# Transboundary Air Pollution and Hazy Accountability: Evidence from South Korea and China *

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**Abstract**

Environmental problems often originate at least partially in other jurisdictions. We argue that transboundary pollution can increase public hostility towards the polluting country and break accountability links in the country that receives some of its pollution from abroad. We examine this argument in the context of trans-boundary air pollution in South Korea. South Korea's air pollution is the worst in the OECD and it partially originates in China. We combine daily air quality measurements with Gallup World Poll surveys from 2015-2022 to show that on days with bad air quality, Koreans become significantly less satisfied with China's leadership but not with the Korean government, including the government's efforts to preserve the environment. We also use air quality as an instrument for subjective satisfaction with air quality and find that subjective beliefs about air quality have a strong negative causal effect on satisfaction with China's leadership but have no significant effect on satisfaction with the Korean government. This evidence suggests that air pollution partially causes negative Korean views towards China and that cross-border deflection of responsibility may relief pressure from the South Korean government to adopt stronger environmental measures. Moreover, we find that the effect runs through reduced confidence in the local economy rather than the effects of pollution on perceived life satisfaction or health.

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# 1 Introduction

Environmental hazards, including fires, floods, chemical spills, air pollution, and nuclear disasters, can serve as catalysts for public demands that the government implement reforms to prevent future hazards. One complication arises from the fact that environmental problems often originate, at least partially, in other jurisdictions. The ability to export pollution potentially reduces domestic demands for abatement. We argue that transboundary pollution can also affect mass politics in the recipient country. First, people may form increasingly negative opinions about a polluting country, which can fuel hostility between states. Second, if people blame a foreign country, then they may become less likely to associate environmental problems with poor government performance, which could alleviate pressure on the recipient government to implement costly policies that reduce local pollution levels.

We investigate this argument in the context of South Korean air pollution, which at least partially originates in China. South Korea suffers from the worst air pollution among OECD countries, with particularly unhealthy levels of PM2.5 ultra-fine dust that pose severe health risks and disrupt public life. Scientists agree that the pollution stems from a combination of local sources and long-range transport from China, particularly the industrial regions in southwestern China and dust storms in the western deserts. Yet, Korean media and politicians often single out China and commentators frequently claim that growing negative sentiment towards China is partially driven by dismay over fine dust, although we are not aware of any evidence that demonstrates this causal relationship. At the same time, South Korea has invested relatively little in renewables while coal fired power plants, a major source of domestic pollution, remain the single most important source of electricity generation (around 40 percent) even as almost all coal must be imported.[1]

Has the transboundary nature of air pollution disrupted the accountability chain in South Korea? Does it aggravate negative sentiment towards China? We answer these questions by investigating how exposure to bad air pollution affects public approval for the Korean and Chinese governments. Establishing a causal link between air pollution exposure and political attitudes presents a significant challenge. Unlike natural disasters, exposure to air pollution is seldom sudden or random. The primary sources of pollution are usually stationary emitters such as factories, traffic, refineries, and power plants. Selection into neighborhoods with higher and lower levels of air pollution is predominantly influenced by socio-economic characteristics, which likely also shape political attitudes. To overcome these inferential issues, we exploit that in Korea wind conditions create strong daily variability in fine dust levels. Public health scholars have used this approach to assess the effect of pollution on deaths from respiratory illnesses (Jia and Ku 2019) and avoidance behavior,

[1] https://www.eia.gov/international/analysis/country/KOR

such as reducing attendance at baseball matches (Jia and Ku 2019; G. Yoo 2021). Scholars have used similar techniques to show that exposure to air pollution lowers government satisfaction in China and Vietnam (Alkon and E. H. Wang 2018; S. E. Kim et al. 2020).

We match daily air quality data in different Korean cities and provinces with survey responses to the Gallup World Poll from 2015-2022. Our analysis employs three empirical strategies to investigate the relationship between air pollution exposure and political attitudes. First, we estimate a local average treatment effect using daily air quality as an instrument for subjective beliefs about air quality. Second, we estimate reduced form models that directly regress pollution levels on political attitudes. Third, we use an instrumental variables mediation analysis to examine if the effect runs through beliefs about the economic effects of air quality or its effects on subjective assessments of life satisfaction and health.

We find that (instrumented) subjective beliefs about air quality have a strong negative causal effect on satisfaction with China's leadership but have no robust significant effect on satisfaction with Korean government's efforts to protect the environment, Korean leadership, presidential approval, and confidence in the national government. The reduced form estimates confirm these insights. Finally, we find that the effect runs through shattered confidence in the local economy rather than subjective assessments of life satisfaction or health.

These findings have three broader implications. First, we contribute to the literature that examines what drives negative opinions among mass public towards other countries. South Korean public opinion has grown increasingly hostile towards China, even surpassing Japan. In certain surveys, Korean public opinion towards China ranks among the most negative in the world (Turcsanyi and Song 2022). Most researchers have attributed this hostility to China's coercive response to the deployment of the Terminal High Altitude Area Defense (THAAD) system (Carothers 2023; Sung and Park 2022). Our study demonstrates that exposure to air pollution also constitutes a significant causal factor contributing to negative views towards China. More broadly, these findings suggest a mechanism through which unresolved cross-border environmental problems can contribute to hostile interstate relations.

Second, the findings suggest that the transboundary nature of the air pollution problem weakens domestic accountability politics. Political economy approaches claim that as a country grows wealthier, citizens will increasingly push for environmental measures as they experience the negative consequences of environmental hazards. Studies that use an approach similar to ours find that on bad air days, the public in China and Vietnam indeed negatively adjusts satisfaction with the local government (Alkon and E. H. Wang 2018; S. E. Kim et al. 2020; Yao et al. 2022). We argue that the mechanism underlying this hypothesis breaks

down in a setting where the sources of pollution partially originate from external factors. This may help explain why Korea continues to rely heavily on coal power plants despite experiencing unusually high levels of air pollution considering its economic development. This also matters for climate mitigation, given that policies that reduce air pollution often also reduce CO2 emissions. More broadly, the findings suggest that evaluations of the responsiveness of national policies to environmental hazards should play close attention to the potential transboundary origins of these hazards.

Third, we offer a mechanism that links beliefs about air quality to political judgments. People are more likely to translate their experiences with environmental hazards into political assessments if the environmental problem has direct easily visible consequences. While fine dust has severe long term health repercussions, the most immediate visible effects are that it slows down public life, including (on severe days) shutting down schools and factories. This results in a sharp loss in confidence about the local economy. Our findings show that Koreans perceive strong local consequences from bad air pollution but they nonetheless blame a foreign entity: China.

Our argument is not that Koreans misattribute blame to China. Scientists agree that Korean air pollution results from a combination of local and foreign sources, although there is no consensus on just how much China contributes. There is some evidence to suggest that the relative importance of Chinese pollution is higher on bad air days. Yet, Korean citizens have better opportunities to influence domestic than Chinese pollution. There are examples of how states can resolve issues of transboundary pollution through international cooperation, such as acid rain in Europe (Grennfelt et al. 2020). But this typically requires good relations between states and a credible institutional framework. Even if Korean citizens are fully rational in the inferences they draw, the conclusion that pollution results in more hostile attitudes towards China but has no consequences for evaluations of Korean environmental policy or leaders matters for the politics of pollution abatement.

