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Pollution matters: The political cost of information disclosure

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Abstract

This study firstly examines the causal effect of environmental information disclosure on political trust and then provides a novel psychological mechanism through which the effect occurred. Exploiting the staggered rolled-out implementation of a national program in China that provides real-time air-pollution information to the public, we find that air pollution adversely moderates the positive effect of information disclosure on political trust. Notably and surprisingly, this “adverse moderation” is concentrated in less polluted areas, where the lack of visible smog led citizens to remain unaware of the actual pollution levels until information is disclosed. Heterogeneity analysis shows that the adverse moderation is more pronounced among urban residents using Internet, an important source for pollution information. Furthermore, we establish that the causal effect operates through the channels of citizens’ mental well-being, demonstrated by a large and statistically significant increase in the risk of mild depression due to heightened concern over pollution.

1 | INTRODUCTION

With the rapid progress of information technology, the implementation of information disclosure and transparency measures have become increasingly popular policies for enhancing political trust (Bok, 1997; Cook et al., 2010). Among all the types of information being disclosed, environmental information disclosure has attracted widespread attention. Recent research has established that the disclosure of environmental information helps to heighten public awareness regarding pollution and increase willingness to pay for means of avoidance (Barwick et al., 2019;

Deschênes et al., 2017; Ito & Zhang, 2020; Tu et al., 2020). However, the causal impact of environmental information disclosure on political trust and the specific conditions under which these effects emerge remain poorly understood. This knowledge gap is especially pronounced when the disclosed information is adverse, such as air pollution. In addition, this issue is particularly significant in authoritarian regimes where grappling with environmental degradation and maintaining political trust are key to maintaining regime legitimacy.

In this paper, we provide one of the first few studies to assess the causal effect of environmental information disclosure on political trust in an authoritarian country. China's real-time pollution monitoring program provides an ideal case for this study. With the launch of the pollution information disclosure program in 2012, an automated nationwide monitoring network was established to collect and report pollution information to the public. Within 2 years, the initiative achieved comprehensive coverage of the entire nation. Taking advantage of the quasi-experimental variations that arose from the staggered rollout schedule of this air pollution monitoring program, we seize the opportunity to examine the causal impact of the information disclosure program on political trust, with cities launching this program in different waves serving as distinct treatment and control groups.

By employing a representative survey dataset derived from the China Family Panel Studies (CFPS) from 2012 to 2016, we apply Difference-in-Difference (DID) method to estimate the effect of air pollution information disclosure on citizens' political trust. A series of additional tests, including event study, placebo test, sample restrictions and extension are conducted to ensure the robustness of the baseline results. The results show that air pollution has a significantly adverse moderating effect on the impact of information disclosure on political trust, that is, a 100% increase in the concentration of PM_{2.5} in the month prior to the interview date led to an additional -0.013 unit decrease in the standardized political trust. This "adverse moderation" effect by local air pollution accounts for approximately 29.55% of the total observed magnitude. Moreover, the "adverse moderation" effect was primarily observed in cities with lower pollution levels. Our heterogeneity analysis revealed that the "adverse moderation" effect is more pronounced among urban male residents who have access to Internet, are not affiliated with the Chinese Communist Party (CCP), have children, and have finished their compulsory education. We explore the potential psychological channels through which this effect occurred: Exposure to pollution information prompted citizens to develop a heightened concern regarding environmental issues. Consequently, citizens bore a greater psychological burdens, exhibiting mild depression symptoms and self-dissatisfaction.

We seek to contribute to the literature on information disclosure and political trust on three fronts. First and foremost, the existing literature on how information disclosure affects citizens' trust toward the authority presents inconclusive results (Chanley et al., 2000; Grimmelikhuijsen et al., 2020; Grimmelikhuijsen & Meijer, 2014). Therefore, it is particularly important to examine the conditions under which information disclosure affects political trust. Different from previous researches, we use a nationally-represented panel dataset and employ reasonable identification strategy to provide robust evidence on the impact of air pollution information disclosure on political trust. Our findings highlight that exposure to high levels of adverse information (in our case, air pollution) locally can potentially undermine the impact of information disclosure on political trust.

Secondly, despite the existing literature's valuable explorations on the mechanisms through which information disclosure impact political trust, there remains a noticeable research gap in comprehending the underlying psychological mechanisms driving this influence. This study adopts an innovative perspective that integrates insights from psychology and environmental

economics, with a specific focus on individuals' psychological responses to pollution information disclosure. Previous studies demonstrate that air pollution exerts adverse effects on both the physical and psychological well-being of individuals (Chen et al., 2018; Chew et al., 2021; Sass et al., 2017; Zhang et al., 2017). We find that the pollution information disclosure has led to statistically significant increase in the risk of having mild depression. The mental health channel provides a novel perspective into the public's psychology when it comes to assess how information disclosure affects their political trust.

Thirdly, our exploration of the information disclosure effect on political trust and its underlying mechanisms is situated within the authoritarian context, setting our work apart from previous research that has primarily focused on democratic regimes. Although the CCP has constructed a repressive apparatus designed to control the information (King et al., 2013, 2014, 2017; Repnikova, 2017; Stockmann, 2013), the CCP has also augmented the government's responsive and consultative side of institutions, providing mechanisms for citizens to uncover more information and voice their opinions (Chen et al., 2016; Truex, 2016). It is thus imperative to understand how disclosing both positive and negative environmental information may affect citizens' political trust toward the local government, which is a key to maintaining CCP's regime legitimacy.

This paper is structured as follows: Section 2 provides literature review on the impact of information disclosure and political trust, and discusses why air pollution may have an adverse moderation on political trust. Section 3 reviews the institutional background of China's environmental information disclosure program. Section 4 provides econometric methods and data sources used in the estimation. Section 5 presents the main estimates and Section 6 discusses psychological mechanisms which may explain the results. Section 7 concludes.

2 | LITERATURE REVIEW

Information disclosure and transparency have consistently been regarded as fundamental pillars of effective governance (Hood, 2010), and are increasingly being adopted as an effective approach to promote public supervision and engagement in diverse areas, including public health, environmental regulation, fighting corruption, and local governance (de Boer et al., 2018; Li, 2023; Porumbescu et al., 2017; Wu et al., 2022; Zhu et al., 2023). Not only do they serve as deterrents to corruption (Bertot et al., 2010), but they also promote accountability (Pina et al., 2007) and cultivate an informed and understanding citizenry (Cook et al., 2010). Another enduring supportive argument and assumption about transparency centers on its effects on the public trust in government policies and institutions. It is believed that it mitigates the challenges of long-standing and widespread declines in levels of citizen trust in government (Chanley et al., 2000).

