Pollution Motivates Hope-Seeking Behavior: Sources of the Pollution-Gambling Link

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Abstract:[1]

In developing countries around the world, air pollution remains a serious issue which has possible unexpected influences on a variety of human decisions. Using a rich panel data structure with air quality observations at a daily frequency, we demonstrate a robust positive relationship between air pollution and lottery gambling and investigate the potential mechanisms for this relationship. Psychological influences account for a significant proportion of this positive relationship, as evidenced by a robust significant effect of reduced visibility conditions on lottery ticket purchases. However, chemical components of AQI (Air Quality Index) are also significantly responsible for the decision to purchase tickets, particularly sulfur dioxide (SO_2), which suggests a larger impact of the early particulate formation process on human behavior than previously considered in most studies. We further show that limited attention to information about air quality levels is a significant factor, by identifying discontinuous jumps in lottery ticket purchases at government provided color-coded AQI transition thresholds around the "Moderate" or "Unhealthy" level, implying that the increase in ticket purchases is cognitively-driven. Finally, adverse regional economic conditions, namely the unemployment rate, significantly enhances the appeal of lotteries under polluted conditions. Altogether, our findings suggest a significant conscious appeal of lottery tickets as a hope-seeking device, providing ex-ante psychological health benefits under negative environmental conditions.

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1. Introduction

Increasing attention has been drawn to the effects of air pollution exposure on human behavior in recent years. While early on social scientists recognized the need to understand how pollution could affect economic behavior such as worker performance (ex. Lagercrantz, et al, 2000), a recent resurgence of interest in the negative impacts of air pollution on mental health (Zhang, Zhang and Chen, 2017), cognitive performance (Zhang, Chen and Zhang, 2018), worker productivity (Graff Zivin and Neidell, 2012; Chang, Graff Zivin, Gross, and Neidell, 2016; He, Liu and Salvo, 2019; Chang, Graff Zivin, and Neidell, forthcoming), sports performance (Lichter, Pestel and Sommer, 2017; Guo and Fu, 2019), and consumption behavior (Barwick, Li, Lin and Zou, 2019) has grown due to the phenomenon of heavy air pollution in the developing world.[2]

Lottery gambling has also been a topic of significant interest, both from the perspective of decision-making (ex. Lien and Yuan, 2015a, 2015b; Lien, Yuan and Zheng, 2017, among others) and from a policy perspective (ex. Perez and Humphreys, 2011; Humphreys and Perez, 2012, among others).[3] In this study, we examine several channels to understand the potential mechanisms for a significant positive relationship between air pollution and lottery gambling. Medical research has focused on the impact of various chemical reactions on biological functioning, while the social sciences have focused mostly on non-biological, reasoning-based motives for human decisions. These fields have not frequently intersected to provide an understanding of how specific human decisions such as risk-taking and consumer purchase decisions could be affected by the presence of the chemical composition in the environment. To begin understanding the mechanism behind air pollution's positive impact on lottery sales, we use an econometric approach to examine a combination of factors which could serve to potentially enhance the appeal of lottery ticket purchase under polluted conditions.

Firstly, by examining lottery sales in the days leading up to the thrice weekly lottery draw of Union Lotto, China's official lottery game which is also the most popular lottery game in China, we find that higher air pollution levels lead to significantly higher lottery ticket sales.[4] The effect is robust across both northern and southern regions of China and is generally driven by the autumn and winter seasons of the year. Examining the simultaneous effects of each component of AQI, we find that the primary AQI component responsible for this increase in lottery purchase is sulfur dioxide (SO_2), particularly during the autumn months. Most prior studies have focused on the effect of particulate matter (PM 2.5 and PM 10) on behavior changes (Graff Zivin and Neidell, 2012; Chang, Graff Zivin, Gross, and Neidell, 2016; Lichter, Pestel and Sommer, 2017; Zhang, Zhang and Chen, 2017; Zhang, Chen and Zhang, 2018; He, Liu and Salvo, 2019; Chang, Graff Zivin, and Neidell, forthcoming). We find that although each official component of AQI indeed contributes significantly positively to the increased lottery ticket purchase when examined separately, when controlling for levels of the different AQI components, the frequently studied particulate matter measure (PM2.5) does not have a significant positive effect, while SO_2 in fact does. Since SO_2 is understood to be a predecessor to particulate matter, the result suggests that behavior could be influenced by air pollution earlier on in the particulate development process than previously considered.