These findings matter beyond their relevance for air pollution. Policies that reduce harmful pollution often also reduce CO2 emissions and thus matter for climate mitigation. The benefits of climate mitigation policies are temporally distant, which leads to underprovision in democracies (Jacobs 2016). Some of the benefits of pollution reduction are immediate and visible. Public demands for reduction of air pollution can be a gateway for mobilization over climate mitigation policies but the transboundary nature of pollution can undermine this mechanism.

In the subsequent sections, we first present our theoretical framework, providing the foundation for better understanding the relationship between air pollution and public opinion on government approval. Following

this, we discuss the context of South Korea, focusing on microdust from China as a source of air pollution in Korea, the Korean government's environmental policies, and public perceptions thereof. Next, we introduce the data sources, outline our empirical strategy, and discuss the results obtained from our analysis. Finally, we conclude by summarizing the key findings, their implications, and potential avenues for future research in this domain.

## 2 Transboundary Pollution and Environmental Accountability Politics

Compared to other economically developed countries, South Korea has unusually bad levels of air pollution. Figure 1 illustrates that unlike in other Organisation for Economic Co-operation and Development (OECD) countries with bad levels of pollution, Korea's pollution became worse between 2010 and 2019 [2]. South Korea started the 2010s as the fourth worst country in terms of fine particle pollution but moved to the number one spot by the end of the decade. An index developed by the energy policy institute at the University of Chicago, The Air Quality Life Index, places Korea as the 16th worst country in the world in terms of how life is affected by air pollution (Greenstone and Fan 2018). This study estimates that Koreans would on average live 1.4 years longer if air quality met the World Health Organization's standard (1.7 years in Seoul).

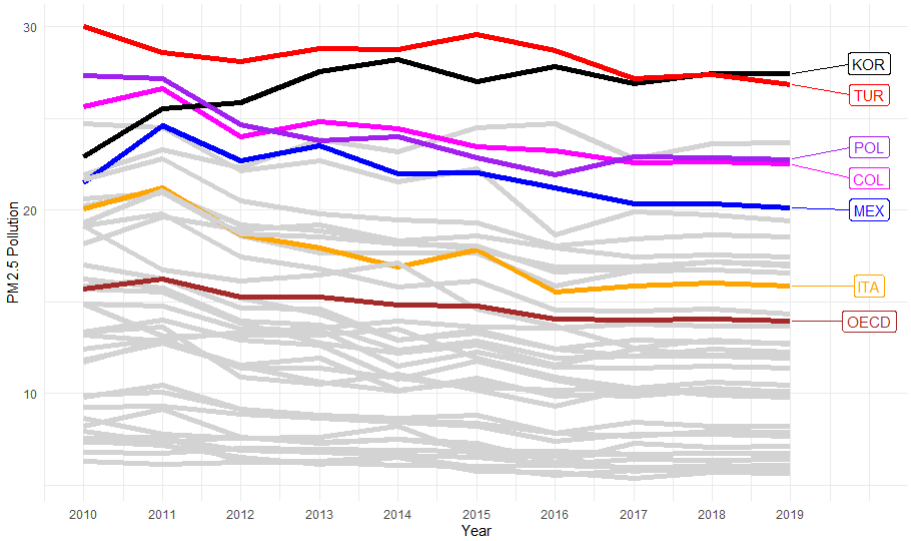



Figure 1: South Korean fine dust pollution compared to other OECD countries, 2010-2019

The Environmental Kuznets Curve (EKC) hypothesis posits an inverted U-shaped relationship between

[2]Data from https://data.oecd.org/air/air-pollution-exposure.htm

per capita income and environmental pollution (Grossman and Krueger 1995). Economic growth initially leads to environmental degradation as industrial output and energy consumption increase. However, most countries reach a turning point, often estimated to be around 8,000 to 9,000 dollars per capita, after which environmental conditions improve (Sarkodie and Strezov 2019). South Korea reached this level in the early 1990s. As of 2022, Korea's GDP stands at $35,000 per capita, suggesting that the country should be well on its way to addressing its pollution issues. By comparison Turkey, the OECD country closest to Korea in trms of air pollution, had a GDP per capita that was just below below $10,000 in 2021.

A key theoretical mechanism underpinning the Environmental Kuznets Curve (EKC) is that citizens demand higher environmental quality as their levels of economic well-being increase.[3] Governments may be reluctant to act without mobilization from below because environmental regulations impose short term costs on domestic industries and because switching from pollutants often requires significant government investments, such as subsidies for renewable energy. Electoral incentives can overcome the more private benefits that industries provide to politicians and can encourage politicians to prioritize environmental investments over other potential uses of government funds. Consistent with this theory, democracies improve environmental protections more quickly than non-democracies after reaching the threshold level of economic development(Farzin and Bond 2006; Güngör, Olanipekun, and Usman 2021). Increases in air pollution reduce the vote shares of incumbents in German elections over a period of two decades (Bellani et al. n.d.).

A theory of environmental accountability must answer two questions. First, why do citizens come to prioritize environmental issues? Second, who do they hold responsible for environmental problems? Both are crucial. Even if citizens find environmental problems highly salient, they must still establish a link between government performance and these problems. Below we discuss each question both theoretically and in the context of the Korean case.

First, a significant body of literature suggests that citizens in developed economies update their policy and political preferences over environmental issues following personal exposure to environmental hazards, although not all studies find significant or uniform effects (e.g. Egan and Mullin 2012; Hazlett and Mildenberger 2020; Hoffmann et al. 2022). Individuals are more likely to translate an environmental concern into political judgments when they see that the hazard has immediate negative consequences. For example, the evidence for the (democratic) EKC hypothesis is considerably stronger for ambient pollution than for deforestation and other environmental problems for which the consequences may be temporally and/or geo-

[3] An alternative mechanism involves an endogenous change in the demand structure for goods and services. As countries grow wealthier, sectors with less environmental impact become increasingly significant. This helps explain a reduction in pollution per marginal unit of GDP but not overall reductions (Roca 2003)

graphically distant (Sarkodie and Strezov 2019). Indeed, politicians in middle-income countries occasionally possess electoral incentives to increase deforestation (Sanford 2021).

A recent review of the literature finds that air pollution is associated with a broad array of negative perceptions and behaviors, including reductions in happiness and life satisfaction, impairment of cognitive functioning, mental disorders, migration, and lower economic productivity (Lu 2020). Assessments about poor air quality can become politically consequential if individuals believe that poor air quality negatively affects their health, life satisfaction, or the economy and if they blame politicians for these effects.

