To Everything There Is a Season: The Effect of Air Pollution on Public Opinion in China

Yana Jin[a,b,*], S.P.Harish[b], Dan Maliniak[b]

[a] *Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010*
[b] *William & Mary, 23185, Williamsburg, Virginia, USA*

Abstract

We test how the real-time air pollution level and its seasonality affect public opinion on authoritarian environmental governance. We match survey data from September 2016 to Jan 2017 in Beijing with real-time outdoor air pollution concentration. We find significant causal effects of air pollution on reported belief in government efficacy and projected regulatory difficulty to clean up the air. Higher air pollution lowers belief (raises projected regulatory difficulty) and the effect is significant only in clean (dirty) season, respectively. Belief in government efficacy is most sensitive to the recent hours' pollution whereas several days average pollution matters most on projected regulatory difficulty. Our findings support an end-heuristic bias, and that residents living in good reference conditions (clean season) are more emotionally influenced by momentary environmental changes. Meanwhile, residents can form an imprecise but reasonable opinion on the severity of pollution and how prolonged the regulatory challenge would be.

Keywords: $PM_{2.5}$, public opinion, government efficacy, seasonality

*Corresponding author

Email address: `yjin@edf.org` (Yana Jin)

1. Introduction

- air pollution' s negative impact on outcomes A B and C
- government policy–citizens call and require their faith–seasonality and temporal changes have a role in shaping their faith–our case study in China
- Maybe table one early?
- what did we do
- in more detail what did we do
- our findings support an end-heuristic bias. Definitions of end-heuristic bias. Why this is important. The implications of our findings.

2. Research Context, Design, and Data

2.1. Biases and Pollution

It is an open question as to whether or not the publics are good at holding their representatives accountable for policy failures or rewarding leaders for policy successes.—> some reference papers of rational voter theory—>rational voter theory is susceptible to cognitive biases→AW paper pointing out an application on air pollution, focusing on cognitive biases A number of studies also suggest that pollution and environmental factors can cause or exacerbate biases. end-heuristic suggest that citizens' evaluations of their government' s performance with respect to the role of air pollution is particularly complex. we argue that two additional factors play an important role in understanding this relationship: seasonality and temporal complexity.

2.1.1. Seasonality

describes seasonality in pollution a paragraph saying our respondents have the same mean belief in the government' s ability across good and bad seasons this contradicts other studies showing rapid changes in pollution have an effect on opinions we argue that seasonal context matters insofar as it affects how individuals use an end-heuristic.

2.1.2. Temporal Dynamics

temporal complexity

2.2. Beijing's Air Pollution and Policies

characteristics and reasons for Beijing' s air pollution Beijing municipal efforts to control air pollution in this context, seasonality may play role in public opinion.

2.3. Empirical Strategy

2.4. Dependent Variables

2.5. Independent Variable

2.6. Main Estimation

3. Results & Discussion

3.1. DLM Results Interpretation

3.2. Seasonality of Pollution Exposure

4. Conclusions

References

References

Appendix

Appendix A. Replicate AW

AW full sample OLS regression, with respondent specific AQI measures

	(1) l_sat	(2) c_sat	(3) l_watch	(4) c_watch	(5) anti_west	(6) life_sat
AQI_new	-0.0403	-0.0321	0.0612	0.0437	-0.0530	-0.0510*
	(0.0382)	(0.0310)	(0.0509)	(0.0436)	(0.0369)	(0.0288)
AQI_new lagged	0.179***	0.0746	-0.138*	-0.0949	0.111	0.0873*
	(0.0504)	(0.0524)	(0.0753)	(0.0579)	(0.0688)	(0.0475)
AQI_new lagged 2	-0.148***	-0.0733	0.0787	0.0329	-0.121*	-0.118**
	(0.0510)	(0.0527)	(0.0737)	(0.0452)	(0.0718)	(0.0462)
hukou	-0.0212	-0.134	-0.0886	-0.100	0.0798	-0.0353
	(0.0973)	(0.0977)	(0.125)	(0.108)	(0.133)	(0.101)
insider	-0.139**	-0.0827	0.369***	0.293***	0.160**	0.0354
	(0.0605)	(0.0640)	(0.0676)	(0.0650)	(0.0695)	(0.0480)
age	-0.0820**	-0.0711**	0.0486	0.0906***	-0.00440	-0.0586**
	(0.0308)	(0.0288)	(0.0349)	(0.0310)	(0.0291)	(0.0272)
soe	-0.120**	-0.0547	-0.0257	-0.0342	-0.0863	-0.165***
	(0.0597)	(0.0618)	(0.0659)	(0.0615)	(0.0664)	(0.0430)
educ	0.00850	-0.00735	0.0350	0.0370	0.0705**	0.0956***
	(0.0305)	(0.0304)	(0.0355)	(0.0297)	(0.0284)	(0.0257)
kids	0.106	0.276***	-0.126	-0.280**	0.295***	0.304***
	(0.0772)	(0.0793)	(0.101)	(0.116)	(0.0910)	(0.0777)
married	0.186**	-0.0215	-0.295***	-0.143	-0.171	0.149*
	(0.0829)	(0.0792)	(0.0952)	(0.0993)	(0.116)	(0.0888)
income	0.0546*	0.0143	-0.0335	-0.0487	-0.0317	0.0174
	(0.0297)	(0.0281)	(0.0308)	(0.0321)	(0.0306)	(0.0263)
gender	0.174***	0.124**	-0.322***	-0.213***	-0.0210	0.0665
	(0.0615)	(0.0532)	(0.0779)	(0.0611)	(0.0583)	(0.0504)
ccp	0.307***	0.255***	-0.416***	-0.309***	-0.0365	0.140**
	(0.0597)	(0.0599)	(0.0708)	(0.0658)	(0.0705)	(0.0548)
parade	0.131*	-0.0796	-0.211**	-0.104	-0.120*	-0.0496
	(0.0693)	(0.0621)	(0.0803)	(0.0730)	(0.0665)	(0.0525)
national	0.245***	0.0510	-0.237**	-0.199**	-0.151	0.00356
	(0.0794)	(0.0483)	(0.101)	(0.0782)	(0.0950)	(0.0650)
Observations	1747	1744	1738	1739	1740	1749

Standard errors in parentheses
Note: Standard errors clustered by date are in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

Figure A1: When changing AW's single daily values of AQI into respondent specific daily values of AQI, AW table 1 regression results do not hold any more.