According to Grimmelikhuijsen (2012, p. 55), transparency is the availability of information about an organization or actor which allows external monitoring of their internal workings or performance. Political trust refers to citizens' beliefs that the government is improving their welfare, which underpins political support and regime legitimacy, particularly during periods of unexpected downturns (Easton, 1965). The media, politicians, citizens, and groups of activists who put pressure on the government all view transparency as a solution that will almost automatically lead to more trust in government. Their basic assumption is that if government is more transparent, then there will be an "open culture" with less room for cover-ups, secrets, and mistakes (Bertot et al., 2010). Increased citizen knowledge of government processes and performance will also increase understanding and trust in government (Bok, 1997; Cook

et al., 2010). Therefore, a government that is more transparently willing to disclose its performance through measurable indicators may be thought of as more trustworthy by the public.

A broad swath of empirical literature has also been devoted to exploring the effect of government transparency on citizens' trust, with greater transparency sometimes associated with more trust (Tolbert & Mossberger, 2006), sometimes less trust (Worthy, 2010), and sometimes with little effect on or correlation with trust at all (Grimmelikhuijsen et al., 2013, 2020; Mabillard & Pasquier, 2016). The existing literature explores several possible mechanisms through which information disclosure may affect citizens' trust. First, the media through which citizens access information plays a crucial role in shaping their trust. The portrayal of the government in the media (Worthy, 2013) and the use of social media or e-government websites for accessing information can differentially affect citizens' trust (Porumbescu et al., 2017). Second, the national cultural context is a key factor as transparency may be less effectively in affecting political trust in cultures with greater distance between authorities and citizens (Grimmelikhuijsen et al., 2013). Third, the content of disclosed information matters. Grimmelikhuijsen et al. (2013) demonstrated that information of negative outcome impacted citizens' trust more than information of positive outcomes.

A highly relevant perspective regarding information transparency study is the information disclosure of air pollution, which is a negative information. The existing literature show that information disclosure of air pollution increases citizens' environmental awareness (Barwick et al., 2019; Wang et al., 2021; Xie et al., 2023), thus influencing citizens' behavioral decisions (Barwick et al., 2019; Deschênes et al., 2017; Ito & Zhang, 2020). However, the aforementioned literature mostly focuses on measuring the impacts of environmental information disclosure on pollution-related avoidance behavior, instead of political attitudes. Previous research mostly related to the theme of this study was conducted by Grimmelikhuijsen and his colleagues. In his 2010 work, Grimmelikhuijsen (2010) focused on the decision-making efforts regarding air quality policy to combat air pollution in a large Dutch municipality. He found that transparency has a limited but significant negative effect on trust in government. That may be explained by a gap between public expectations of rational decision-making and the reality of the chaos involved in public decision-making that is exposed through transparency. Grimmelikhuijsen and Meijer (2014) used air pollution maps to probe transparency and found that it did affect some citizens (particularly less knowledgeable and less trusting ones) but not others. By comparing Dutch information transparency pertaining to air pollution and South Korean information transparency regarding identity theft, Grimmelikhuijsen et al. (2013) suggested that national cultural values play a significant role in how people perceive government transparency and trust in government.

Some studies have shown that the exposure to air pollution may increase people's blood pressure, hormones, insulin resistance, and biomarkers of oxidative stress and inflammation (Li et al., 2017). Air pollution is also documented to be correlated with stress, anxiety, impatience, and anti-social behavior (Chew et al., 2021; Sass et al., 2017). Existing literature has shown that air pollution has negative impact on mental health (Chen et al., 2018; Zhang et al., 2017), cognitive performance (Zhang et al., 2018) and political trust (Alkon & Wang, 2018; Horz et al., 2023; Yao et al., 2022). Therefore, we build this theoretical framework in Figure 1, air pollution serves as a moderator in the impact of information disclosure on political trust. Although information disclosure may increase public's evaluations of the local governance, visible high levels of PM_{2.5} can alter perceived pollution levels via salience, which could then evoke negative moods and make individuals more impatient or anti-social. We provide a possible psychological mechanism to explain how the impacts of information disclosure on political trust occurred, which is largely understudied.

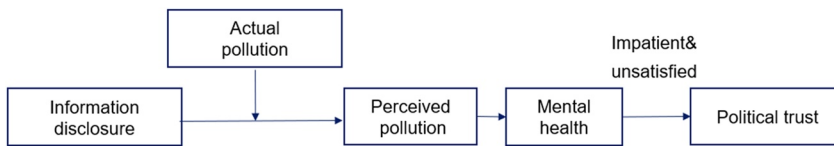


FIGURE 1 Theoretical framework for the “disclosure effect”—the role of pollution. We plot the main framework for the results and potential mechanism for the impact of environmental information disclosure on political trust.

This study stands as an endeavor to examine the causal impact of environmental information disclosure on political trust in an institutional context different from democratic regimes: China. First, there is very limited research on the impact of providing pollution-related information in developing countries despite the fact that they experience the worst pollution in the world. China’s environmental disclosure program covers 98% of its population, representing a significant shift in environmental policy among developing countries. Second, China’s information disclosure primarily served as a way for the central government to address the principal-agent problem, as emphasized by Greenstone et al. (2022). Unlike many western democracies, the primary objective of this disclosure was not driven by citizen demands or to enhance citizens’ trust, thus minimizing the risk of reverse causation in empirical analysis. This is evident from the Chinese government’s proactive efforts to mitigate pollution ahead of a military parade to ensure clear and blue skies on the day of the parade in Beijing (Alkon & Wang, 2018). Third, this study also illuminates the potential varied consequences of such disclosure on political trust within an authoritarian regime framework, where the cultivation of political trust plays a crucial role in ensuring the smooth functioning, upholding regime legitimacy, and stability of a political system (Hutchison & Johnson, 2011; Marien & Hooghe, 2011). Moreover, given the prevalence of self-censorship among Chinese, our estimation provides a conservative lower bound for the impact of information disclosure on political trust.

3 | ENVIRONMENTAL INFORMATION DISCLOSURE IN CHINA

China has long experienced the weak enforcement of environmental regulation at the local level, primarily attributed to the dearth of reliable pollution data. Until 2012, most Chinese cities faced significant challenges in providing real-time pollution measurements, which hindered public access to pollution information. In 2000, the Ministry of Environmental Protection (now known as the Ministry of Ecology and Environment) initiated the disclosure of the Air Pollution Index (API) for certain tier-1 and tier-2 cities. Notably, the monitoring stations were initially overseen by local environmental bureaus, whose leaders were appointed by local governments. Unfortunately, the absence of automated data collection and validation mechanisms resulted in data manipulation, either by omitting readings from highly polluted days or intentionally downplaying the seriousness of air pollution (Ghanem & Zhang, 2014; Greenstone et al., 2022). In this way, public awareness of air pollution and its associated health risks was extremely limited before 2012. Government agencies, the media, and the general public often referred to the PM_{2.5} as “fog” rather than “smog.” Since fog is commonly associated with natural beauty in poetry and music, there was little public awareness of the health risks posed by PM_{2.5} (Barwick et al., 2019).