There is robust evidence that micro dust increases mortality from respiratory and cardiovascular diseases, particularly among the elderly and young children (Jia and Ku 2019). The Korea Environment Institute estimates that dust annually causes up to 1.8 million illnesses. Micro-dust mostly does its damage because particles get trapped in the lungs or even the bloodstream. Micro-dust particles consist of many compounds that can be dangerous, including sulfur dioxide emitted from the many coal-fired power plants in Korea. This can cause lung cancer and cardiovascular diseases. This is why PM2.5 particles are sometimes called a "silent killer." [4]

By contrast, the effect on the local economy and life satisfaction are much more immediate and visible. Koreans frequently consult apps for the latest dust estimates, wear fine dust masks in substantial numbers, remain indoors, and adopt other strategies to avoid poor air quality (G. Yoo 2021; W. Yoo 2019). This may visibly decrease traffic in malls, restaurants, and retail shops. On days marked by poor air quality, the South Korean government sometimes takes emergency reduction measures such as closing schools, factories, and coal-fired power plants, which contribute to pollution. Government officials have the discretion to compel such measures when the average fine dust concentration surpasses certain levels. [5] Initially implemented across the larger Seoul region in December 2017, this pollution mitigation strategy was codified into special law and extended to additional regions of South Korea on February 5th, 2019. For example, in March 2020 the Korean government idled up to 28 of its 60 coal power plants to reduce air pollution. [6] The estimated average economic cost of a day with poor air quality is $138 million and a 2019 survey on microdust revealed that 71% of respondents claimed their workplace's production activities were being negatively affected by fine dust pollution.[7]. Such a decline in local economic activities can potentially amplify the public's perception of deteriorating local economic conditions, which in turn could teach them their government's efforts to protect the environment have fallen short.

[4] https://www.loe.org/shows/segments.html?programID=19-P13-00048segmentID=1
[5] https://www.airkorea.or.kr/portal/web/contents/contentView/?pMENU$_NO = 148$
[6] https://www.reuters.com/article/us-southkorea-coal-power/south-korea-to-close-up-to-28-coal-fired-power-plants-in-march-idUSKBN20O182
[7] https://www.joongang.co.kr/article/23413038home

There is a vast literature that demonstrates the robust link between individual assessments of the economy and the government (Lewis-Beck and Stegmaier 2018, e.g.). It is thus plausible that more negative views about the local economy triggered by excessive pollution would also translate into more negative views about the Korean government. However, this presumes an answer to our second question about attribution: that Koreans hold the Korean government accountable for bad pollution.

Cross-border pollution potentially obscures this mechanism. Transboundary pollution is pollution which is emitted in one country, and deposited or causing harm in another country. A country, like China, that can externalize some of its pollution will have fewer incentives for abatement (Ansuategi and Perrings 2000). Theoretically, the recipient country could compensate the originator country for diminishing polluting activities. However, this depends on the successful completion of an international bargain that may be complex and faces high transaction costs in the absence of strong institutions. Moreover, if the pollution flows in just one direction, then the recipient country has little leverage. While there are some examples of successful resolutions of such problems, most notably acid rain in Europe (Grennfelt et al. 2020), they require complex international bargains.

Our argument is not that Korean citizens are wrong to attribute blame to China. It is clear that China is an important source of Korean air pollution both for reasons its government can do little about, dust storms in the deserts, but also due to industrial activity. There is considerable uncertainty over just how much of the pollution comes from different sources. A joint study conducted by South Korea, China, and Japan examined long-range air pollutant transport in the Northeast Asian region from 2000 to 2017, including an analysis of ultrafine dust (PM2.5) from 2013 to 2017. The study presented the overall annual average and found that China contributed 32 % to South Korea's fine dust, while South Korea's contribution was 51 %. However, it is possible that during particularly bad pollution days a higher percentage originates in China. According to a report by the head of the Korean National Institute of Environmental Research, during high concentration periods in February and March, China's contribution is estimated to be up to 70 %. There is little doubt, however, that local Korean pollution also contributes significantly to the problem. Moreover, chemicals, such as SO2 emissions from coal fired power plants, can attach themselves to microdust particles, which worsen their health effects.

If, as the democratic EKC model assumes, mobilization from below would move governments to adopt policies they would prefer to avoid, then the government would have incentives to emphasize China's contribution to Korea's pollution problem. A number of Korean politicians have underscored the impact of Chinese microdust on air pollution in Korea. For instance, in 2018, Joon-Pyo Hong, who was then the leader

of the conservative Liberty Korea Party, addressed the issue during a session focused on microdust countermeasures. He pointed out that "fine dust and pollutants from Chinese factories are carried by westerly winds and come to Korea," and raised the question, "Shouldn't China pay an environmental fee to Korea for the environmental burden caused by their economic development?"[8]

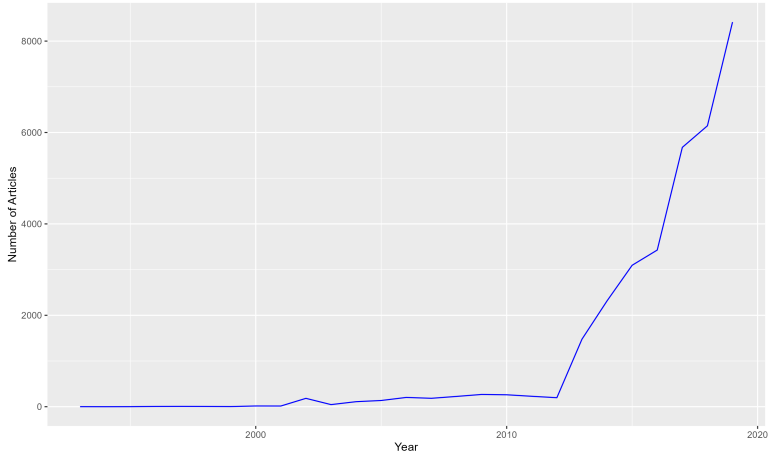
One intermediary factor could be ideology. Conservatives have long viewed the rise of China with greater skepticism than more liberal or left-wing citizens and Conservative Presidents have been more hard line versus China (Jung and Jeong 2016). Conservatives may also be less concerned about environmental issues, although we are unaware of studies documenting this with regard to air pollution. It could be that the accountability process differs when there is a Conservative President and for conservative voters. We control for the interaction between respondent ideology and the President's ideology in the empirical analysis.

Studies show that the Korean media focuses on China in their news reporting about micro dust (Shapiro and Bolsen 2018).Our own examination of historical reportage by South Korean media platforms substantiates this observation. We employed the Bigkinds application - a Korean counterpart of LexisNexis - to quantify the instances where "China" and "microdust" were jointly mentioned in articles. The outcome of this analysis revealed that the phrase "Chinese-origin fine dust" first appeared in a Kyunghyang Shinmun publication dated January 24, 2012. This article referenced multiple experts who proposed that a continuous high-pressure system situated over the Chinese continent was responsible for transporting fine dust to Korea. These experts stressed that China's impact on the high-concentration fine dust phenomenon in Korea could not be overlooked (Shinmun 2012). Figure 2 shows that subsequent to this initial publication, the volume of articles linking China to fine dust surged from 1,477 in 2013 to 8,416 in 2019.[9] A significant portion of these articles focused on pollutants and fine dust emissions arising from China's industrialization process, thus contributing to the narrative that emphasizes China's role in South Korea's air pollution problem. In 2020, the tendency to attribute air pollution to China witnessed a downturn, primarily due to the temporary suspension of industrial activities and trade resulting from the COVID-19 pandemic. Despite this decline, more than 1,000 articles discussing the connection between China and air pollution were still published during that year.