The overwhelming majority of economic studies regarding pollution's effect on human behavior focus on establishing the correlation or causal effect between pollution and particular choices or outcomes.[5] However, to our knowledge, few if any studies attempt to explain the mechanism for the relationship between pollution and behavior. The

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[2] For a more complete listing of pollution-related studies, we refer to Lu (2020) which provides a current review of the existing literature on the psychological, economic, and social effects of air pollution.

[3] We refer to Humphreys and Perez (2013), which provides a detailed survey of the literature on lottery demand.

[4] A positive relationship between air pollution and lottery gambling is also supported in an independently conceived study, Chew, Liu and Salvo (2019), which focuses specifically on establishing a robust causal relationship between particulate matter (PM 2.5) and purchase of China's 3D lottery and related games. Our study benefits from their work in establishing a causal relationship between pollution and gambling behavior, which allows us to focus on the possible mechanisms through which air pollution influences gambling. However, our study departs substantially from theirs by investigating the potential mechanisms for the positive relationship, particularly through psychological and economic channels.

[5] See also Chew, Huang and Li (2017) which tests the effect of pollution conditions on economic preference parameters in a laboratory experiment, and Gao, Lien, Wang and Zheng (2019) which examines the effect of pollution on financial analysts' forecasting performance.

mechanisms for pollution's influence on behavior may be especially important for those domains of interest involving human choice. In the case of choice-based behavior, several potential factors could influence human decisions. The first and perhaps most obvious of the categories when considering pollution-related behavior is through biological channels. For example, one or more chemical components of AQI could lead to biological needs (similar to hunger), which eventually lead the decision-maker, perhaps to some extent involuntarily, to a particular choice. Another potential channel is through the influence on psychological states through mood, which then lead the decision-maker to a choice. Still another potential channel is through information provided, which suggests a more cognitive, deliberate choice being made. Finally, economic conditions could set the psychological state of the decision-maker leading to a disposition for particular choices. Although this is not an exhaustive list of the possible channels for the effect of pollution on gambling, these are the main factors that we consider in this paper.

Next, beyond our basic findings on the relationship between lottery gambling and AQI components, our study examines three main factors which could drive the pollution-gambling link: 1. Visibility conditions, which are often correlated with air pollution and can be controlled for in order to assess the chemical versus perceptional impact of air pollutants on decisions; 2. The role of information provision and limited attention to AQI in the pollution-driven gambling appeal; 3. How regional economic conditions interact with the decision to purchase lottery tickets on high air pollution days.

First, we use visibility data from the National Oceanic and Atmospheric Administration (NOAA) to assess how the correlation between high AQI levels and reduced sunlight and air transparency accounts for the relationship between pollution and gambling behavior. Previous studies have used visibility conditions as a proxy for AQI when official statistics are unavailable (Du, Li and Yuan, 2014). Utilizing the data period in which the two data series overlap allows us to decompose the visual influences of air pollution from the air pollutant content itself in explaining lottery gambling. Our baseline estimate suggests that reduced visibility accounts for about 22% of the increase in lottery sales found per AQI point overall. In other words, reduced visibility conditions due to pollution plays a significant role in individuals' pollution-driven desire for lottery gambling - and since actual AQI content is controlled for throughout the analysis, this effect may be interpreted as perceptional or mood-driven in nature.