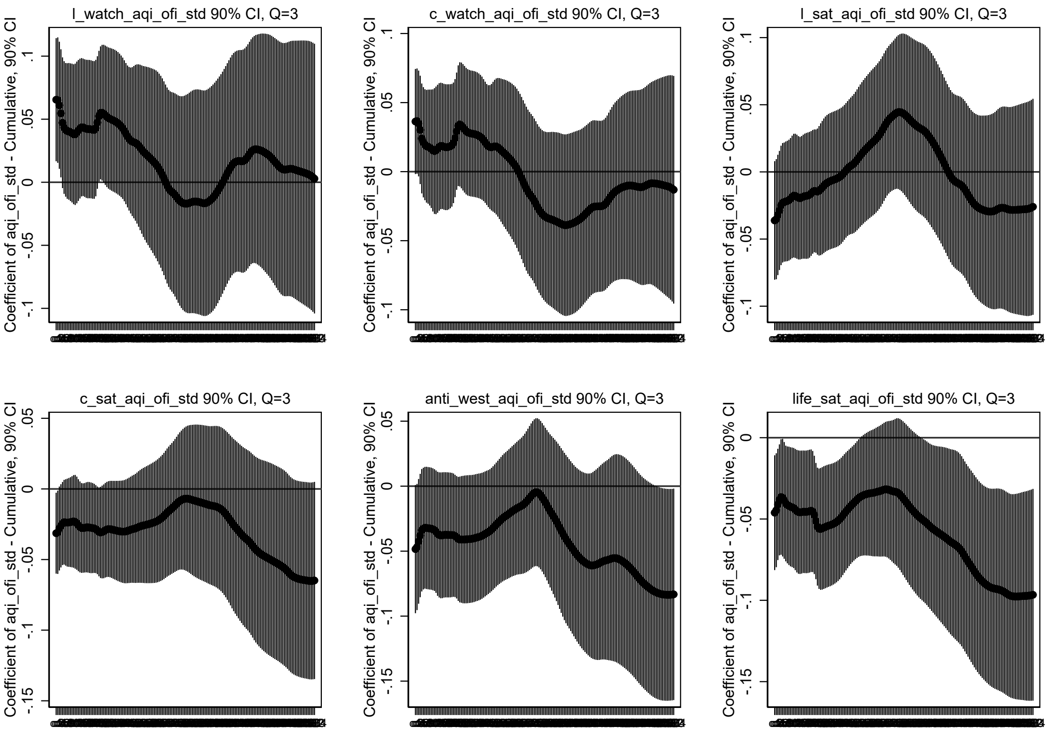

Figure A2: DLM models (Q=3, lags = 4 to 167) results on AW's raw data provide insights for the temporal dynamics of the pollution's effect. Comparing these 6 plots to the 6 models coefficients size and trends in table in Figure A1, they are consistent.

Appendix B. Appendix Figures and Tables

Appendix B.1. Figures

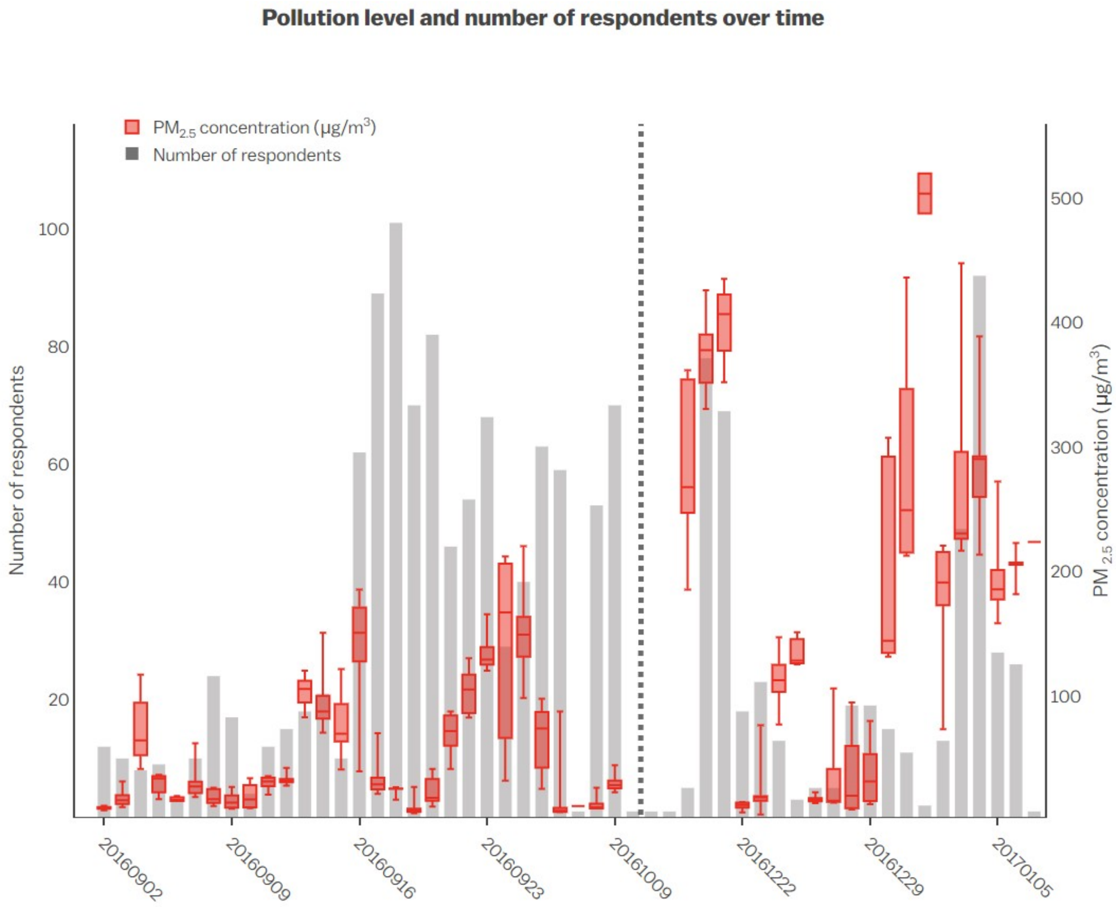

Figure B3: Pollution level and number of respondents over the autumn and winter.The dashed line separates two seasons sub-samples.