The year 2012 marked a notable turning point in China’s efforts to tackling pollution, as a series of measures aimed at enhancing pollution information disclosure were implemented. The

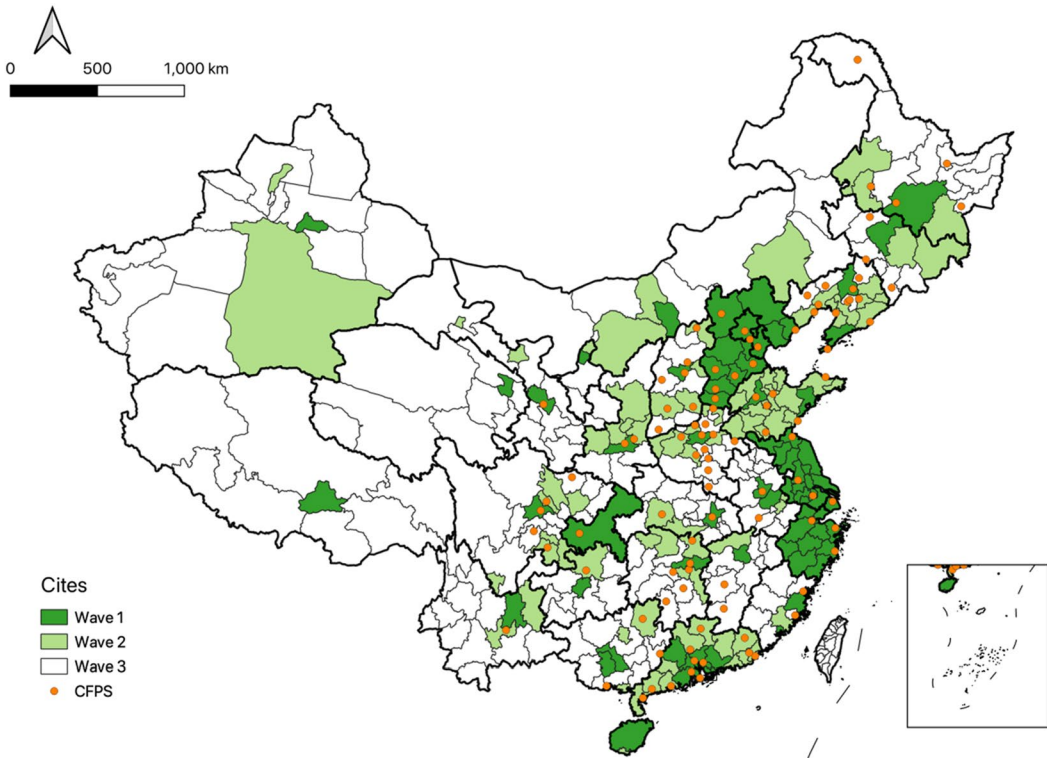


FIGURE 2 The distribution of three waves of environmental monitoring stations in China. The dots represent the cities where respondents were surveyed in China Family Panel Studies dataset, which is the data source for subsequent analysis.

first was the revision of air quality standard in 2012, when the Air Quality Index was introduced, replacing the previous API. The update included more stringent standards for PM₁₀, and added PM_{2.5}, O₃, and CO. Second, an automated nationwide monitoring network was established to collect and report pollution information across the country. With data from over 1600 monitoring stations now updated on an hourly basis, individuals can conveniently access real-time information on air pollution through various channels, including MEE's website, provincial and municipal environmental bureau websites, and numerous mobile apps and third-party websites. The introduction of the automated monitoring system significantly improves public access to pollution information.

The implementation of the automated monitoring system was carried out in three waves, as depicted in Figure 2. The first wave involved 74 key polluting cities, including provincial capitals and special administrative zones, with a total of 496 stations. These cities were required to complete the upgrade by January 1, 2013. The second wave involved 116 cities from the list of Environmental Improvement Priority Cities and the list of National Environmental Protection Exemplary Cities (both lists were compiled before 2007). These cities hosted 449 stations and were mandated to join the system by January 1, 2014. The third wave called for the remaining 177 cities to build 552 stations by the end of November of 2014. Crucially, the automation policy was implemented at the city level, with different stations within each city automated simultaneously to ensure uniform coverage across the monitoring network. Until 2016, the newly established monitoring network covered more than 98% of the entire country. The disclosure of air pollution

information has yielded notable improvement in the quality of air pollution data and extended public access to pollution information.

Importantly, the roll-out schedule for monitoring stations and information disclosure is un-correlated with day-to-day variation in local pollution levels. The three-wave schedule was primarily based on predetermined hierarchical designations: administrative centers in the first wave, environmental priority cities in the second wave, and the remaining cities in the last wave. Related researches have indicated that variation in air pollution concentration was largely random across roll-out dates in different cities (Greenstone et al., 2022; Wang et al., 2021). Moreover, no national policies coincided with the schedule or the spatial coverage of the information program. This information disclosure policy offers an ideal context for our study on the causal impact of information disclosure on political trust.

4 | DATA AND METHOD

4.1 | Data

We employ a panel dataset derived from the CFPS, a nationally representative survey launched in 2010 by the Institute of Social Science Surveys at Peking University. Our analysis draws upon data from three waves of the CFPS survey, conducted in 2012, 2014, and 2016. The CFPS survey follows a rigorous multistage probability sampling procedure, including 162 counties across 25 provinces that collectively represent approximately 95% of China's total population. Additionally, the CFPS provides rich information on the demographic information, interview month, and city of residence for each respondent, enabling us to match them with city-level social and economic characteristics, as well as to indicate whether the respondents are surveyed before and after the air pollution disclosure program. The orange dots in Figure 2 shows the distribution of cities where the respondents participating in CFPS. Out of the total 128 cities in our sample, there are 23 (17.97%) cities had information disclosure prior to the launch of the CFPS2012, 74 (57.81%) cities between CFPS2012 to CFPS2014, and the remaining 31 (24.22%) cities initiated the disclosure of air pollution before the launch of the CFPS2016.

4.1.1 | Measures of political attitudes

Since the 2012 wave of the CFPS, political trust in local government officials has been consistently measured. Respondents were requested to provide ratings on a scale from 0 to 10, where 0 denotes a complete lack of trust and 10 reflects extremely high levels of trust. The original question posed was "To what extent do you disagree or agree with the statement: 'Overall, I trust local officials?'" (0 = completely disagree; 10 = completely agree). This 0–10 scale serves as our proxy measure for political trust. We used this as our key dependent variable.