A survey experiment demonstrates that media frames solely attributing blame to China result in decreased satisfaction with China, whereas frames blaming both Korea and China reduce satisfaction with both actors (Shapiro and Bolsen 2019). This finding provides important evidence for the causal effects of media frames. However, the aggregate effects depend on the average news diet of Koreans. Another study examines the

[8] https://newsis.com/view/?id=NISX20180201$_0$000220215
[9] Collected by the authors based on searches in Bigkinds

Figure 2: Number of Korean News Articles Mentioning China and Microdust




impact of frames on cooperation with China (Shapiro, Bolsen, and Y. Kim 2022). In a 2019 survey of 1007 adults in Korea, 82 percent of the respondents indicated that China is more responsible for microdust than Korea.[10]

A strong version of the hazy accountability argument is that Korean citizens respond to pollution exposure by updating their views about China but not domestic environmental policies nor the Korean government or president. However, there is no logical reason why citizens couldn't hold both or neither government responsible for poor air quality. The extent to which pollution reduces satisfaction with the Chinese and/or Korean governments is an empirical question. We thus test the following two hypotheses:

**Hypothesis 1 (H1):** *Exposure to air pollution increases dissatisfaction with the Korean government's efforts to preserve the environment (and the Korean government/ president).*

**Hypothesis 2 (H2):** *Exposure to air pollution increases dissatisfaction with the Chinese government.*

A corollary to these hypotheses is that we expect most of the effect to run through reduced confidence in the local economy.

# 3 Data

We match daily air quality data in different Korean cities and provinces with survey responses to the Gallup World Poll from 2015-2022. The Gallup World Poll is a global survey that has been conducted annually since 2005. The poll covers a wide range of topics, including health, well-being, work, economy and leadership.The

[10] http://m.monthly.chosun.com/client/mdaily/daily$_v iew.asp?idx = 6383Newsnumb = 2019036383$

poll extends across over 160 countries and regions, incorporating a representative sample of adults aged 15 and above. In South Korea, an annual survey has been conducted from 2005 to 2022, targeting a nationally representative sample of approximately 1000 individuals. This survey is typically carried out over two months in the summer and fall seasons, utilizing both landline and mobile phones. Comprehensive details pertaining to each survey wave, including the sample size, survey period, and methodology, are provided in the appendix. We limit the analysis to the 2015-2022 period due to the availability of the air quality measurements of fine dust.

The surveys directly asked respondents whether they are satisfied or dissatisfied with the quality of air. Our primary dependent variable for Korea is the response to the question whether a respondent is "satisfied or dissatisfied with government efforts to preserve environment." Theoretically, the answers to this question should respond most directly to concerns about air pollution. We do not have a comparable measure about the environmental performance of the Chinese government. However, if we are interested in overall growing hostility towards the Chinese government, then we should focus on a more direct evaluation of its government rather than just its environmental policies. Respondents were asked whether they approve or disapprove of the leadership of China, South Korea, and the United States.[11] There is some advantage to using identical questions about China and Korea. However, the question about Korea's leadership is not the most direct evaluation of government performance on the environment and may encourage respondents to think about Korea's international leadership, including its ability to pursue its interests versus China. Theoretically, the democratic EKC hypothesis focuses on Korean environmental policies whereas hypothesis 2 is about the foreign policy consequences of transboundary pollution.

We also use two additional questions that more directly evaluate the Korean government and politicians. First, a question asks whether an individual approves of the current Korean President. Presidential approval is a particularly relevant political indicator even if it is not a direct question about the environment. Second, we use a general question about "Confidence in the national government." We include evaluations of the United States as a placebo check: individuals may have strong views about the USA but there is no good theoretical reason to believe that these views should follow from beliefs about air pollution. In the appendix we also use evaluations of Japan as an additional placebo check.

In order to assess the mechanisms, we use the Gallup World Poll's Local Economic confidence Index, which is based on the combined responses to two questions asking respondents, first, to rate economic conditions in their city or area today, and second, whether they think economic conditions in their city or area as a whole

[11] Respondents who answer don't know are recoded as .5. Dissatisfied is 1 and satisfied 0

are getting better or getting worse. The Index has a theoretical maximum value of +100 and a theoretical minimum value of -100. In 2015 and 2016 respondents were instead asked about confidence in economic conditions in their "country" rather than their city. Pollution could also affect people's beliefs about their personal finances. We therefore also examine an index that measures a respondent's subjective evaluations of their personal finances. [12]

In order to assess whether the effect of air pollution runs through non-economic life circumstances, we include the Gallups "Daily Experiences Index" and the "Personal Health Index." We know that on bad air days people adjust their daily routines and develop more respiratory illnesses. It may be that people have more negative experiences on bad air days or downgrade beliefs about their personal health. Gallup's "Daily experience index" is inspired by Daniel Kahneman's conception of "experienced well-being" and evaluates whether people had a serious of positive or negative experiences on the day prior to the survey.[13] The personal health index includes a battery of questions about general health problems as well as the health related questions from the daily experience index.[14]

The data also includes demographic and socio-economic characteristics of respondents, including age, gender, household income in U.S. dollars, and education.[15] We use these as control variables in most regressions. Unfortunately the survey does not include a direct measure of respondent partisanship or ideology. We constructed a measure based on three indicators: respect for children, respect for women, and how to deal with the poor,. These indicators are available across waves, they make a strong scale (cronbach's alpha=.7), and they strongly predict presidential approval contingent on who is the President. Controlling for gender, age, education, and income a respondent who is to the left on this spectrum is 30 percentage point more likely to approve the President when the President is from the left than when the President is conservative. We include the interaction between respondent ideology and President party as a control in the regression models. All results hold when we exclude this control and all controls.

Table 1 provides summary statistics.

[12] Which one of these phrases comes closest to your own feelings about your household's income these days: living comfortably on present income, getting by on present income, finding it difficult on present income, or finding it very difficult on present income? (WP2319). Are you satisfied or dissatisfied with your standard of living, all the things you can buy and do? (WP30). Right now, do you feel your standard of living is getting better or getting worse? (WP31)

[13] Did you feel well-rested yesterday? (WP60), Were you treated with respect all day yesterday? (WP61), Did you smile or laugh a lot yesterday? (WP63), Did you learn or do something interesting yesterday? (WP65), Did you experience the following feelings during a lot of the day yesterday? How about enjoyment? (WP67), How about physical pain? (WP68), How about worry? (WP69), How about sadness? (WP70), How about stress? (WP71), How about anger? (WP74)

[14] Do you have any health problems that prevent you from doing any of the things people your age normally can do?(WP23) Now, please think about yesterday, from the morning until the end of the day. Think about where you were, what you were doing, who you were with, and how you felt. Did you feel well-rested yesterday?(WP60) Did you experience the following feelings during a lot of the day yesterday? How about physical pain? (WP68) How about worry?(WP69) How about sadness?(WP70)

[15] Three levels: elementary only, up to 3 years beyond elementary, 4 years or more