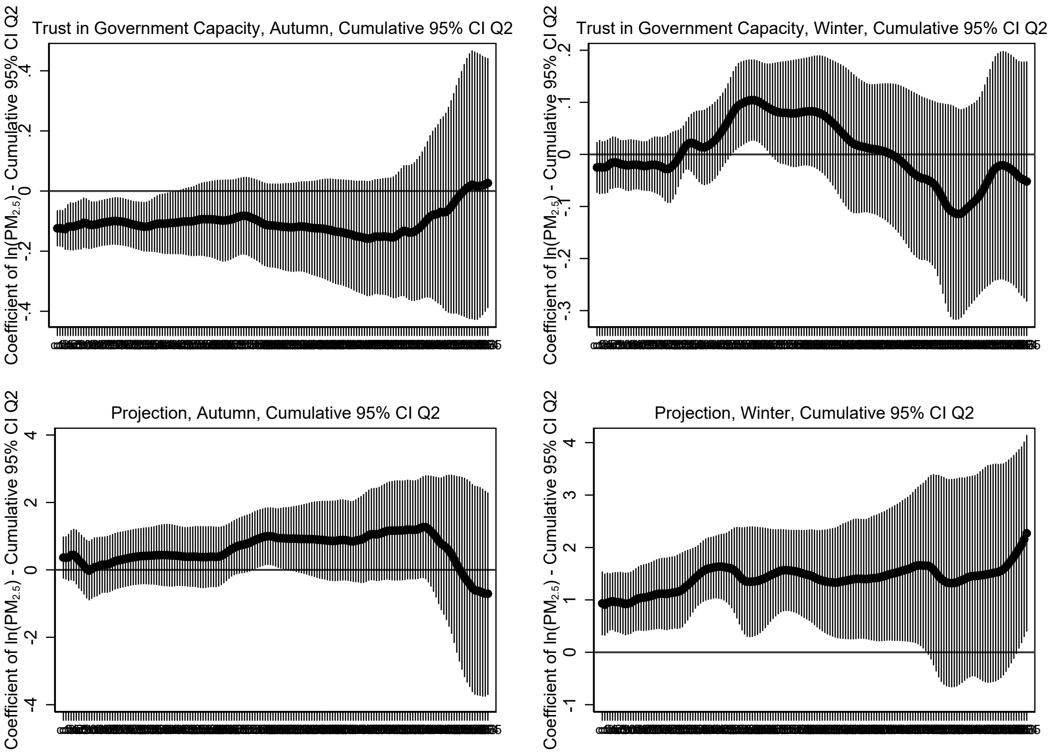

Figure B4: DLM cumulative Q=2.

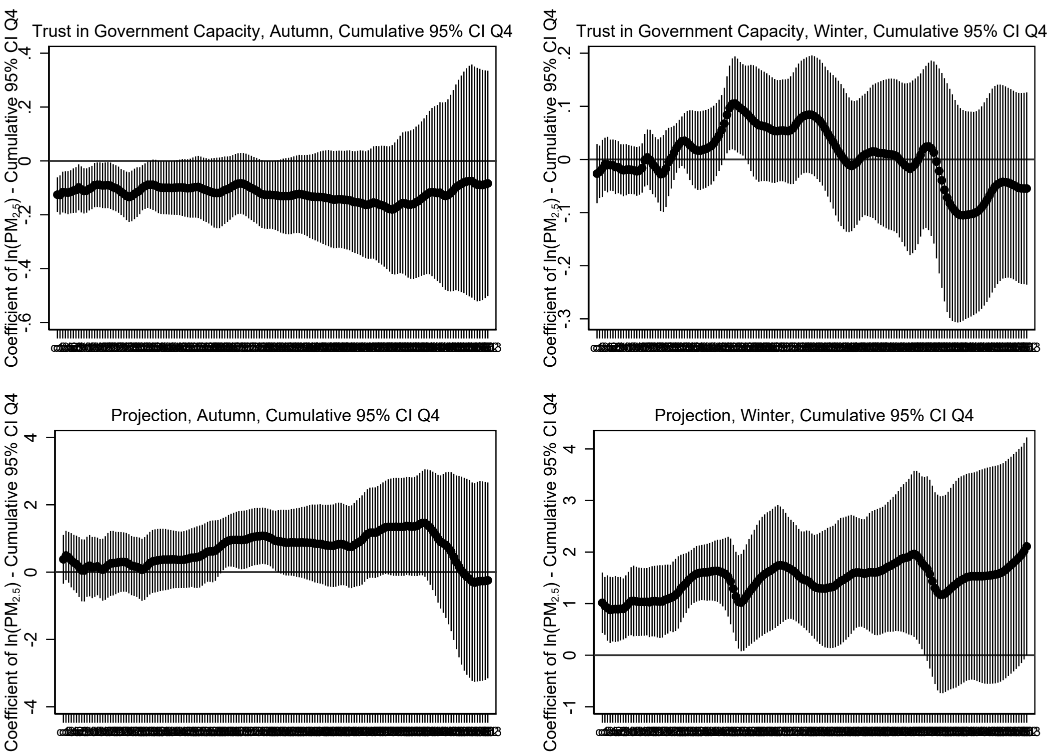

Figure B5: DLM cumulative Q=4.