Secondly, we examine the role of information about AQI and limited attention to AQI levels on lottery purchase. If the effect of pollution on gambling behavior is purely through a biologically driven channel, then providing information about AQI should not have a significant impact on the amount of lottery tickets sold. A recent study (Barwick, Li, Lin and Zou, 2020) however, finds that information provision regarding pollution promotes avoidance behavior. In addition, once AQI information is provided to individuals, the color-coded categories of pollution intensity should not have a discontinuous effect on lottery sales, since two different but adjacent color-codings are only a single AQI point away from one another and are thus only marginally different in terms of actual air quality. If such a discontinuous effect exists, it suggests that limited attention to the AQI number itself drives individuals to be reliant on color-coded categories in determining the degree of air pollution present, and in turn, how much they want to buy lottery tickets. We find that indeed, lottery sales are disproportionately responsive to the AQI number that immediately qualifies as "moderately polluted" (color code red), which indicates that lottery ticket consumers pay significant attention to pollution rating categories in considering their lottery ticket purchases. Furthermore, this effect exists only after the public release of daily AQI statistics and pollution category color coding by the Ministry of Environmental Protection of China (MEP) from year 2013 onward, which supports the attention mechanism.

Finally, we examine the role of regional economic conditions on the appeal of tickets. Regional unemployment rates and GDP per capita are both significantly associated with additional lottery sales in terms of their interaction effect with pollution levels. This provides general support for the idea that an important appeal of lottery tickets is the hope that they provide to individuals for an appealing future (Ng, 1965).

We note that while it might be considered natural to conjecture that heavy air pollution has an adverse effect on mental health, cognitive performance, and worker productivity as shown in previous studies, the relationship between air pollution and lottery gambling may be less intuitive and perhaps more surprising. A negative influence of air pollution on some of the previously studied domains, such as productivity and cognitive performance, mainly involves passivity on the part of the decision-maker – ie. polluted conditions may lead individuals to be less proactive or less able in pursuing mental wellness, cognitive achievement and high productivity. However, for the case of lottery gambling, in order for a significantly positive effect to exist, deliberate action is required on the part of individuals – ie. actively purchasing lottery tickets that they would not have purchased otherwise.

This finding stands in notable contrast to the more generally negative relationship between air pollution and consumer activity found in Barwick, Li, Lin and Zou (2019), which found a significant avoidance effect of pollution information on consumers' spending behaviors.[6] The discrepancy between their results, which utilize credit card data to assess overall expenditure behaviors, and ours, which focuses on realized lottery demand, indicates that lottery tickets have a specific appeal to consumers during high pollution periods which does not extend to expenditure and consumption activity more generally. In other words, based on prior findings on avoidance behavior due to air pollution, our results imply that there is something indeed different about the appeal of lottery purchase compared to other types of purchases more generally; it is not merely that pollution enhances the overall utility value of making purchases.

Our study also contributes to the literature studying the role of lottery gambling on individual well-being, which has largely focused on the ex-post effects of lottery winnings. Recent studies find that winning the lottery increases psychological health (Gardner and Oswald, 2007), happiness and well-being (Kim and Oswald, 2020), and sustained life satisfaction (Lindqvist, Ostling and Cesarini, 2020). Aside from psychological well-being, studies have found potentially detrimental effects of lottery wins on physical health through increased risky behaviors (Apouey and Clark, 2015), while in countries with limited social safety nets the effect of physical health is significantly positive (Kim and Koh, 2021). Compared to these studies, our analysis focuses on the *ex-ante* benefits and motivation for lottery purchase, which given the fairly small chances of winning and channels established in this paper, are substantially psychological in nature. Our findings are also consistent with the survey-based results in Beckert and Lutter (2012), which finds that life dissatisfaction and social disadvantage are a significant factor in lottery demand.

The remainder of the paper is organized as follows: Section 2 presents the basic results on AQI and lottery sales, including robustness checks and decompositions across regions and seasons; Section 3 discusses the relative impacts of visibility and AQI compound components; Section 4 provides the evidence on information and attention influences on lottery gambling. Section 5 discusses the relationship between the pollution-lottery effect and regional economic variables. Section 6 concludes.

2. Basic Results

We collect lottery sales data from the China Welfare Lottery Management Center (CWLM). This dataset contains provincial level lottery sales for each lottery draw over the period 2005 - 2017.[7] Each year has approximately 154 lottery draws.[8] There are 1994 lottery draws in total over our total investigation period and the average amount of lottery ticket sales per draw is 8,370,689 RMB. The vast majority of lottery ticket sales in China occur in grocery and other types of convenience stores which sell everyday items, as well as dedicated lottery ticket stores.[9] We exploit a rich panel data structure across the 31 administrative provinces and nearly 2000 distinct lottery draws over the sample time period, their associated sales and daily AQI data, to assess the relationship between air pollution and lottery ticket sales.