Table 1: Summary statistics

| | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|
| AQI pm2.5 (lag) | 68.85 | 30.73 | 7 | 181 | 7,984 |
| Composite AQI (lag) | 71.95 | 29.32 | 15 | 181 | 8,002 |
| Yellow Warning | 0.13 | 0.33 | 0 | 1 | 10,147 |
| Red Warning | 0.02 | 0.16 | 0 | 1 | 10,147 |
| Dissatisfied w. Air | 0.40 | 0.49 | 0 | 1 | 9,882 |
| Dissatisfied Govt Preserve Environment | 0.59 | 0.48 | 0 | 1 | 10,143 |
| Disapprove China Leadership | 0.63 | 0.43 | 0 | 1 | 10,137 |
| Disapprove ROK Leadership | 0.62 | 0.47 | 0 | 1 | 9,023 |
| Disapprove USA Leadership | 0.49 | 0.46 | 0 | 1 | 10,131 |
| Presidential Approval | 0.49 | 0.48 | 0 | 1 | 7,012 |
| No Confidence National Government | 0.64 | 0.47 | 0 | 1 | 10,129 |
| Economic Confidence Index | -44.00 | 65.83 | -100 | 100 | 2,000 |
| Local Economic Confidence Index | -1.87 | 69.20 | -100 | 100 | 6,047 |
| Financial Life Index | 33.37 | 27.53 | 0 | 100 | 9,047 |
| Daily Experience Index | 67.44 | 25.19 | 0 | 100 | 10,147 |
| Personal Health Index | 73.91 | 25.77 | 0 | 100 | 10,147 |
| Ideology | 0.60 | 0.33 | 0 | 1 | 8,047 |
| Female | 1.44 | 0.50 | 1 | 2 | 10,147 |
| Age | 49.60 | 18.47 | 15 | 99 | 10,134 |
| Education | 2.26 | 0.68 | 1 | 3 | 10,110 |
| Household Income | 52772.07 | 60738.14 | 0 | 1776920 | 8,047 |

The air quality data come from the World Air Quality Index (WAQI), which collects and standardizes air pollution data from national and local agencies, including Air Korea.[16] This data is available since late 2014. The PM2.5 individual Air Quality Index (AQI) directly measures the fine dust concentration that has created most of the controversy in Korea.[17] We also compute a composite AQI by taking the maximum of the various individual AQIs, as recommended by the WAQI documentation.[18] The correlation between the composite AQI index and the AQIpm2.5 is .94, reflecting that fine dust is the major cause of air pollution in Korea.

By international standards, an AQI of 0-50 gets a green label (healthy), 51-100 gets a yellow warning, 100-150 an orange warning (unhealthy), and larger than 150 a red warning (very unhealthy). Air Korea uses a slightly different color scheme that starts with blue (0-50) and attaches a green label to AQIs of 51-100. Yellow warnings are at AQI levels of 101 or higher and a red warning for levels of 150 and higher. This public message could increase awareness of air pollution, which could affect attitudes and behavior. For example, attendance at baseball matches is significantly lower when there is a public warning even after controlling

[16] https://aqicn.org/data-platform/register/

[17] The AQI is not the same as concentrations, which are measured in $\mu g/m^3$. The AQI standardizes across pollutants. For example, 23.5 $\mu g/m^3$ in PM2.5 and 103 $\mu g/m^3$ of PM10 both correspond to an AQI of 75, reflecting that fine dust has a much larger impact on air quality.

[18] AQI = max( AQIPM2.5, AQIPM10, AQIO3, AQIno2, AQIso2, AQIco)

for AQI levels (G. Yoo 2021). We created dummy variables that capture potential threshold level effects. The levels around the red warning are also when public authorities can formally take emergency measures, such as school closures (since 2018).[19] We collected data on these emergency measures and use them for robustness checks.[20]

The database contains measurements from individual weather stations. This allows us to merge local air quality data for respondents who live in the main cities: Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan. For the remaining respondents, Gallup only records the province in which they reside. We chose the air quality measurement from the largest city in each province to match air quality data with individual respondents. By far the largest number of respondents who do not reside in a city (22 percent of respondents) live in Gyeonggi-do, which is the province that surrounds Seoul. We also collect data on temperature and rainfall, which may correlate with air quality and potentially with political evaluations. In the appendix, we report models that control for these variables.

Figure 3: Variation in Air Quality Index within Survey Periods by Region

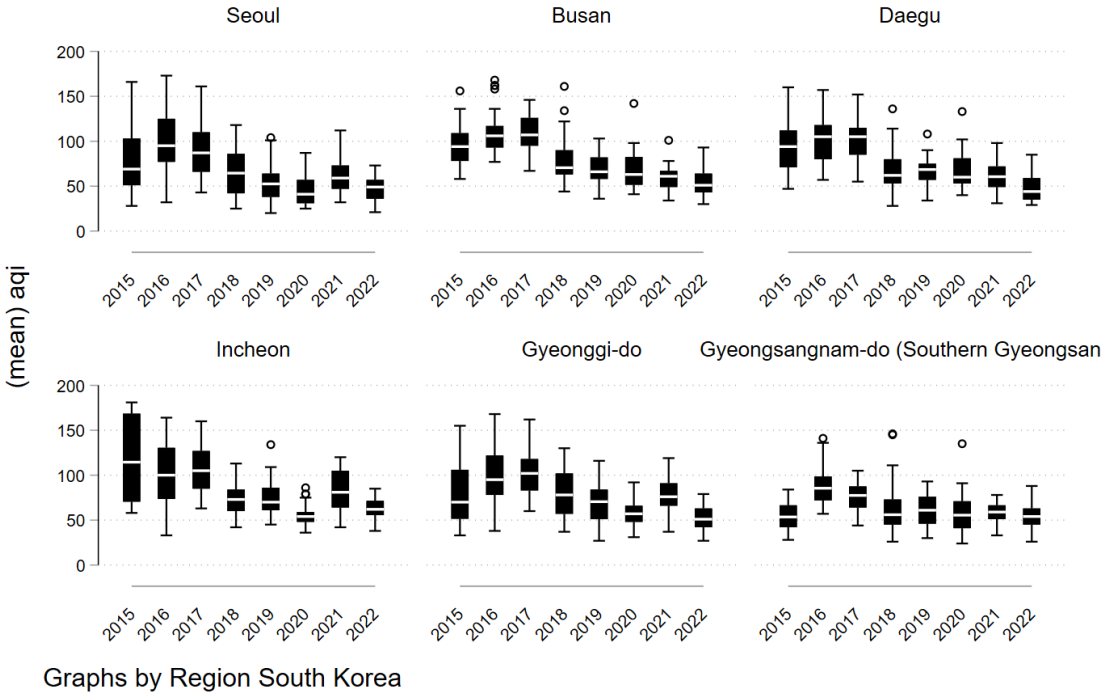



Figure 3 plots the variation in AQI levels within each survey wave for the four largest cities and the two

[19] More precisely, if fine dust reaches 50 $\mu g/m^3$ (an AQI of 136) with a forecast of maintaining or exceeding the same level for the subsequent day. Likewise, the measures can be triggered when a warning or an alert is issued, and the fine dust forecast for the next day is expected to exceed 50 $\mu g/m^3$. Lastly, when the fine dust forecast for the following day goes beyond 75 $\mu g/m^3$, this too activates the pollution reduction measures.