We incorporate other trust measures and mental health indicators into our further analysis. The CFPS includes questions encompassing trust measures (e.g., doctors, neighbors, parents, Americans) and local government performance evaluations. By including these alternative attitudes measures in our robustness test, we are able to thoroughly examine the extent to which environmental information exposure may shape individuals' political attitudes. Furthermore, we also consider respondents' mental health status in our analysis. The CFPS asks respondents a series of questions regarding their mental health, including: "To what extent did you feel stressed

in the past month?"; "To what extent did you feel confident about your future?"; and "Overall, how satisfied are you with your life?" By incorporating these measures into our analysis, we aim to assess the extent to which individual-level factors such as stress, confidence, and life satisfaction may act as a mechanism for this "adverse moderation" effect. To maintain consistency of measurement across indicators, we standardize all variables measuring perceptions to 0–1.

4.1.2 | Measurements of air pollution

To overcome the limitations in the reliability and temporal coverage of PM_{2.5} data prior to the implementation of the disclosure program, we adopt a novel approach that utilizes aerosol optical depth (AOD) data obtained from NASA's Terra satellite to compute county-level PM_{2.5} concentrations. This dataset has been widely used in economics papers (Xie et al., 2023; Yao et al., 2022). Greenstone et al. (2022) demonstrates that the automated monitoring systems have led to significant improvements in the quality of China's air pollution data, as post-automation trends from real-time monitoring data are closely aligned with those derived from satellite-based pollution measures. In this way, this approach provides us with a more geographically detailed and reliable measure of PM_{2.5}.

4.1.3 | Automation dates across cities

We manually collect information on the automation dates of air monitoring stations in all cities from local government websites. Notably, cities exhibited diverse implementation timelines, with the initial wave of monitoring stations established between May and December 2012 in 74 major cities, including key population and economic centers like the Beijing–Tianjin–Hebei Metropolitan Region, the Yangtze River Delta, the Pearl River Delta, direct-administered municipalities, and provincial capitals. Subsequent waves followed at later dates. The variation in station automation timing across cities provides an opportunity to investigate the causal impact of the information disclosure on political trust, utilizing cities from different launch waves as treatment and control groups.

4.1.4 | Additional data sources

To enhance our data analysis, we collect supplementary information on key variables potentially influencing the information disclosure and political trust. Firstly, station-level monthly weather conditions, including temperature, precipitation, cloud thickness, relative humidity, wind speed, and air pressure, are sourced from the China Meteorological Data Sharing Service System. By controlling for weather factors, we aim to isolate the effect of information exposure on political trust from weather-related factors, which are well-documented to affect individuals' emotional states (Graff Zivin et al., 2020). We employ the inverse-distance weighting algorithm to convert weather variables from station to county level. Secondly, city-level socio-economic indicators, including population and GDP per capita, are obtained from the China City Yearbook. Thirdly, we collect daily Baidu Index data for the most-searched pollution-related keywords, "smog" and "PM_{2.5}," to proxy for public awareness and active information-seeking behavior related to pollution.

Finally, we merge all these variables with CFPS respondents based on the interview location and date. We drop observations with missing values for our key dependent variables: political trust. The summary statistics are shown in Table 1 and Table S1. We finally have an unbalance panel with 77,275 observations. As shown in Table 1, the political trust has an average of 0.498, which is similar to related research (Sha, 2023). The gender ratio is balanced, the average age is 47 years old, and 88% of respondents are married. The average years of schooling are 7.57, and the average annual household income per capita is about CNY 47,864. Average county-level monthly PM2.5 concentrations in our sample period are $38.53 \mu\text{g}/\text{m}^3$. Monthly concentrations of PM2.5 vary from 4.11 to $226.69 \mu\text{g}/\text{m}^3$, with a standard deviation of $19.96 \mu\text{g}/\text{m}^3$, close to the other research using the same dataset (Chen et al., 2022). Summary statistics on variables of weather conditions and regional economic development fall within ranged that can be reasonably expected.

4.2 | Empirical strategy

Leveraging the joint variation in the timing of the information disclosure and the air pollution levels, we apply the DID approach to estimate the political outcome of the information disclosure, drawing inspiration from Barwick et al. (2019). The basic model (Equation 1) is:

$$\begin{aligned} \text{Trust}_{ijkt} = & \alpha + \beta_1 \log \text{PM2.5}_{jkt} + \beta_2 \log \text{PM2.5}_{jkt} \times \text{Disclosure}_{kt} \\ & + \beta_3 \text{Disclosure}_{kt} + \gamma_1 X_{ijkt} + \gamma_2 W_{jkt} + \delta_i + \lambda_t + \varepsilon_{ijkt} \end{aligned} \quad (1)$$

where the outcome variable Trust_{ijkt} is respondent i 's political trust in county j in city k at date t ; the variable disclosure_{kt} is binary, with value 1 indicating that the information disclosure is adopted in city k in date t and value 0 otherwise; $\log \text{PM2.5}_{jkt}$ is the log of the 30-day average concentration of PM2.5 prior to interview date t in county j in city k . We control for time-varying county-level weather conditions and city-level socio-economic characteristics W_{jkt} that could correlate with the information disclosure and respondents' political trust. X_{ijkt} is a set of time-varying individual covariates: age, age squared, urban registration status (HUKOU), marital status, household income, and years of schooling. In addition, we control for individual fixed effects δ_i for the confounding impacts arising from unobserved factors of the individual respondent that do not change over time, such as the differences in personal preferences toward the government. We add month-by-year fixed effects λ_t to account for shocks common to all observations in a particular month of the year. We allow for idiosyncratic differences, ε_{ijkt} , to be correlated across individuals within a county, and clustered standard errors at the individual level.

In Equation (1), β_1 measures the marginal impact of air pollution on political trust, denoting "the gradient of political trust to air pollution before the information disclosure" by Barwick et al. (2019). The interaction term, β_2 , which is our primary interest, captures the differential political impact of information disclosure across respondents exposed to varying levels of air pollution. In other words, β_2 quantifies how air pollution influences respondents' political reactions to information disclosure. In particular, if β_2 is negative and β_3 is positive, it implies that air pollution adversely moderates the effect of access to air-pollution information on political trust.

We conduct a series of robustness tests to validate the baseline results are unlikely to be biased by unobservable confounders. Specifically, if we expect that cities with a higher level of air pollution are more likely to implement the program sooner (or later), we would observe differential pre-trends in air pollution before the start of the program. We do not find such pre-trends in the

TABLE 1 Summary statistics.