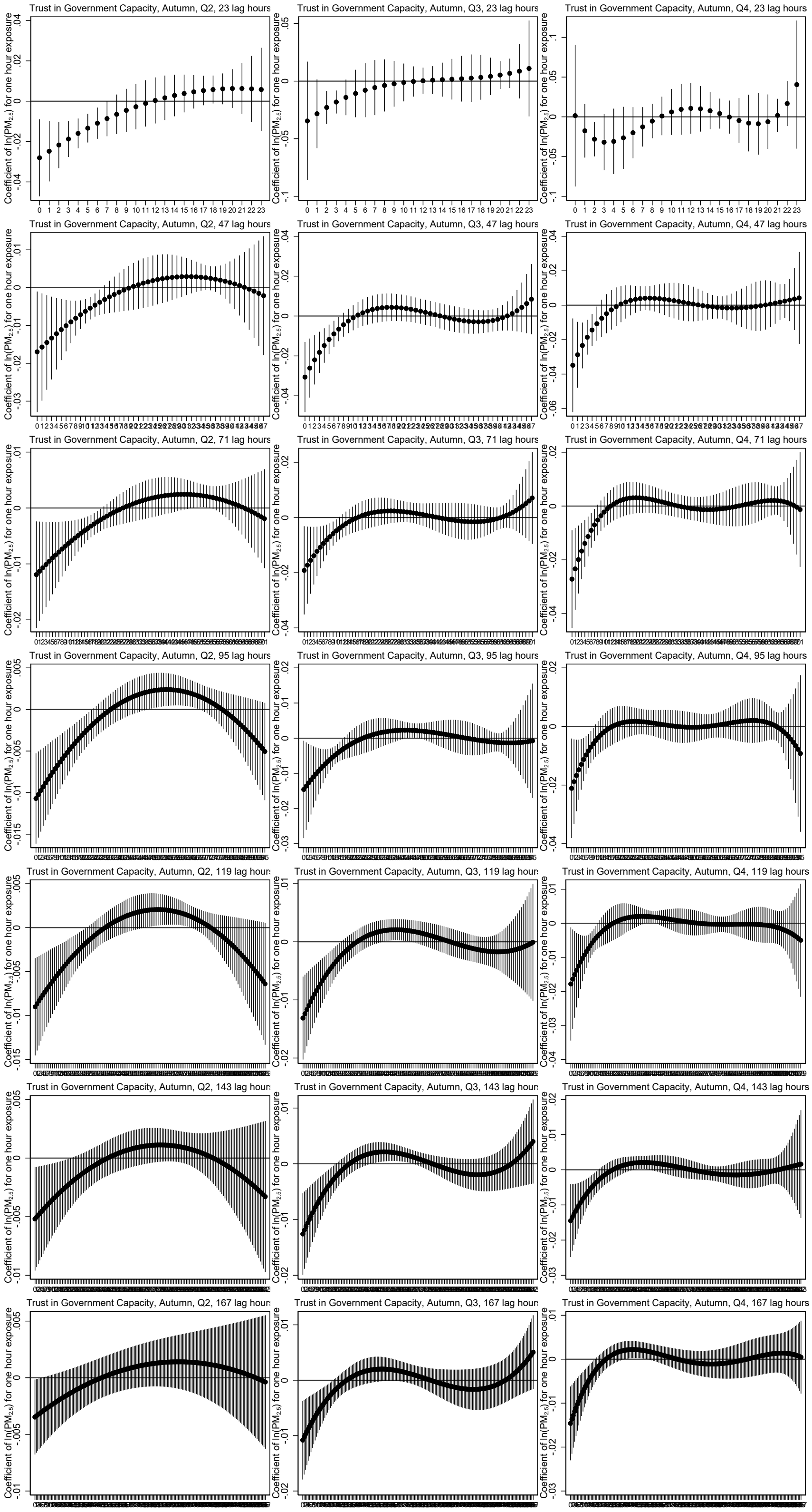

Figure B6: DLM individual hours believe autumn. plot columns are for Q=2, 3, 4; plot rows are for lags = 24, 48, 72, 96, 120, 144 and 167.

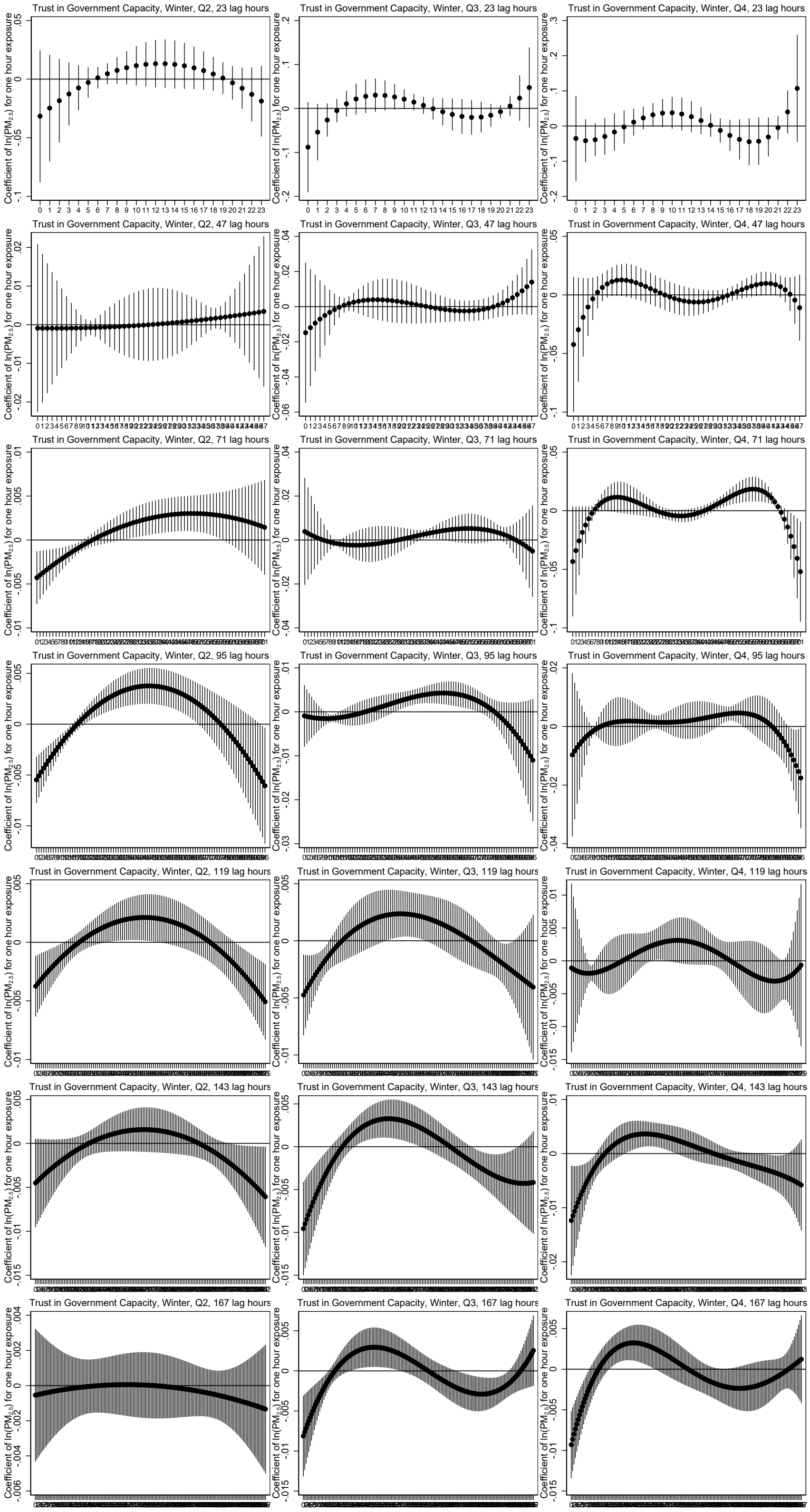

Figure B7: DLM individual hours believe winter. plot columns are for Q=2, 3, 4; plot rows are for lags = 24, 48, 72, 96, 120, 144 and 167.