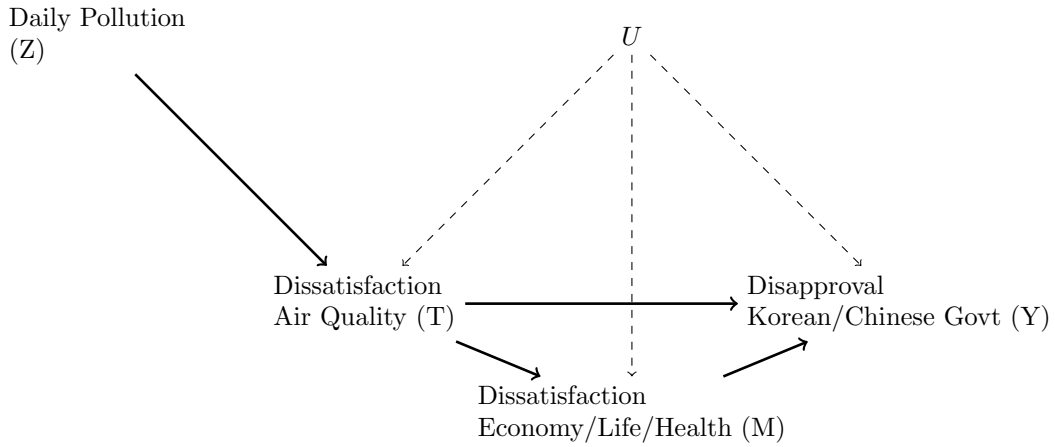
[20] https://www.airkorea.or.kr/web/board/1/?pMENU$_N O = 143$

largest provinces. There is considerable variation within each wave. Mean levels of pollution have been down since the COVID pandemic but there were still many days with pollution warnings. In an ANOVA, region explains 8 percent of the variation in AQI levels and day 65 percent. Thus, the temporal variation is much more important than regional differences.

# 4 Empirical Strategy

Figure 4 sketches a simple causal diagram of the accountability process for air pollution. High levels of actual pollution should lead people to adjust their satisfaction levels over air quality, which in turn might affect concerns about the local economy and/or dissatisfaction with life and health. This then could lead to lower levels of approval of the Korean government. On the other hand, if Koreans largely blame China for poor air quality, then they may downgrade their views of the Chinese government. Or they could do both (or neither).

Figure 4: Hazy Accountability DAG




This causal diagram treats pollution levels (AQI) as an instrument (Z) for satisfaction with air quality, which is the treatment (T). Confidence in the economy and satisfaction with life and health are mediators (M), which can influence our outcomes (Y), which is approval with the Korean or Chinese government. We do not start by estimating the full structural model, which would require the strongest set of assumptions. We start with a basic two-stage least squares model that estimates the effect on instrumented beliefs about air quality directly on our outcome variables, thus excluding the mediators. This causal estimate is a Local Average Treatment Effect (LATE). Not all Koreans will adjust their subjective evaluations of air quality based on daily variations in fine particles. This process is not random. For example, people vary in their

exposure to outdoor air and the extent to which they are affected by poor air quality. There are people who are (dis)satisfied with air quality regardless of daily pollution levels. Thus, as in any instrumental variables model, the LATE is causally identified but it is not a population estimate.

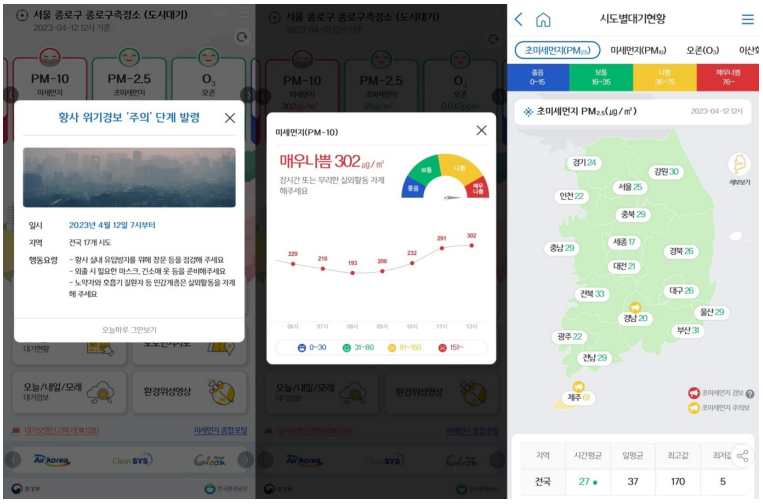
We also estimate the direct effect of fluctuations in AQI (Z) on evaluations of the Chinese and Korean governments (Y). These reduced form estimates offer population estimates of physical air quality fluctuations on evaluations of the government. This is the strategy that is most common in the literature. This is an Intention to Treat (ITT) estimate in that it ignores that not everyone "complies" (adjusts satisfaction of air quality) in response to poor air quality days.[21] The advantage of the structural (LATE) estimates is that it allows us to examine whether daily fluctuations in air quality actually shape beliefs about air quality. In the last section, we estimate the mediation effect, assuming that Z is both an instrument for beliefs about air quality and (conditionally) for beliefs about the economy, life, and health (Dippel, Ferrara, and Heblich 2020). This model requires the strongest assumptions but it allows us to assess the full causal chain.

There are unobservables (U) that are likely associated with both evaluations of air quality and the government. For example, people who are less satisfied with their health, family or economic circumstances may also perceive that air quality is worse and may be unhappier with the government. One perennial obstacle to causal inference in air pollution studies is that poorer people tend to live in areas with worse air quality. Using daily fluctuations in air quality as an instrument for dissatisfaction helps circumvent this issue. Daily fluctuations in air quality are largely unpredictable, as they are predominantly influenced by wind conditions on any given day. Consequently, the Korean public relies on fine dust forecasting and alert systems to stay informed about air quality changes. For instance, the Korea Environment Corporation operates Air Korea (shown in figure 5), which provides location-specific fine dust levels and air pollution alerts through internet browsers and mobile applications. This service enables the public to access air quality information not only for their residential area but also for all regions within the country. All models include location fixed effects to account for mean level differences in pollution.

The exclusion criterion that needs to be satisfied for the instrumental variables estimation is that air pollution does not affect government approval through other channels than beliefs about air pollution. In this design, the biggest threats to causal inference stem from the time-series nature of the data: including the presence of seasonality and temporal autocorrelation (Muñoz, Falcó-Gimeno, and Hernández 2020). Daily variation in AQI is mostly driven by wind strength and direction. There is some seasonal variation in air quality: month of the year explains 9 percent of the variation in AQI. Winter months have higher average

[21] the LATE is equivalent to the ratio of the estimated ITT effect and the estimated proportion of compliers.

Figure 5: Air Korea Mobile Application with Real-time Air Quality Information




Note: Figure 3 presents three screen captures from the Air Korea mobile application, each illustrating distinct information available within the application. The leftmost screen capture displays an alert for yellow dust. The center screen capture exhibits the application screen indicating a "very bad" local air quality. Lastly, the rightmost screen capture showcases the application presenting air quality information for all regions in Korea.

levels of pollution but none of the surveys were conducted in the winter. Most surveys were done in a three month period between May and September. However, there are bad air days during all months. Weekends have slightly higher AQIs but the difference is very small (1.8). All our findings are robust to the inclusion of day of the week and month fixed effects. All models include both year and regional/city fixed effects.

There is some persistence in air quality: the coefficient on lagged AQI is .7. But the persistence is not long: AQI from three days ago is barely predictive of current day AQI (coefficient .1). Thus, there are some wind patterns that cause unusual AQIs for a few days in a row but there is also a lot of variation. We find no evidence that poor air quality days are more likely near the end or beginning of our survey windows, which would raise potential concerns about confounding influences from sampling strategies. One additional potential confounding factor is temperature. We have not yet assessed the robustness of our findings to this.