Variable	Definition (unit)	Obs	Mean	SD	Min	Max
Social trust						
Political trust	Levels of trust in local government officials	77,275	0.498	0.260	0	1
Parent trust	Levels of trust in respondent's parents	76,946	0.878	0.222	0	1
Neighbor trust	Levels of trust in respondent's neighbors	77,202	0.609	0.261	0	1
American trust	Levels of trust in Americans	75,410	0.208	0.242	0	1
Stranger trust	Levels of trust in strangers	77,032	0.183	0.209	0	1
Doctor trust	Levels of trust in doctors	77,211	0.630	0.272	0	1
Overall social trust	Overall levels of social trust	77,039	0.544	0.498	0	1
Other attitudes						
Government satisfaction	Satisfaction of local government performance	74,594	0.608	0.225	0	1
Awareness of environment problem	Awareness of environment problem	76,101	0.626	0.273	0	1
Awareness of corruption problem	Awareness of corruption problem in China	74,820	0.652	0.284	0	1
Awareness of inequality problem	Awareness of inequality problem in China	76,187	0.684	0.248	0	1
Personal happiness	Respondent's personal happiness	77,196	0.739	0.234	0	1
Life satisfaction	Satisfaction with respondent's own life	77,222	0.648	0.267	0	1
Mental health	Mental health level base on K-6 indicator	77,275	0.197	0.159	0	1
Mild depression	Mild depression base on K-6 indicator	77,275	0.522	0.500	0	1
Moderate depression	Moderate depression base on K-6 indicator	77,275	0.187	0.390	0	1
Severe depression	Severe depression base on K-6 indicator	77,275	0.036	0.187	0	1

TABLE 1 (Continued)

Variable	Definition (unit)	Obs	Mean	SD	Min	Max
Control variable: City-level						
Population	Population (million)	77,275	5.876	4.410	0.451	33.921
GDP per capita	GDP per capita (CNY)	77,275	45,982.645	28,760.662	7712	146,518
Baidu index of haze	City-level monthly Baidu index of haze	40,560	39.158	91.890	0	6863.807
Baidu index of pollution	City-level monthly Baidu index of pollution	40,560	20.316	27.736	0	209.710

robustness test based on Equation (2). Apart from event study, we also conduct placebo test that manipulated the timing of information exposure, an examination of the effects of information disclosure on other types of trust, and various sample restrictions.

$$\begin{aligned} \text{Trust}_{ijkt} = & \alpha + \beta_1 \log \text{PM2.5}_{jkt} + \sum_{q \neq -1} \beta_{2q} \log \text{PM2.5}_{jkt} \times \text{Disclosure}(t = q)_{kt} \\ & + \sum_{q \neq -1} \beta_{3q} \text{Disclosure}(t = q)_{kt} + \gamma_1 X_{ijkt} + \gamma_2 W_{jkt} + \delta_i + \lambda_t + \varepsilon_{ijkt} \end{aligned} \quad (2)$$

5 | RESULTS

5.1 | Baseline results

In this section, we present the regression results from the Equation (1), and the findings are displayed in Table 2. We gradually include control variables to the baseline model, as presented across columns of Table 2. The incremental introduction of individual-level, city-level, and weather factors causes little changes in the estimates of β_2 and β_3 , which suggests a limited role observed and unobserved confounding factors played in our regression specification.

In Table 2, the coefficients reveal significant insights. β_2 , the coefficient for Disclosure, is significantly positive, whereas the coefficient of interaction term, β_3 , is significantly negative. The estimated coefficient of interaction term is negative and statistically significant at the 5% level, even after controlling for all relevant covariates. These findings indicate that air pollution has a statistically significant diminishing effect on the relationship between information disclosure and political trust. Specifically, after the information disclosure, a 100% increase in the concentration of PM2.5 would lead to a negative 0.013 unit decrease in the standardized political trust, which is estimated to be statistically significant at the 5% level. The negative coefficient of interaction term suggests that the local air pollution levels act as a moderator, dampening the otherwise positive impact of information disclosure on political trust. This “adverse moderation” effect by local air pollution accounts for approximately 29.55% of the total observed magnitude.

The aforementioned empirical findings provide compelling evidence regarding the heterogeneous nature of the effect of information disclosure on political trust across cities characterized by varying levels of pollution. To further unravel this intricate moderation effect, we classify respondents into four groups based on the mean PM2.5 levels observed in their residing cities during the sample period, and re-estimated the baseline model. The results reveal that, for cities

TABLE 2 Baseline results.

	(1)	(2)	(3)	(4)
Dependent variable	Political trust (0–1)			
lnPM2.5	−0.005 (0.006)	−0.006 (0.006)	−0.006 (0.006)	−0.002 (0.007)
Disclosure	0.060*** (0.020)	0.053*** (0.020)	0.054*** (0.020)	0.044** (0.021)
lnPM2.5#Disclosure	−0.017*** (0.005)	−0.016*** (0.005)	−0.016*** (0.005)	−0.013** (0.006)
Individual controls	No	Yes	Yes	Yes
City controls	No	No	Yes	Yes
Weather controls	No	No	No	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Month by year fixed effect	Yes	Yes	Yes	Yes
<i>N</i>	77,275	77,275	77,275	77,275
Adj. <i>R</i> ²	0.3421	0.3431	0.3431	0.3433
DV mean	0.497			

Note: The dependent variable (DV) is standardized political trust. lnPM2.5 is the log of the average concentration of PM2.5 of 30 days prior to the interview date in the county where respondent was surveyed. All regressions across columns control for individual fixed effects and month by year fixed effects. Individual controls include age, age squared, years of schooling, HUKOU status, marriage status, and family size. Weather controls include temperature, wind speed, precipitation, pressure, sunlight duration, and humidity. City controls include GDP per capita and population. Standard errors in parentheses, clustered at the household level.

***, **, * indicate significance at 1%, 5% and 10%.

with higher pollution levels (as depicted in Columns 4 and 5 in Table 3), the adverse moderation of air pollution was not observed. In contrast, for cities characterized by lower pollution levels, the adverse moderation effect become evident (Column 2 and 3). Strikingly, respondents residing in cities with slightly below-average pollution levels, as shown in Column 3, emerge as the primary drivers of this effect. This particular group manifested the most pronounced coefficient magnitude among the four groups, with a coefficient of -0.055 , highlighting the salient role of air pollution played in the causal effect of environmental information disclosure on shaping political trust.

Our findings offer valuable insights into the differential impacts of information disclosure on political trust across cities characterized by varying levels of pollution. Evidently, in cities with higher pollution levels, it is plausible that residents are already aware of the air pollution before the introduction of the monitoring stations, because of the visibility of smog. Consequently, residents already possessed a heightened environmental awareness, which did not significantly change with the information disclosure program. Conversely, individuals living in areas with lower pollution levels, but not the lowest, are more susceptible to a noticeable shift in their perception of air quality after information disclosure. This group of people might not possess awareness regarding the existence of any air pollution in the absence of an air monitoring system. Upon being exposed to the disclosed information, they became aware of the severe air quality conditions, potentially fostering negative perceptions toward the local officials. Figure S1 further illustrates the heterogeneity of information disclosure on political trust across cities with varying

TABLE 3 Baseline results: city pollution.