The AQI data is collected from the Ministry of Environmental Protection of China (MEP). The AQI data starts from year 2008 and the index values range from 0 to 500. The AQI is determined by the levels of 6 atmospheric pollutants, namely sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), fine particulate matters (PM 2.5 and PM 10)

[6] See also Neidell (2009) regarding avoidance behavior on outdoor activities.
[7] The Union Lotto has been sold publicly since 16-Feb-2003. Before 1-Jan- 2005, the CWLM only disclosed the national aggregate level sales data, but not the provincial level data.
[8] For the years of our analysis, the number of lottery draws per year ranged from 152 to 154. Lottery draws take place on each Tuesday, Thursday and Sunday, with suspension for the annual Spring Festival.
[9] The government made the sale of lottery tickets using online channels altogether illegal in 2018.

and ozone (O_3).[10] According to the standard established by the Ministry of Environmental Protection of China, the AQI ranges from 0 to 500 and has 6 groups: excellent (0-50), good (51-100), lightly polluted (101-150), moderately polluted (151-200), heavily polluted (201-300) and severely polluted (larger than 300). Visibility data is collected from the U.S. National Oceanic and Atmospheric Administration (NOAA) and is expressed in kilometers of visibility.[11] Appendix A, Table A1 displays summary statistics for the main variables in our analysis over the sample period.

To examine the relationship between lottery sales and air pollution, we adopt the following baseline model for lottery sales based on the province-level panel dataset:

$$ln(Y_{it}) = \alpha + \beta \ln(X_{it}) + \rho W_{it} + \gamma_i + \delta_t + \varepsilon_{it} \, ,$$

where Y_{it} is lottery sales on day t for province i, extrapolated by averaging across the upcoming lottery round.[12] X_{it} are air pollution measures. Weather variables W_{it}, are included as controls, namely the average local temperature, wind speed, and an indicator for rain. In addition, we include province fixed effects γ_i , and day-of-week fixed effects δ_t, to capture the provincial-specific characteristics and lottery sales time-specific features, respectively. This allows us to omit control variables associated with particular provinces and years from the regression, while still accounting for their potential influences on lottery sales. ε_{it} denotes the error term. To further control for province-specific effects, the standard errors are clustered at the province level.

Table 1. Baseline Results

Dependent variable: Log Lottery Ticket Sales

	(1)	(2)
Ln AQI	0.067***	
	(11.103)	
Ln Visibility		-0.064***
		(-6.596)
Constant	15.793***	16.216***
	(343.059)	(347.736)
Observations	56,102	55,410
Number of Provinces	31	31
Adjusted R-squared	0.155	0.149
Weather controls	Yes	Yes
Year FE	Yes	Yes
Province FE	Yes	Yes
WeekDay FE	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 1 shows the baseline aggregate results, for years 2014 through 2018 which reflects the availability of AQI components data to be shown in Section 3, for comparison purposes. Column (1) shows that the relationship between AQI and lottery ticket sales is positive and significant. During days of high AQI, more lottery tickets were purchased by consumers than in days of low AQI. Since the regressions include year, province and day of the week (corresponding to lottery round in each week) fixed effects, this aggregate result cannot be accounted for merely by heterogeneity in time or regional factors. Column (2) shows that there is a negative relationship between visibility and ticket sales; as visibility

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[10] Data for the disaggregated components of AQI is available from 2014 onward. For this reason, we focus on data starting from 2014 in those specifications for which we are interested in comparing the effects with AQI components.

[11] Visibility data is available from 1960 onward from NOAA.

[12] This approach allows us to preserve the daily frequency of AQI information, which is our main variable of interest, while the tradeoff is a less precise measure of daily lottery sales due to the data constraint of lottery sales data being at the lottery round level. We note that we have also conducted all the regressions using lottery rounds and averaged daily AQI over rounds, obtaining results that are nearly identical in terms of significance levels, signs, and relative magnitudes. The results are available on request. The exception is in Section 4 which addresses ticket buyer's limited attention, we implement the regressions only using the current main approach due to the necessity to preserve the precision of the AQI value in order to test the limited attention hypothesis.

increases, ticket sales decrease. Since reduced visibility is associated with higher air pollution, and is often used as a proxy measure for pollution (Du, Li and Yuan, 2014), this regression similarly shows that higher levels of air pollution are associated with higher ticket sales.