Another potential issue is that poor air quality may lead some people to lose confidence in the local economy even if they do not realize that pollution is the cause of the temporal slowdown in economic activity. Although Koreans are well-informed about pollution and the apps are popular, it may still be the case that some people simply observe closed factories and less activity without making the link to air pollution. This would create a direct arrow from daily pollution to local economic confidence in the DAG, which would violate the exclusion restriction in the instrumental variables analysis. We discuss this issue in the mediation analysis.

# 5 Results

## 5.1 Two-Stage Least Squares

The first stage models the relationship between daily air quality levels and air quality warnings on a respondent's dissatisfaction with air quality. We had no strong priors about model specifications. We tried models with different lag structures, quadratic terms, and including or excluding the yellow, orange, and red warnings. Table 2 provides six alternative specifications. The AQI measures are divided by 100 to facilitate interpretation. There is a significant and modestly sized relationship between objective air quality and dissatisfaction with air quality. A one standard deviation increase in daily AQI corresponds to about a 3 percentage point increase in dissatisfaction with air quality. A red warning adds about a 4 percentage point increase, although this is only borderline significant. We did not find additional effects for yellow and orange warnings, perhaps because the red warnings are associated with closures and other measures. The analyses showed that air quality on the day prior to the interview was a much stronger predictor of perceived air quality than the day itself, presumably because interviews were primarily conducted in the mornings.

Table 2: First Stage Regression of AQI on Dissatisfaction with Air Quality (robust standard errors clustered on region)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Composite AQI (lag) | 0.082*** | | 0.074*** | | | |
| | (0.016) | | (0.015) | | | |
| AQI pm2.5 (lag) | | 0.072*** | | 0.062*** | 0.086*** | 0.073*** |
| | | (0.014) | | (0.014) | (0.015) | (0.015) |
| Red Warning | | | 0.028 | 0.036 | | 0.045* |
| | | | (0.020) | (0.023) | | (0.023) |
| Obs. | 7743.00 | 7726.00 | 7743.00 | 7726.00 | 7751.00 | 7751.00 |
| R2 | 0.16 | 0.16 | 0.16 | 0.16 | 0.13 | 0.14 |
| Robust effective F | 26.05 | 27.03 | 16.82 | 15.09 | 18.36 | 19.19 |
| Critical F value | 23.11 | 23.11 | 9.70 | 9.56 | 10.45 | 10.05 |
| Region/Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Control Variables | Yes | Yes | Yes | Yes | No | No |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

The next step is to test whether the instruments are sufficiently strong for robust statistical inference. Practitioners frequently reject concerns about weak instruments if the first-stage F statistic exceeds 10 (Stock and Yogo 2002). However, regular F statistics may be high even when instruments are weak under conditions of heteroscedasticity (Olea and C. Pflueger 2013; Andrews, Stock, and Sun 2019). This is an issue in our case as air quality (the instrument) is observed at the regional or city level rather than the individual level.

The table reports the results of the Olea-Pflueger robust test for weak instruments, which tests the null hypothesis that the estimator's approximate asymptotic bias (or Nagar bias) exceeds 10 percent of a "worst-case" bias with a significance level of 5 percent (Olea and C. Pflueger 2013). The "worst-case" bias captures the case when the instruments are completely uninformative. The table reports both the robust effective F statistic and the critical F value needed to reject this null hypothesis (Olea and C. Pflueger 2013; C. E. Pflueger and S. Wang 2015). This test is now widely recommended for heteroscedastic data even though many studies still rely on less conservative F-tests (Andrews, Stock, and Sun 2019).

The table shows that the critical F values indeed exceed 10 but that the instrument is sufficiently strong for further inference. The tests are suggestive that instruments based on the AQIpm2.5 measure may be slightly stronger than those based on the composite AQI. However, we estimated models using all specifications from table 2. We mention when findings are not robust to alternative specifications.

Table 3 presents the LATE estimates when using the AQIpm2.5 estimates as the instrument. Dissatisfaction with air quality has a strong and highly robust statistically significant effect on dissatisfaction with China's leadership. This effect is significant regardless of the instrument, inclusion of control variables, the inclusion of additional fixed effects for month and day of the week, and for different presidential terms. The LATE effect is very large: dissatisfaction with air quality caused by exposure to fine dust increases dissatisfaction with China for around 60 percent of "compliers." We do not believe that this maps into an average treatment effect for the population. As suggested before, the individuals who adjust their satisfaction with air quality based on exposure are likely a somewhat distinct group. The reduced form estimates may give a better sense of the overall effect.

Table 3: Instrumental Variables Estimates for Dissatisfaction with Air Quality on Leadership Evaluations (robust standard errors clustered on region, instrument is AQI pm2.5)

| | Gvt Environment | China | USA | ROK | President | Gvt Confidence |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Dissatisfied w. Air | −0.025 | 0.543** | 0.029 | 0.384 | −0.271 | 0.099 |
| | (0.232) | (0.276) | (0.125) | (0.294) | (0.408) | (0.247) |
| Obs. | 7740.00 | 7735.00 | 7733.00 | 7721.00 | 6733.00 | 7728.00 |
| Region/Year FE | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Control Variables | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

By contrast, dissatisfaction with air quality has no significant effect on dissatisfaction with the Korean government's efforts to preserve the environment, evaluations of ROK's leadership, presidential approval or on confidence in the national government. If we eliminate controls, there is a significant effect (at the

ten percent level) in the expected direction on efforts to preserve the environment and dissatisfaction with Korea's leadership. However, these effects are not robust. Reassuringly, satisfaction with air quality does not explain evaluations of US leadership in any model we estimated.

Table 4: OLS Regression of Dissatisfaction with Air Quality on Leadership Evaluations (robust standard errors clustered on region)

| | Gvt Environment | China | USA | ROK | President | Gvt Confidence |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Dissatisfied w. Air | 0.151*** | 0.032*** | 0.022* | 0.054*** | 0.059*** | 0.068*** |
| | (0.013) | (0.010) | (0.011) | (0.011) | (0.015) | (0.011) |
| Obs. | 7783.00 | 7778.00 | 7776.00 | 7764.00 | 6776.00 | 7770.00 |
| Region/Year FE | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Control Variables | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Before continuing to the reduced form estimates, it is useful to consider the OLS regressions that do not instrument for perceptions of air quality. Table 4 presents the results. Subjective negative assessments of air quality are significantly and negatively associated with all government evaluations, including the United States. This is strongly suggestive of the issues with endogeneity we highlighted earlier. There is a strong correlation between dissatisfaction with air quality and dissatisfaction with government efforts to protect the environment.

One possibility is that negative assessments of the environment and the governments efforts to protect the environment often coincide for reasons that have little to do with exposure to pollution, such as ideology. However, the findings are robust to our controls for ideology. Moreover, we find no evidence that short-term exposure to actual pollution affect attitudes about the government's environmental policies. The instrumental variable estimates are much larger than the OLS estimates for evaluations of China but not for dissatisfaction with the government's environmental policies. This suggests that the large estimates are not due to a poorly diagnosed weak instrument problem.

## 5.2 Reduced form regressions

Table 5 shows the reduced form regressions. For ease of interpretation, we just present the results with lagged PM2.5 levels. The appendix has tables for the other AQI measurements and the warning labels with F stats for the joint significance of the coefficients. There is strong evidence that Koreans increase dissatisfaction with China on poor air quality days. A one standard deviation increase on the air quality index is associated with about a 2 percentage point increase in dissatisfaction with China. These reduced form estimates are

useful because they give a sense of the population effect of poor air quality even if they are agnostic about the mechanism through which the effect occurs.