	(1)	(2)	(3)	(4)	(5)
	Political trust (0–1)				
Dependent variable	Full-sample	0%–25%	25%–50%	50%–75%	75%–100%
lnPM2.5	−0.002 (0.007)	0.006 (0.012)	0.020 (0.018)	−0.001 (0.023)	0.018 (0.019)
Disclosure	0.044** (0.021)	0.117** (0.057)	0.184*** (0.069)	0.107 (0.084)	0.078 (0.064)
lnPM2.5#Disclosure	−0.013** (0.006)	−0.035** (0.018)	−0.055*** (0.020)	−0.029 (0.022)	−0.020 (0.016)
Individual controls	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes	Yes
Month by year fixed effect	Yes	Yes	Yes	Yes	Yes
N	77,275	18,801	16,901	15,314	19,724
Adj. R ²	0.3433	0.3160	0.3123	0.3831	0.3662

Note: We divide cities into four groups based on their air pollution level during the sample period. Column (2) represents the cleanest cities while column (5) is the most polluted cities. Standard errors in parentheses, clustered at the household level.

***, **, * indicate significance at 1%, 5% and 10%.

levels of air pollution. In summary, the logic in Figure 2 is supported and potential underlying mechanisms that we will further explore in Section 6.

5.2 | Robustness

To provide further support for the validity of our baseline results, we conduct a comprehensive set of robustness checks, including (1) event-study analysis, (2) placebo test that changed the timing of environmental information exposure, (3) examination of the impact on other types of trust and attitudes (placebo test), (4) sample restrictions, and (5) extension to CFPS2018 data.

First, we conduct an event-study analysis using different time periods, including 6-month and 3-month intervals. We plot the estimates of coefficients and their 95% confidence intervals in Figure 3. The results display a robust and consistent pattern that prior to the implementation of the information disclosure, the coefficients were small and statistically insignificant. After the information disclosure, the disclosure coefficient is significantly positive. Conversely, the interaction term exhibited a statistically significant negative effect, indicating that higher pollution levels moderated the otherwise positive impact of information disclosure. The dynamic effect also showed that the “adverse moderation” effect cannot persist for a long time, and could only exist for about 9 months. This event study results suggest that the impacts of staggered implementation of air monitoring stations was unrelated to preexisting trends in the relationship between political trust and air pollution information disclosure, reaffirming the robustness of our baseline findings across varying time intervals.

We also perform a placebo test by replacing the information disclosure program with a placebo policy dummy defined as occurring one, two, or three years prior to the actual start date

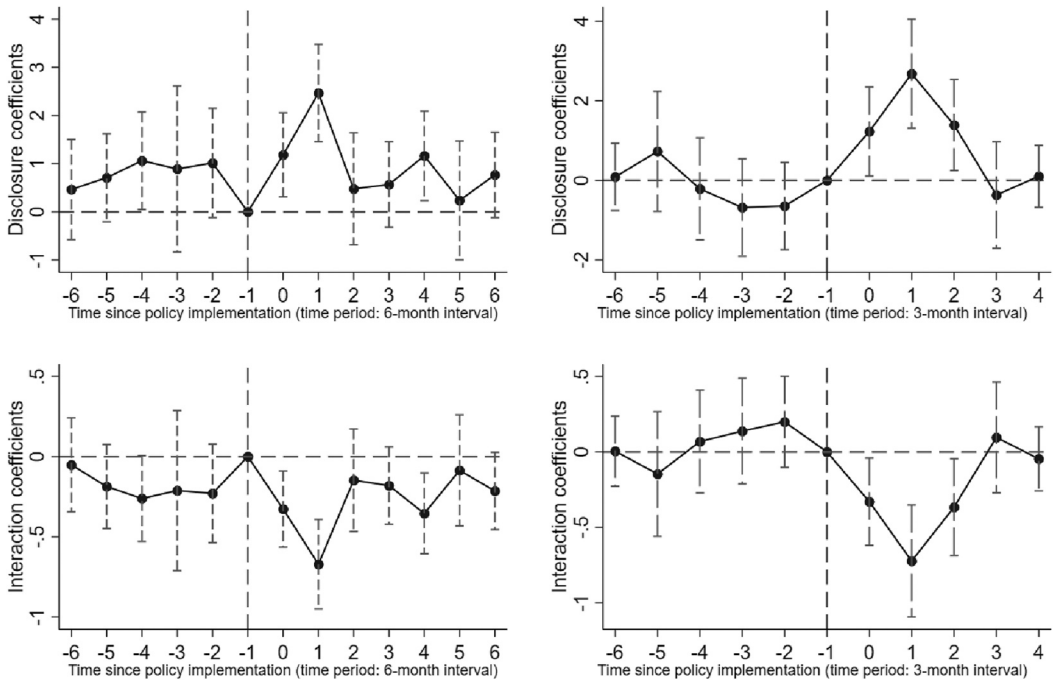


FIGURE 3 Event study estimates of information disclosure on political trust. The regression equation is specified in Equation (2). The dependent variable, is standardized political trust (0–1). Coefficient of β_3 (disclosure coefficient), coefficient of β_2 (interaction coefficient), as well as 95% confidence intervals, with different time interval (3 and 6 months), are plotted in the figure.

of the true timing. The results, as shown in Table S2, indicate no statistically significant changes in the coefficient. Moreover, we use other trust-related variables, such as trust in parents, doctors, and Americans, as dependent variables instead of political trust (see Table S3). We do not find a similar pattern for individuals' trust toward other entities, suggesting information disclosure had a distinct effect on political trust toward the local officials. Conversely, the CFPS survey includes a similar indicator to political trust, wherein respondents assess the performance of local governments. We use this indicator as an additional outcome variable, and the results are presented in Table S4. The negative sign of the interaction term coefficient and its statistical significance validate the robustness of our findings. Furthermore, we divide the sample into northern and southern China, finding that the “adverse moderation” effect mainly manifests in southern China where air pollution level is lower (Chen et al., 2013). This regional division aligns with our baseline results shown in Table 3.

Finally, we use different sample restrictions to support our baseline results. We exclude respondents who answered the survey outside the regular survey window, which were when they got interviewed during extreme weather conditions, and when cities implemented pollution monitoring in the early 2000s, mainly in the provincial capitals. We also excluded respondents who had lived in a different city other than their usual residential area during the sample period. The results of our sample restriction analysis, presented in Table S5, are consistent with our baseline results. We also extend the sample data to CFPS2018, and the robust results are shown in Table S6. These robustness checks provide further evidence that our baseline findings are reliable and robust.