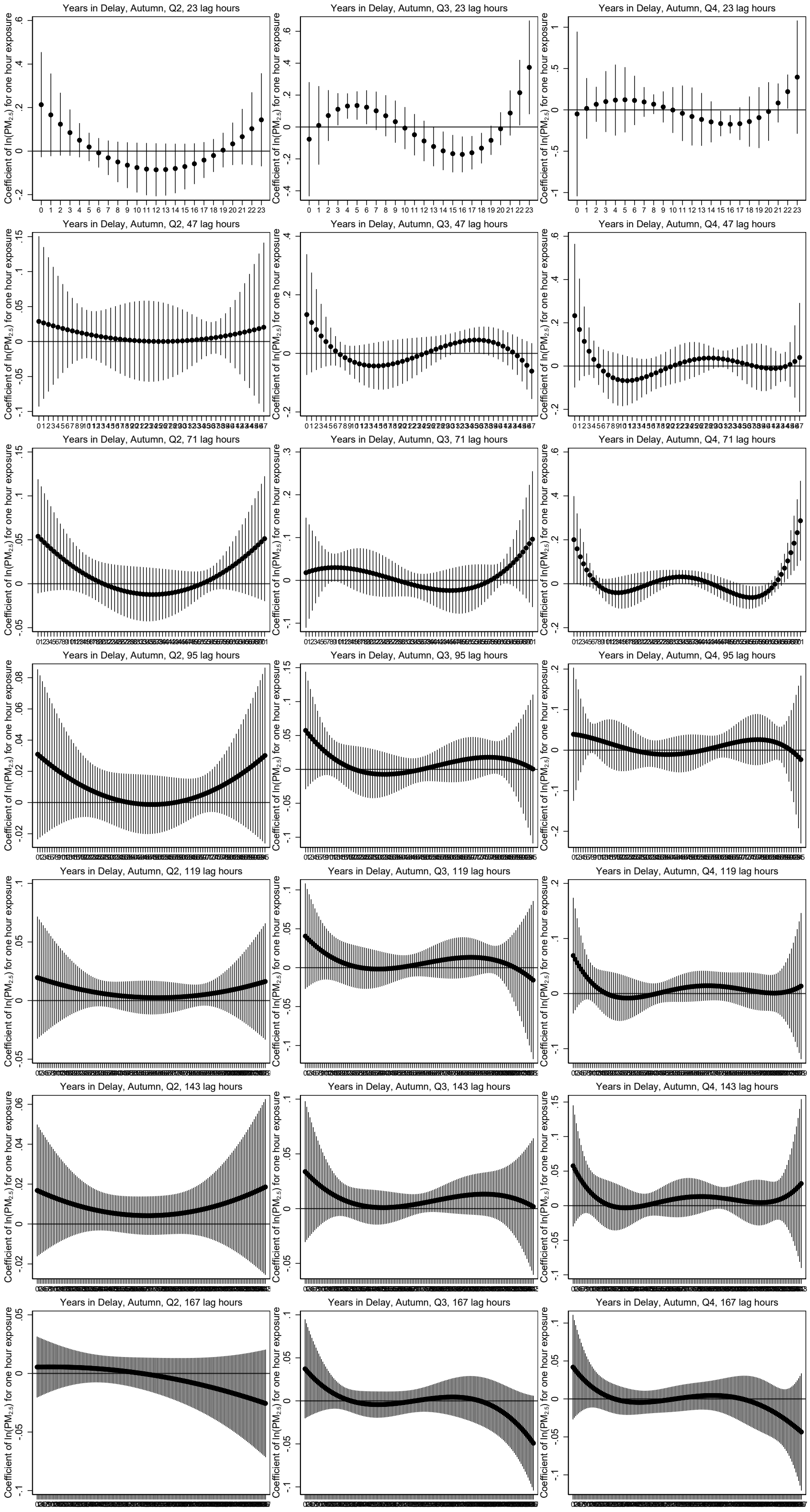

Figure B8: DLM individual hours projection autumn. plot columns are for Q=2, 3, 4; plot rows are for lags = 24, 48, 72, 96, 120, 144 and 167.

