YES		YES		YES		YES	
Month fixed effects	YES		YES		YES		YES		YES	
Year fixed effects	YES		YES		YES		YES		YES	
Observations	12946		12946		12946		12946		12946	
Clusters	5074		5074		5074		5074		5074	
Methodology	LPM		LPM		LPM		LPM		LPM	
Number of previous years	2016-2017		2015-2017		2014-2017		2013-2017		2008-2017	

Notes: Robust standard errors are clustered by household and reported in parentheses.

$*$ p <.10

$**$ p <.05

$***$ p <.01

TABLE 6

Robustness Checks: Controlling for Indoor Air Pollution Measures

Dependent variable	**(1) Entrepreneurship**		**(2) Entrepreneurship**		**(3) Entrepreneurship**	
PM2.5 (μg/m^3)	-0.009*	(0.005)	-0.010**	(0.005)	-0.011*	(0.006)
Indoor air pollution from smoking behaviors	-0.032***	(0.010)				
Indoor air pollution from spouse's smoking behaviors			-0.019	(0.013)		
Indoor air pollution from cooking fuel					-0.059***	(0.012)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	11837		11922		9287	
Clusters	4903		4830		4589	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	13.64		13.64		10.71	
Kleibergen-Paap rk Wald F-statistic (instrument)	185.976		186.127		114.620	

Notes: Robust standard errors are clustered by household and reported in parentheses.

$*$ p <.10

$**$ p <.05

$***$ p <.01

TABLE 7

Robustness Checks: Sub-group Analysis according to Economic Performance

	(1)		(2)		(3)	
Dependent variable	**Entrepreneurship**		**Entrepreneurship**		**Entrepreneurship**	
PM2.5 (μg/m^3)	-0.015	(0.019)	0.015	(0.011)	-0.029***	(0.010)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	835		1803		10308	
Clusters	479		776		4178	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	3.79		7.52		7.46	
Kleibergen Paap rk wald F-statistic (instrument)	14.339		56.524		55.643	
Sample	Bottom 10% economic status		Top 10% economic status		Exclude Top and Bottom 10% economic status	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 8

Robustness Checks: Sub-group Analysis according to Urban-Rural Area Type

Dependent variable	**(1) Entrepreneurship**		**(2) Entrepreneurship**	
PM2.5 (μg/m^3)	-0.006	(0.007)	-0.011*	(0.006)
Control variables	YES		YES	
City fixed effects	YES		YES	
Month fixed effects	YES		YES	
Year fixed effects	YES		YES	
Observations	6987		5959	
Clusters	2931		2143	
Methodology	2SLS		2SLS	
t-statistic (instrument)	9.85		9.51	
Kleibergen Paap rk wald F-statistic (instrument)	96.945		90.441	
Sample	Rural area		Urban area	

Notes: Robust standard errors are clustered by household and reported in parentheses.

$*$ p <.10

$**$ p <.05

$***$ p <.01

TABLE 9

Robustness Checks: Alternative Measure of Air Pollution

	(1)	
Dependent variable	**Entrepreneurship**	
Distance weighted PM2.5 (μg/m^3)	-0.021**	(0.010)
Control variables	YES	
City fixed effects	YES	
Month fixed effects	YES	
Year fixed effects	YES	
Observations	12946	
Clusters	5074	
Methodology	2SLS	
t-statistic (instrument)	8.05	
Kleibergen-Paap rk Wald F-statistic (instrument)	64.758	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 10

Robustness Checks: Potential Mediation Effects of Crime and Outside Investment

Panel A. City's crime rates

	(1)		(2)		(3)	
Dependent variable	**City's crime rates**		**Entrepreneurship**		**Entrepreneurship**	
PM2.5 ($\mu g/m^3$)	-3.235	(7.925)	-0.116	(0.324)	-0.276	(1.702)
City's crime rates					-0.049	(0.310)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	6075		6075		6075	
Clusters	3204		3204		3204	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	0.41		0.41		0.17	
Kleibergen-Paap rk Wald F-statistic (instrument)	0.167		0.167		0.028	

Panel B. City's outside investment

	(1)		(2)		(3)	
Dependent variable	**City's outside investment**		**Entrepreneurship**		**Entrepreneurship**	
PM2.5 ($\mu g/m^3$)	0.274***	(0.062)	-0.010**	(0.005)	-0.009**	(0.004)
City's outside investment					-0.003***	(0.001)
Control variables	YES		YES		YES	
City fixed effects	YES		YES		YES	
Month fixed effects	YES		YES		YES	
Year fixed effects	YES		YES		YES	
Observations	12946		12946		12946	
Clusters	5074		5074		5074	
Methodology	2SLS		2SLS		2SLS	
t-statistic (instrument)	13.95		13.95		13.92	
Kleibergen-Paap rk Wald F-statistic (instrument)	194.630		194.630		193.734	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 11