5.3 | Heterogeneity

Having established a robust causal relationship between information disclosure and political trust, we extend our inquiry to investigate how the magnitude of the “adverse moderation” varied across different subgroups of the population. In essence, our results suggest that information sensitivity plays a crucial role in determining citizens’ responsiveness to certain effects. Those individuals who have access to Internet and a strong ability to process the information tend to exhibit a more pronounced response, as demonstrated in Table 4. This heightened responsiveness is particularly prominent among urban male residents who use Internet, not affiliated with the CCP, have children, have finished compulsory education (secondary school).

Given that information disclosure on air pollution is primarily disseminated through internet-based platforms, we hypothesize that individuals who use the Internet as their main information source are more likely to exhibit a greater impact. The results, as presented in column (2) in Table 4, demonstrate a significant difference in the moderation effects, based on whether individuals use or do not use the Internet. Specifically, for individuals who use the Internet, the coefficient of the interaction term is -0.022 , which is 70% higher than the baseline results. This finding suggests that individuals who rely on the Internet to obtain information are more susceptible to the impact of environmental information disclosure.

We also find that individuals affiliated with the CCP are less susceptible to the impact of information disclosure, possibly due to the constant influence of political ideology. The CCP’s emphasis on state control and regulation may render its members less responsive to the impact of new environmental information disclosure. Moreover, the presence of children in households lead to a higher awareness of air pollution, as indicated by the interaction term’s coefficient (-0.017), which is larger in magnitude than the baseline result. This effect can be attributed to parents’ heightened concerns about their children’s health and well-being, which motivated them to be more attentive to environmental concerns (Zhang et al., 2018). Interestingly, our results also suggest that individuals who have completed higher education exhibited a pronounced impact, which may result from their increased awareness and understanding of environmental issues. Higher education can enhance individual’s ability to process and interpret complex information, leading to greater sensitivity to environmental concerns.

6 | MECHANISMS

This section seeks to explore the underlying mechanisms behind the effects of information disclosure on political trust. Specifically, we propose mental health as a potential channel. We hypothesize that information disclosure regarding air pollution may influence political trust by adversely affecting residents’ mental well-being due to heightened concern on air pollution.

According to our exploration of the potential channel, residents became more concerned about air pollution and had increased environmental concern after being exposed to pollution information. It increased residents’ psychological burden and dissatisfaction with government performance, thereby reducing political trust. We also estimated an event-study specification of the Baidu Index, which implied city-level search intensity using the online search volume of pollution-related keywords on Baidu. As plotted in Figure 4, after information disclosure, the search intensity related to “haze” and “pollution” significantly increased. Moreover, exposure to environments with more severe air pollution directly reduced residents’ satisfaction with their own lives, thereby reducing political trust.

TABLE 4 Heterogeneity analysis.

Panel A	(1)		(2)		(3)		(4)		(5)		(6)	
	Use internet		Yes		CCP member		Yes		Have children		Yes	
InPM2.5	-0.008 (0.009)	0.004 (0.009)	-0.003 (0.007)	0.012 (0.019)	-0.003 (0.007)	0.012 (0.019)	-0.005 (0.014)	-0.003 (0.007)	-0.005 (0.014)	-0.003 (0.007)	-0.003 (0.007)	-0.003 (0.007)
Disclosure	0.022 (0.027)	0.078*** (0.029)	0.046** (0.021)	0.016 (0.063)	0.046** (0.021)	0.016 (0.063)	0.016 (0.063)	0.016 (0.063)	0.016 (0.063)	0.016 (0.063)	0.016 (0.063)	0.057** (0.023)
InPM2.5#Disclosure	-0.006 (0.007)	-0.022*** (0.008)	-0.014** (0.006)	-0.004 (0.017)	-0.014** (0.006)	-0.004 (0.017)	-0.004 (0.017)	-0.004 (0.017)	0.002 (0.011)	0.002 (0.011)	-0.017*** (0.006)	-0.017*** (0.006)
N	48,097	29,174	71,862	5412	71,862	5412	5412	5412	17,255	17,255	60,020	60,020
Adj. R ²	0.3141	0.3632	0.3363	0.4258	0.3363	0.4258	0.4258	0.4258	0.3413	0.3413	0.3442	0.3442
Panel B	(1)		(2)		(3)		(4)		(5)		(6)	
	Male		Yes		Urban residents		Yes		Finish compulsory education		Yes	
InPM2.5	-0.008 (0.009)	0.005 (0.009)	0.005 (0.008)	-0.008 (0.011)	0.005 (0.008)	-0.008 (0.011)	-0.008 (0.011)	-0.008 (0.011)	-0.004 (0.010)	-0.004 (0.010)	0.003 (0.008)	0.003 (0.008)
Disclosure	0.038 (0.027)	0.050* (0.028)	0.021 (0.026)	0.068** (0.034)	0.021 (0.026)	0.068** (0.034)	0.068** (0.034)	0.068** (0.034)	0.037 (0.032)	0.037 (0.032)	0.050* (0.026)	0.050* (0.026)
InPM2.5#Disclosure	-0.010 (0.007)	-0.016** (0.008)	-0.006 (0.007)	-0.020** (0.009)	-0.006 (0.007)	-0.020** (0.009)	-0.020** (0.009)	-0.020** (0.009)	-0.011 (0.009)	-0.011 (0.009)	-0.014** (0.007)	-0.014** (0.007)
N	43,502	33,773	46,450	30,825	46,450	30,825	30,825	30,825	37,758	37,758	39,517	39,517
Adj. R ²	0.3169	0.3767	0.3268	0.3567	0.3268	0.3567	0.3567	0.3567	0.2941	0.2941	0.3810	0.3810
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 4 (Continued)

Panel B	(1)	(2)	(3)	(4)	(5)	(6)
	Male		Urban residents		Finish compulsory education	
Individual fixed effect	No	Yes	No	Yes	No	Yes
Month by year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Month by year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses, clustered at the household level.