Table 5: Reduced Form Regressions of Air Quality and Dissatisfaction with Government (robust standard errors clustered on region)

| | Gvt Environment | China | ROK | USA | President | Gvt Confidence |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| AQI pm2.5 (lag) | −0.003 | 0.050** | 0.021 | 0.003 | −0.021 | −0.002 |
| | (0.018) | (0.018) | (0.023) | (0.012) | (0.030) | (0.021) |
| Obs. | 7946.00 | 7940.00 | 7926.00 | 7938.00 | 6919.00 | 7934.00 |
| R2 | 0.19 | 0.13 | 0.10 | 0.10 | 0.11 | 0.12 |
| Region/Year FE | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Control Variables | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

By contrast, AQI levels are not significantly associated with evaluations of the Korean government's efforts to preserve the environment. This was true for all specifications that we estimated. The correlation with evaluations of Korean leadership are significant at the 10 percent level if we eliminate controls but this finding is not robust. There are no significant associations with US leadership, presidential approval, or confidence in the national government.

Table 6: Instrumental Variable Regressions of Perception of Air Quality with Subjective Evaluations of Economy, Daily Experiences, and Personal Health (robust standard errors clustered on region)

| | Nat Econ | Local Econ | Personal Econ | Daily Experience | Personal Health |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Dissatisfied w. Air | 3.419 | $-110.260^{***}$ | $-22.566^{*}$ | $-16.203$ | $-13.309$ |
| | (57.415) | (33.469) | (12.400) | (11.601) | (9.135) |
| Obs. | 1915.00 | 5811.00 | 7726.00 | 7726.00 | 7726.00 |
| Region/Year FE | $Yes$ | $Yes$ | $Yes$ | $Yes$ | $Yes$ |
| Control Variables | $Yes$ | $Yes$ | $Yes$ | $Yes$ | $Yes$ |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

## 5.3 Mechanisms

The theory section stipulates that people update their beliefs about the state of the local economy on bad air days. There are many visible signs of reduced economic activity, such as closed factories, fewer vendors and people on the street, and less traffic. This section first examines whether bad air pollution is indeed linked to beliefs about the local economy and whether it influences other potentially important subjective beliefs about personal finances, life satisfaction, and health. We then evaluate how much of the effect of poor air quality runs through updated beliefs about the local economy.

Table 6 offers the instrumental variable estimates. The results are striking. Subjective air quality has a very large effect on confidence in the local economy. This is the LATE effect and it is much larger than the OLS estimates but there is also a sizeable and statistically significant effect in the reduced form regressions. On the other hand, there is no statistically significant effect on subjective evaluations of personal finances, daily experiences, or personal health (although the coefficients are all negatively signed).

Next we estimate a causal mediation analysis to examine how much of the effect of beliefs about poor air quality run through confidence in local economic conditions. We use an algorithm for mediation analysis that allows a single instrument for both the treatment T (perceptions about air quality) and the mediator M (confidence in local economic conditions) and the outcome Y (approval of China) (Dippel, Ferrara, and Heblich 2020). The mediation analysis decomposes the total effect of T on Y into the indirect effect of T on Y that operates through M and the residual direct effect. The algorithm accomplishes this by running three separate 2SLS regressions, which estimate the effect of T on M, the effect of T on Y , and the effect of M on Y conditional on T.

The findings suggest that essentially all of the effects of perceived air quality on satisfaction with China's leadership run through increasingly pessimistic assessments of the local economy.[22] When estimating the model on views about the Korean government's environmental efforts, 72 percent of the effect runs through perceptions of the local economy (although the overall effect is not significant).

Since the effects were so large, we re-estimated the models from table 3 using AQI directly as an instrument for confidence in local economic institutions rather than beliefs about air quality. Doing this did not alter our conclusions: the estimates show a strong and statistically significant relationship with dissatisfaction with China's leadership but not evaluations of the Korean government. We also estimated a mediation analysis that examines how much of the effect of air pollution on confidence in the local economy is mediated through satisfaction with air quality. The estimates suggest that only a little over half (55 percent) of the effect runs through satisfaction with air pollution. This could be because there is measurement error in the dichotomous measure of subjective beliefs about air pollution and/or because individuals may update beliefs about the local economy on bad air days without explicitly thinking about air pollution, as suggested earlier. If the latter point is true than our causal diagram in figure 4 needs a direct arrow from air quality to confidence in the local economy. This would violate the exclusion restriction in the instrumental variables estimates from table 3. However, this would not invalidate the reduced form estimates nor the instrumental variable estimates with confidence in the local economy as the treatment variable (given that all of the effect of perceived air quality on disapproval of the Chinese government runs through confidence in the local economy).

As before, we should be careful not to interpret these as average treatment effects of confidence in the local economy: these are structural estimates of how air pollution affects confidence in the local economy and then results in political evaluations. It may well be that other shocks in economic confidence are associated with reduced satisfaction with the Korean government.

# 6 Conclusion

In conclusion, this paper presents evidence that transboundary air pollution significantly affects public opinion and international relations. Our findings demonstrate that air pollution causes negative perceptions of China in South Korea, underscoring the potential of transboundary air pollution to strain bilateral relations. Furthermore, we find that air pollution affects public opinion by eroding public confidence in local economic

[22] Indeed, the basic model estimates that this is slightly more than 100 percent. The Kleibergen-Paap F-statistic for excluded instruments in first stage one (T on Z): 36.435, first stage two (M on Z—T): 8.218

conditions, rather than subjective evaluations of health or life satisfaction.

Interestingly, our analysis reveals no consistent impact of bad air pollution days on satisfaction with the South Korean government's environmental preservation efforts or other government evaluations. This contrasts with similar studies in Vietnam and China, suggesting that the transboundary nature of the pollution may be to blame for the broken accountability chain in South Korea. We thus propose that transboundary pollution has three potential negative effects on social welfare: it reduces incentives for pollution control in both the polluting and receiving countries and may exacerbate hostility between them.

This paper opens up avenues for future research and extensions. Further studies could explore other regions affected by transboundary pollution, such as Bangladesh, which is the largest recipient of such pollution (Du et al., 2020). Historically, there have been many incidences of conflicts over transboundary pollution. In 1970s, Northern Europe, Scandinavian countries like Sweden and Norway experienced substantial environmental damage due to acid rain, despite relatively low domestic emissions of SO2 and NOx. These countries were downwind of major polluters, such as the UK and West Germany, and the acid rain resulting from the emissions of these nations acidified lakes and rivers, harmed wildlife, and damaged forests in Scandinavia. Similarly, in North America, the northeastern states and southeastern provinces of Canada experienced acid rain primarily due to the emissions from power plants in the Midwestern United States. This led to significant environmental damage, including the acidification of lakes and harm to aquatic life.

Additionally, a more in-depth examination of the primary sources of transboundary emissions, such as China and India, could provide a better understanding of how these dynamics impact domestic politics and international relations. As the world grapples with environmental degradation, comprehending the intersection of public opinion, international relations, and environmental policy will be critical in devising effective solutions to address these multi-faceted global challenges.

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