In the sections that follow, we decompose this positive relationship between air pollution factors and lottery ticket sales to obtain a better understanding of the sources of this relationship.

2.1. Non-linear relationships

The effect of air pollution on lottery purchase is unlikely to be linear in nature. To understand more about the potential non-linear relationship between visibility measures and lottery purchase, we estimate the following specification to examine the effect of extreme air quality (based on province level standards), on lottery attraction:

$$ln(Y_{it}) = \alpha + \beta Dummy_{it} + \rho W_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is again the lottery sales in time t for province i, and W_{it} are weather control variables. Provincial and time specific influences are captured by fixed effects γ_i and δ_t, respectively. $Dummy_{it}$ is an extreme air quality indicator which is equal to one if the air quality indicator departs farther from the local average level in time t, as further described below. ε_{it} is the error term. Standard errors are again clustered at the province level.

There are two steps in generating the extreme air quality indicators in the variable $Dummy_{it}$. First, we sort air visibility observations in descending order for each province for the years of our analysis, 2005 to 2017. Next, based on this procedure, we group air quality into eight categories: Top 1, Top 1-5, Top 5-10, Top 10-25, Bottom 1, Bottom 1-5, Bottom 5-10 and Bottom 10-25. Top 1 is an indicator variable for the top 1 percent of the air quality days for each province. In the same setting, the group Bottom 1 contains the worst air quality days for each province. The extreme air quality indicator serves as a province-specific measure of relative air quality.

The results of these regressions are shown in Table 2. These individual regressions with the dummy variables as defined above demonstrate that each category of extreme air qualities are consistent with the general pattern that poor air visibility increases the appeal of lottery gambling. From the top level of visibility moving downward to slightly lower visibilities (columns 1 to 4), the coefficient is monotonically decreasing in absolute value, which supports that lottery ticket purchases decline as visibility increases. From the worst visibility (column 5) to moderately bad visibility (column 8) the coefficient is consistently positive, indicating the appeal of lottery purchase during those poor visibility days. The peak of influence on lottery sales occurs at the worst 1^{st} to 5^{th} percentile of visibility days.

As a robustness check, we also implement the identical regressions as in Table 2, but additionally incorporating log AQI as a control. The coefficients are of similar magnitudes and significance, and are relegated to Appendix A for reference.

We also estimate a similar regression for nominal values of the AQI pollution measure in Table 3. The value of the variable $Dummy_{it}$ represents the following 6 categories of AQI values: AQI 50 or below, AQI between 50 and 100, AQI between 100 and 150, AQI between 150 and 200, AQI between 200 and 300, AQI above 300. The variable *Good_Moderate* is a dummy variable for AQI below 100, while the variable *Unhealthy* is a dummy variable for AQI above 150. The coefficients on the regressions, displayed in Table 3, show consistently that controlling for regional and time specific characteristics, higher AQI is associated with higher lottery ticket purchase while lower AQI is comparatively associated with reduced ticket purchases. We also note that the AQI level of 150 serves as a natural turning point in lottery sales, below which the relationship between sales and pollution level is negative and monotonically shrinking, and above which the relationship is positive and monotonically decreasing. The exception is that for AQI above 300, the effect is insignificantly different from zero, which could be due to generally to reduced or altered activities under extremely poor air quality (such as staying indoors), as well as relatively limited occurrences in the data of AQI above 300. The coefficients on the *Good_Moderate* and *Unhealthy* indicator variables also confirm this general pattern.

Again, as a robustness check, we also implement the identical regressions as in Table 3, but additionally incorporating log visibility as a control. The coefficients are of similar magnitudes and significance, and are also relegated to Appendix A for reference.