***, **, * indicate significance at 1%, 5% and 10%.

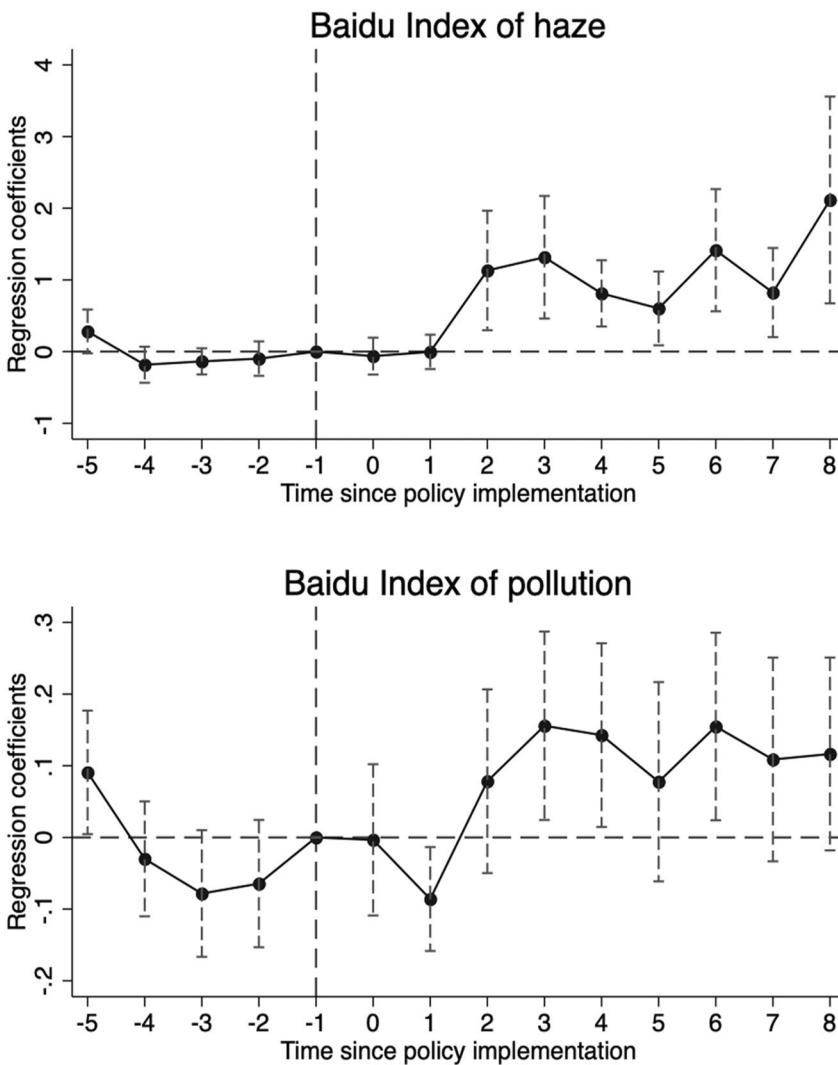


FIGURE 4 Event study estimates of information disclosure on pollution-related *Baidu Index*. We estimate a standard event study specification of the impact of environmental information disclosure on pollution-related *Baidu index* based on city-monthly dataset. Coefficient, as well as 95% confidence intervals, with 6-month time interval, are plotted in the figure.

We then estimate the impact of information disclosure and pollution interaction on residents' mental health, as shown in Table 5. In CFPS, adult mental health is evaluated using the K6 scale, initially developed by Kessler et al. (2003). This psychological tool comprises six distinct items tailored to measure symptoms associated with depression and distress. The total of these six items yields a composite score ranging from 0 to 24, with higher scores indicating severer mental health issues. We defined a set of dummies to indicate mild depression ($K6 \geq 4$), moderate depression ($K6 \geq 8$), and severe depression ($K6 \geq 13$). In Table 5, Column (1) shows that information disclosure and air pollution levels had effects on mental health at the 10% significant level. Columns 2–4 show that the information disclosure has led to a large and statistically significant increase in the risk of mild depression, while no such effect for moderate and severe depression. Columns 5 and 6 present the results when employing two indicators for happiness and an index

TABLE 5 Mechanism: mental health.

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
K6 indicator (standardized to 0–1)	Mild depression (4 ≤ K6 < 8)	Moderate depression (8 ≤ K6 < 13)	Severe depression (K6 ≥ 13)	Happiness	Self-satisfaction	
InPM2.5	0.006* (0.004)	0.002 (0.013)	0.034*** (0.010)	0.004 (0.005)	0.005 (0.007)	0.012* (0.007)
Disclosure	−0.020* (0.012)	−0.105** (0.041)	−0.015 (0.032)	0.017 (0.015)	0.034 (0.021)	0.103*** (0.021)
InPM2.5#Disclosure	0.006* (0.003)	0.029*** (0.011)	0.008 (0.009)	−0.004 (0.004)	−0.010* (0.006)	−0.026*** (0.006)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Month by year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	77,275	77,275	77,275	77,275	77,166	77,209
Adj. R ²	0.4286	0.3010	0.2658	0.1645	0.1897	0.3325
DV mean	0.198	0.326	0.187	0.036	3.696	3.580

Note: Standard errors in parentheses, clustered at the household level.

***, **, * indicate significance at 1%, 5% and 10%.

of life satisfaction as the dependent variables. Column 6 highlights that the pollution level significantly moderates the impact of disclosure on self-satisfaction. Both results support the mental health channel we proposed.

7 | CONCLUSION

In this paper, we adopted a DID method to study how pollution information disclosure affects political trust in an authoritarian setting, utilizing a representative survey data (CFPS) from China. Our results suggest that the positive impact of information disclosure on political trust was adversely moderated by local air pollution levels, constituting approximately 29.55% of the total observed magnitude. We also presented a comprehensive set of robustness checks to support the validity of our baseline results. The results of event-study, placebo test, and various sample restrictions are consistent with our baseline estimation.

Additionally, specific groups of people are more likely to be impacted after being exposed to air pollution information, lowering their trust toward the local government. Our analysis revealed that the adverse moderation effect of air pollution was notably more pronounced among urban residents who have better knowledge on Internet, an important source for pollution information.

Furthermore, we explored psychological channel to account for the “adverse moderation” of air pollution: citizens’ mental wellbeing arising from heightened environmental concern. We demonstrated that information disclosure of more severe pollution increased citizens’ perception of environmental issues, thereby enabling their anxiety and concerns regarding air pollution. In summary, the unintended adverse moderation occurs through the mental health channel, whereby pollution information disclosure increased individuals’ psychological burden. After the information disclosure on air pollution, residents realize the shortcomings of the government’s previous governance in environmental issue and become unsatisfied, but the occurrence of this mechanism also depended on local pollution levels.

In summary, our empirical findings reveal a significant and positive causal relationship between environmental information disclosure and political trust. This indicates that exposure to high levels of air pollution may undermine the impact of information disclosure on political trust. Our findings advance the existing knowledge that, when it comes to gauge the effects of environmental information disclosure on political trust, we should not overlook the moderating effect local pollution levels may cause, through the channel of impacting citizens’ mental well-being.

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DATA AVAILABILITY STATEMENT

Data source: China Family Panel Studies (CFPS). Users can visit Peking University Open Research Data platform to register as a user and apply for the availability. Users are subjected to the regulations and agreements of data application policy of CFPS. The link for the website: <https://open-data.pku.edu.cn/dataset.xhtml?persistentId=doi:10.18170/DVN/45LCSO>. Despite the individual level data, the county and prefecture administration ID information needs to be applied individually. Data are available from the author(s) with the permission of China Family Panel Studies.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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