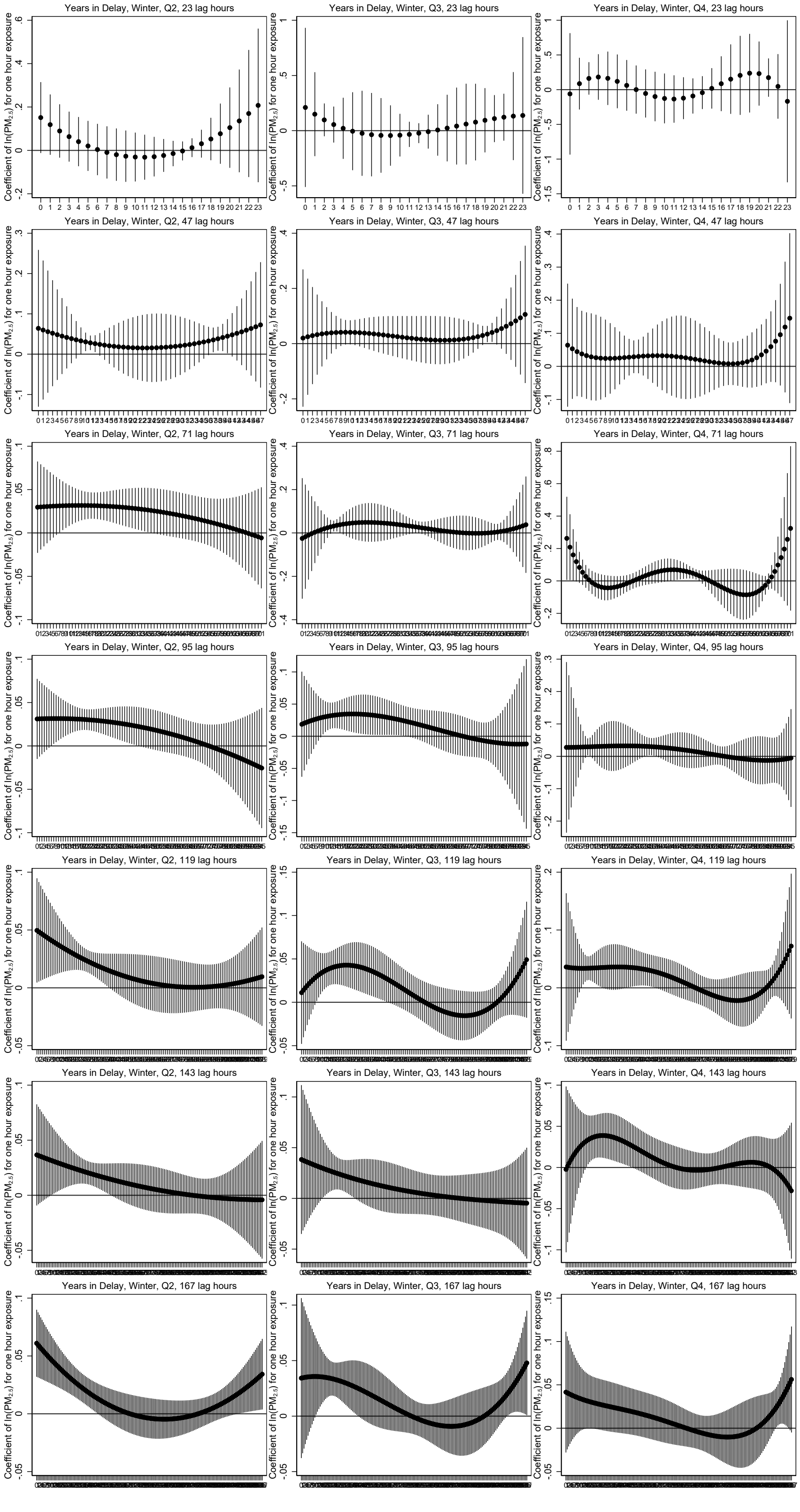

Figure B9: DLM individual hours projection winter. plot columns are for Q=2, 3, 4; plot rows are for lags = 24, 48, 72, 96, 120, 144 and 167.

Appendix C. Robustness Checks

We conducted four sets of analyses to support the robustness of our main findings. First, we show that $PM_{2.5}$ predicts the perceived past 24 hours of air quality (Figure C10) in both seasons. Second, we use the Air Quality Index (AQI), PM_{10}, SO_2, NO_2 as an independent variable, and obtained similar but weaker effects as compared to the main analysis, whereas ground-level ozone (O_3) has no effects. Third, we run regressions using z-score (i.e. standardized rather than the natural logarithm of pollution concentration) and obtained similar effects (Figure C12). Finally, we provide a placebo test by showing that our air pollution measure does not predict respondent knowledge of O_3 (Figure C13).

Appendix C.1. Pollution Measure

Our measure of $PM_{2.5}$ actually measures perceptions of air pollution levels, and this is important because it bolsters our confidence that our air pollution measure is not just an artifact. We use two questions in the survey, "How would you describe the air quality in the area you live in today (during the past 24 hours)?" and "How would you describe the air quality in the area you live during the past one year?" to determine the relationship between our $PM_{2.5}$ measure and perceptions of short and long term air pollution. Figure C10 presents results that regresses the perceived air quality (measured by 5-point Likert scale answers from very bad to very good) on the natural logarithms of Beijing's hourly average pollution concentration for various pollutants. The results show a strong relationship between our measure of $PM_{2.5}$ and the respondent's perception of daily air quality. The effect is insignificant for predicting perceived average air quality for the past one year. Our main $PM_{2.5}$ variable not only measures air pollution levels objectively, it also reflects what respondents think about the air quality at the time of the survey. Meanwhile, it does not change the subjective assessment of longer-term air quality which is desirable for our research objectives. AQI and PM_{10} have strong prediction power for perceived short term air quality in both seasons. The effect of SO_2 and NO_2 are similar in direction but are less or insignificant. These are reasonable. AQI is a unitless measure describing the general pollution level. It is composed of multiple pollutants (PM_{10}, $PM_{2.5}$, NOx, SO_2, O_3), and typically reflects the highest pollutant level.

During our study time period, the AQI mostly reflects $PM_{2.5}$ level (corr = 0.997). PM_{10} includes $PM_{2.5}$ (corr = 0.981). NO_2 (corr = 0.908) and SO_2 (corr = 0.577) are precursors of $PM_{2.5}$ in atmospheric chemical reactions. O_3 is invisible and does not monotonically correlate with $PM_{2.5}$ (corr = -0.293).

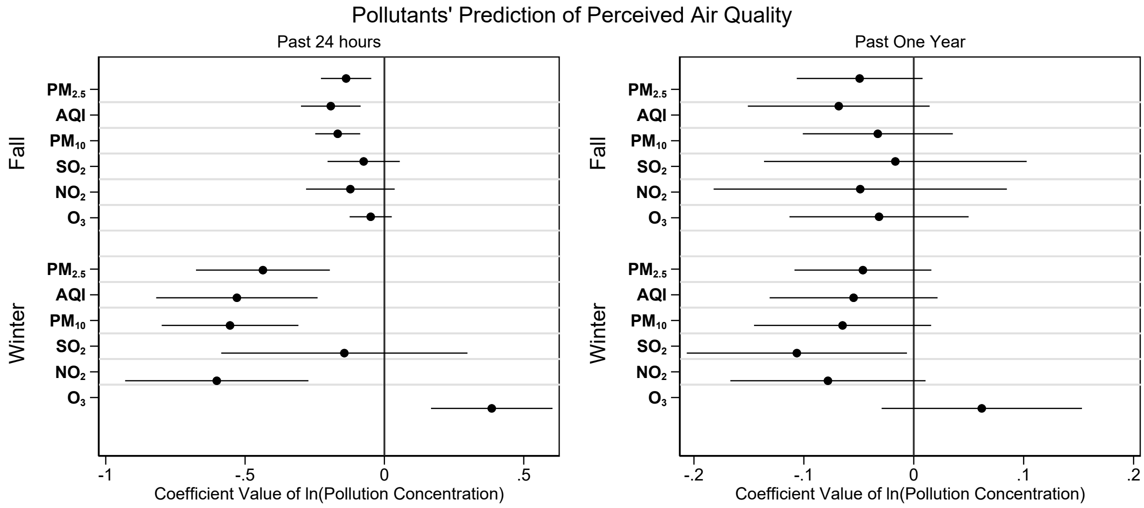

Figure C10: Effect of hourly pollution on perceived daily and yearly average air quality.

Appendix C.2. Other Pollutants' Effect on Public Opinion

In this study, we use $PM_{2.5}$ as our main measure of air pollution. Here we check whether AQI and other pollutants also influence perceptions of government efficacy like $PM_{2.5}$. Given the strong correlation between $PM_{2.5}$ concentration and AQI, PM_{10}, SO_2 and NO_2 as mentioned in section Appendix C.1, these effects shown in Figure Appendix C.2 are expected. The pollutants with a stronger prediction for perceived air quality (Figure C10) also show a stronger effect on belief of government efficacy during 'clean' season, and on projected regulatory difficulty during the 'dirty' season.