Robustness Checks: Excluding Non-entrepreneurial Population

	(1)	
Dependent variable	**Entrepreneurship**	
PM2.5 (μg/m^3)	-0.009**	(0.004)
Control variables	YES	
City fixed effects	YES	
Month fixed effects	YES	
Year fixed effects	YES	
Observations	12226	
Clusters	4955	
Methodology	2SLS	
t-statistic (instrument)	14.78	
Kleibergen-Paap rk Wald F-statistic (instrument)	218.491	
Sample	Exclude non-entrepreneurial population	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 12

Robustness Checks: Excluding Migrants

	(1)	
Dependent variable	**Entrepreneurship**	
PM2.5 (μg/m^3)	-0.008*	(0.005)
Control variables	YES	
City fixed effects	YES	
Month fixed effects	YES	
Year fixed effects	YES	
Observations	12240	
Clusters	4816	
Methodology	2SLS	
t-statistic (instrument)	13.53	
Kleibergen-Paap rk Wald F-statistic (instrument)	183.098	
Sample	Exclude migrants	

Notes: Robust standard errors are clustered by household and reported in parentheses.

$*$ p <.10

$**$ p <.05

$***$ p <.01

TABLE 13

Robustness Checks: Alternative Sample

Dependent variable	(1) Entrepreneurship		(2) Entrepreneurship	
PM2.5 (μg/m^3)	-0.011**	(0.006)	0.002	(0.010)
Control variables	YES		YES	
City fixed effects	YES		YES	
Month fixed effects	YES		YES	
Year fixed effects	YES		YES	
Observations	9720		9086	
Clusters	4292		3453	
Methodology	2SLS		2SLS	
t-statistic (instrument)	12.19		5.95	
Kleibergen-Paap rk Wald F-statistic (instrument)	148.632		35.427	
Sample	Exclude 2018		Same age group in CFPS	

Notes: Robust standard errors are clustered by household and reported in parentheses.

∗ p <.10

∗∗ p <.05

∗∗∗ p <.01

TABLE 14

Robustness Checks: Summary Statistics on Income Pre- and Post-choice of being an Entrepreneur

	All adults		Workers		Entrepreneurs		Welch's t-statistic
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Personal income (thousand yuan)	19.564	16.716	19.155	14.143	20.027	19.261	-0.436

Notes: Robust standard errors are clustered by household and reported in parentheses.

$*$ p <.10

$**$ p <.05

$***$ p <.01

FIGURE 1
Conceptual Model of the Processes

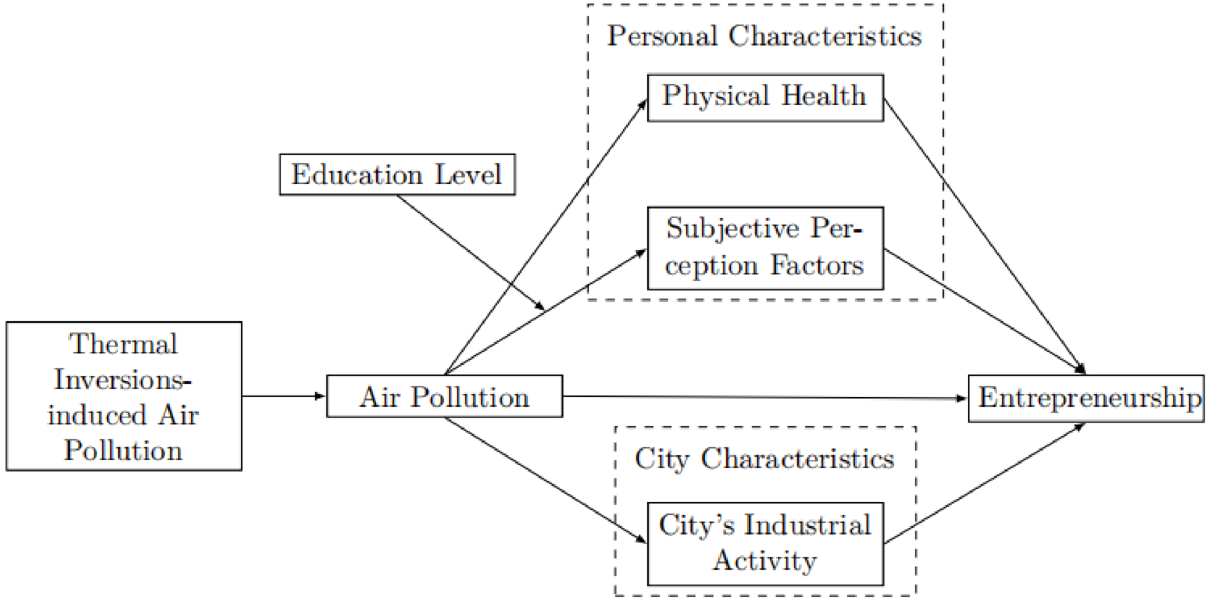

FIGURE 2
Trends in Annual Mean Air Pollution and Entrepreneurship