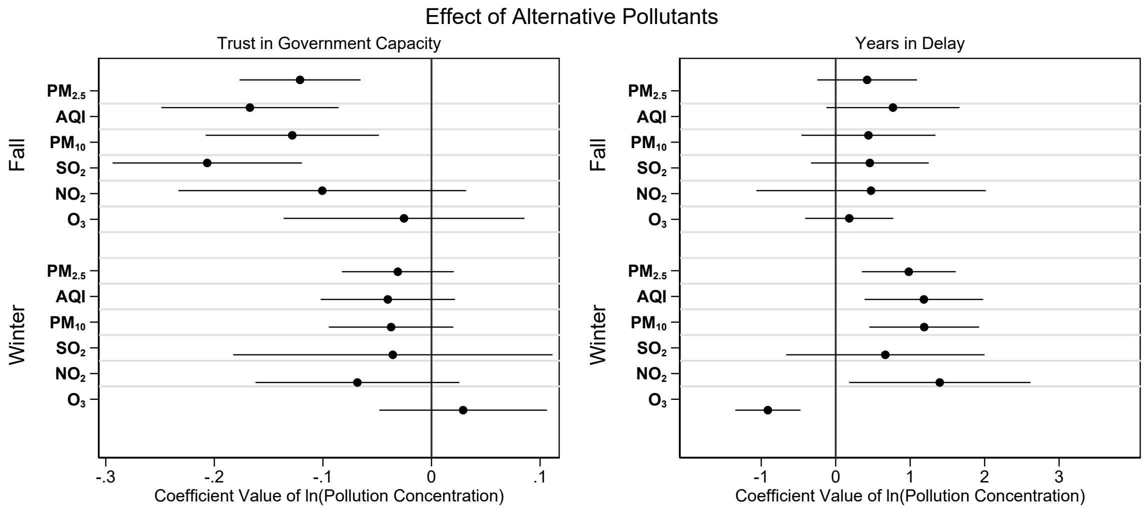

Figure C11: Effect of AQI and other pollutants on belief in government efficacy and projected regulatory difficulty. All models include the full set of control variables: respondent demographics, respondent experience, baseline perception, influential days and meteorological information. See the main text for a discussion of these control variables. Standard errors in all models are clustered by date.

Appendix C.3. Z-score Results

The value and variation of pollution levels may both influence public opinions. As the baseline level and variation of pollution are of different magnitude in autumn and winter, we want to see if our main results hold by using a standardized pollution level within each season. Figure C12 confirms the robustness of the main findings.

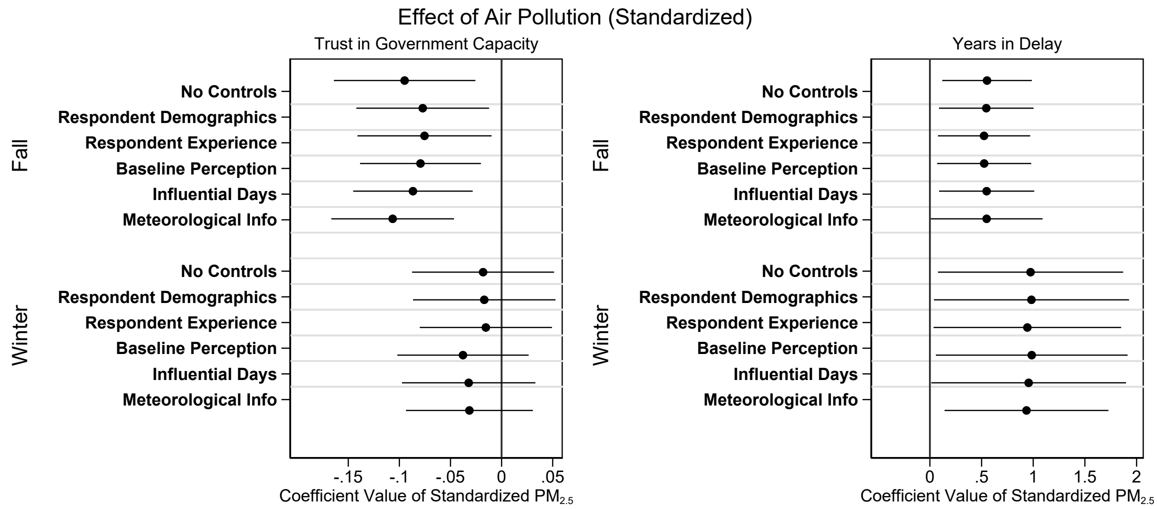

Figure C12: Effect of $PM_{2.5}$ using z-score measures of pollution. The models include different sets of control variables progressively. See the main text for a discussion of these control variables. Standard errors in all models are clustered by date.

Appendix C.4. Placebo Test

Next, we show that our main $PM_{2.5}$ variable does not change a respondent's opinion on issues that are theoretically unrelated to the air pollution level. We use the respondent's stated knowledge of ground-level ozone pollution for this placebo test. If our measure of pollution is valid, then it should not change the respondent's knowledge about a topic. Figure C13 shows, as we expect, that there is no statistically significant relationship between our measure of air pollution and the respondent's knowledge of ground-level ozone pollution. This increases confidence in our air pollution measure and the robustness of our main results.

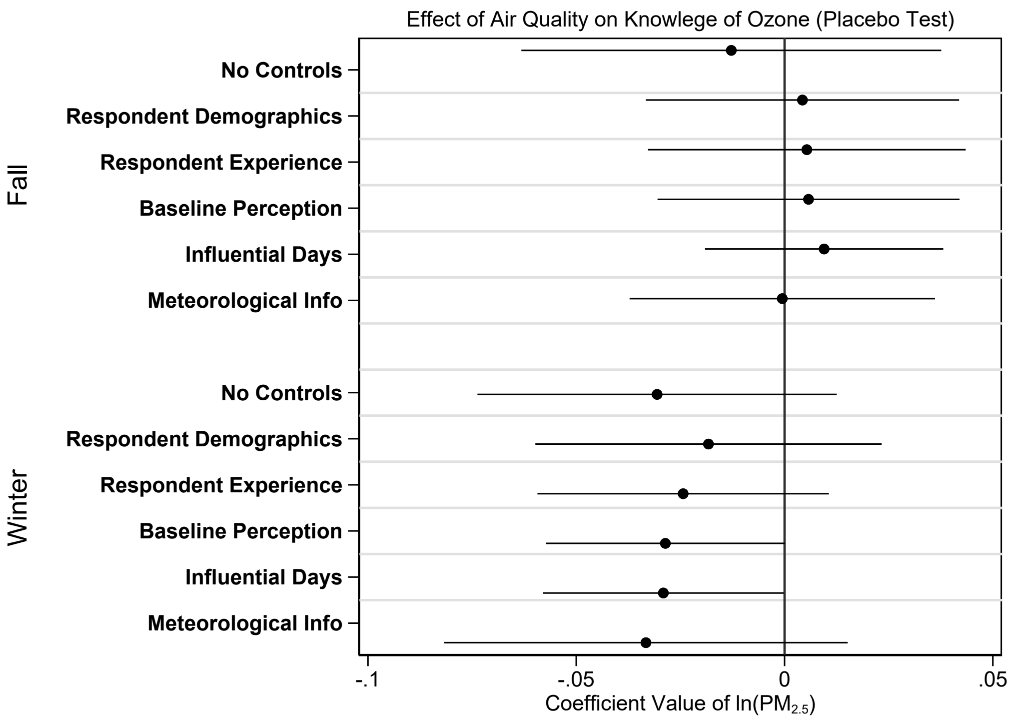

Figure C13: Effect of $PM_{2.5}$ on knowledge of ground-level ozone pollution. The models include different sets of control variables progressively. See the main text for a discussion of these control variables. Standard errors in all models are clustered by date.

Appendix C.5. Summary Statistics and Data Sources

Table C1: Summary Statistics

	Autumn		**Winter**		**Total**	
	Mean	SD	Mean	SD	Mean	SD
Belief in Government Efficacy (5 scales)	3.16	0.92	3.15	0.93	3.15	0.92
Belief in Health-Air Pollution Impact (5 scales)	4.00	0.74	4.09	0.82	4.03	0.77
Annual Household Income (RMB thousands)	145.08	131.37	170.93	151.36	153.72	138.86
Resident Length Category, (short = 1, 2-5 years = 2, above 5 years = 3)	1.59	0.70	1.64	0.68	1.61	0.69
Mortality Risk Rank for Air Pollution (from highest = 1 to lowest = 6)	3.81	1.74	3.39	1.76	3.67	1.76
Years in Delay (Years)	9.60	7.37	10.63	7.82	9.94	7.54
Knowledge of Ozone	0.38	0.49	0.46	0.50	0.40	0.49
Bachelors Degree (0/1)	0.47		0.51		0.48	
Female (0/1)	0.48		0.50		0.49	
Air Pollution Symptoms of Friends/Family (0/1)	0.92		0.97		0.94	
Influential Event (0/1)	0.17		0.00		0.11	
Weekend (0/1)	0.35		0.05		0.25	
Perceived Past 24 Hours Air Quality (5 scales)	3.17	0.92	1.81	1.05	2.72	1.16
Perceived Past One Year Air Quality (5 scales)	2.55	0.93	1.75	0.88	2.29	0.99
Air Quality Index (AQI)	83.36	62.21	283.85	137.14	150.66	133.58
$PM_{2.5}$ (($\mu g/m^3$, past one hour)	59.05	52.34	250.47	132.86	123.31	126.15
PM_{10} ($\mu g/m^3$, past one hour)	71.58	54.11	296.69	145.08	149.96	144.00
SO_2 ($\mu g/m^3$, past one hour)	3.60	2.38	17.04	9.28	8.11	8.54
NO_2 ($\mu g/m^3$, past one hour)	41.09	18.77	118.90	47.36	67.21	48.34
O_3 ($\mu g/m^3$, past one hour)	63.88	51.74	14.42	14.20	47.32	48.92
Past 24 Hours Temperature (\textcelsius)	19.64	4.06	-1.41	1.35	12.60	10.50
Wind Speed (m/s)	2.13	1.51	1.73	1.28	2.00	1.45

The demographics of our survey are comparable to that of the city of Beijing. Air Quality Index (AQI) definition in China: Excellent (0-50), Good (51-100), Slightly Polluted (101-150) Moderately Polluted (151-200) Heavy Polluted (201-300), Hazardous (300+). Hourly monitored pollution concentration and AQI are available at data.epmap.org. We averaged pollution data from all of Beijing's monitors with the exception of Guanting Reservoir station which typically records near zero pollution given its location. Temperature and wind speed data are available at NOAA.

Appendix C.6. Influential Events

The below table provides a list of dates with influential events that took place during the period of September 2016—January 2017.

Date	Description
9/4/2016	G20 Summit in Hangzhou
9/10/2016	Typhoon Meranti
9/15/2016	The successful launch of Shenzhou 11 & Mid-Autumn Festival
9/16/2016	Mid-Autumn Festival
9/17/2016	Mid-Autumn Festival
10/1/2016	National Day Holiday (10/1-10/7)
10/2/2016	National Day Holiday (10/1-10/7)
10/3/2016	National Day Holiday (10/1-10/7)
10/4/2016	National Day Holiday (10/1-10/7)
10/5/2016	National Day Holiday (10/1-10/7)
10/6/2016	National Day Holiday (10/1-10/7)
10/7/2016	National Day Holiday (10/1-10/7)
11/12/2016	The death of Yu Xu, the first airwoman of Chengdu J-10 aircraft
12/8/2016	Campus bullying accident in a Beijing Middle School
1/27/2017	Chinese New Year

Appendix C.7. Survey Questions

Variable	Survey Question (Freely Translated English /Original Chinese Text in Survey)
Belief in Government Efficacy	To what extend do you believe that the government can implement new programs and achieve the expected effects? 您觉得有多大程度相信政府能实施新项目并达成效果?
Years in Delay	How many years do you think are needed to significantly improve the air quality of where you live (i.e. where the good air quality days are the majority)? 您觉得，从现在起大概需要经过多少年的治理，您所在的地方的空气质量才有可能明显改善，变成以空气质量优良天为主?
Knowledge of Ozone	Have you heard of ground level ozone? (Note, not asking about the hole in the ozone layer) 您是否听说过近地面臭氧 (请注意不是臭氧层空洞)?
Perceived Past 24 Hours Air Quality	How would you describe the air quality in the area you live in today (during the past 24 hours)? 您认为今天 (过去 24 小时里) 您所在的地方的空气质量如何?
Perceived Past One Year Air Quality	How would you describe the air quality in the area you live during the past one year? 您认为过去一年里您所在的地方的空气质量如何?
Mortality Risk Rank for Air Pollution	We have listed 6 mortality risks below. Please rank the following 6 mortality risks from 1 to 6. 我们列举了 6 种死亡风险，请将您认为的最常见的死亡风险排在最上方，依次向下，直到您认为最罕见的死亡风险，给它们排个序。更常见的死亡风险的意思是：相对而言，人群中有更多的人死于该风险 The choices are air pollution, food poisoning, occupational, smoke, transport and violence
Air Pollution Symptoms of Friends/Family	Have your family members or friends ever experienced any of the following symptoms, which you believe to have been caused by air pollution? 您的家人朋友是否曾经出现以下情况，并且您相信正是空气污染导致的?
Resident Length	How long have you been living in the city of your current residence? 您在目前居住的城市生活了多久?
Health-Air Pollution Impact	How certain do you believe air pollution produces significant morbidity and mortality risks of major illnesses? 您在多大程度上相信空气污染带来重大疾病风险?