Table 2: Lottery Sales and Visibility Groups

	Dependent variable: Log Sales								
	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln Visibility	-0.064***								
	(-6.596)								
Top 1% Vis		-0.053***							
		(-4.396)							
Top 1% to 5% Vis			-0.044***						
			(-3.963)						
Top 5% to 10% Vis				-0.044***					
				(-4.921)					
Top 10% to 25% Vis					-0.044***				
					(-5.989)				
Bottom 1% Vis						0.054***			
						(4.886)			
Bottom 1% to 5% Vis							0.056***		
							(6.105)		
Bottom 5% to 10% Vis								0.053***	
								(6.591)	
Bottom 10% to 25% Vis									0.047***
									(6.724)
Constant	16.216***	16.083***	16.084***	16.086***	16.092***	16.082***	16.080***	16.078***	16.070***
	(347.736)	(443.850)	(443.705)	(443.524)	(439.436)	(444.183)	(447.383)	(450.039)	(454.720)
Obs	55,410	55,410	55,410	55,410	55,410	55,410	55,410	55,410	55,410
R-sq	0.149	0.134	0.136	0.138	0.143	0.134	0.138	0.140	0.145
# of Province ID	31	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3: Lottery Sales and AQI Groups									
	Dependent variable: Log Sales								
	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln AQI	0.001***								
	(10.219)								
AQI_50 or less		-0.037***							
		(-5.116)							
AQI_100 or less			-0.058***						
			(-8.431)						
AQI_150 or less				-0.068***					
				(-5.382)					
AQI_150 or more					0.069***				
					(5.308)				
AQI_200 or more						0.059***			
						(3.573)			
AQI_300 or more							0.039*		
							(1.945)		
Good_Moderate								-0.058***	
								(-8.162)	
Unhealthy									0.058***
									(8.162)
Constant	16.025***	16.093***	16.128***	16.150***	16.081***	16.086***	16.088***	16.129***	16.070***
	(446.463)	(443.057)	(416.634)	(372.797)	(450.939)	(445.216)	(441.519)	(415.412)	(454.292)
Obs	56,102	56,102	56,102	56,102	56,102	56,102	56,102	56,102	56,102
R-sq	0.152	0.141	0.147	0.141	0.141	0.137	0.135	0.147	0.147
# of Province ID	31	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

We note that the different units of the variables used in Table 2 and Table 3 make it difficult to make direct comparisons about the magnitudes of coefficients for the case of Visibility versus AQI. The AQI itself is a constructed index measured uniformly across regions, while our visibility measure is based on satellite date accounting for regional visibility distributions. The previously mentioned robustness check tables in Appendix A, which control for AQI and visibility respectively, show that both AQI and low visibility contribute significantly to lottery sales while maintaining the significance and general ordering of magnitudes of these regressions designed to detect non-linear effects.

Our subsequent Table 4 in Section 3 of our analysis further includes both AQI and Visibility in the empirical specification as continuous variables and shows that both factors are significant with the other factor held constant, and that their effects are of similar order of magnitude based on the variable definitions.

2.2 Effects across regions and seasons

It is widely perceived that northern China has substantially worse air quality than southern China, and these perceptions are verified in the AQI data. Indeed, the differential heating policy in North and South leading to pollution level differences has been previously utilized to identify the effect of air pollution on mortality (Almond, Chen, Greenstone and Li, 2009; Chen, Ebenstein, Greenstone and Li, 2013). A natural question for our study of lottery gambling is whether individuals in northern and southern China respond similarly to short-term variation in pollution with respect to lottery ticket purchase decisions. Figure 1 shows the definition of northern and southern China, which is the commonly acknowledged official definition.[13]

Figure 1: Map of Northern and Southern China

Subdividing the sample between northern and southern China using the standard definition depicted above, the regression specifications in Table 4A show that the pollution-gambling relationship holds significantly across both North and South, and that the effects are of similar magnitude, although of slightly stronger in magnitude in the North.

A further question is whether the pollution-lottery relationship is robust across seasons. Air pollution in China is known to have a seasonal component. In particular, the average air pollution can often be higher in the winter due higher energy usage via coal burning for heating systems. Table 4B shows the analogous regressions subdivided by the four seasons in the year. The results show that summer is not the season that drives the relationship between pollution and lottery gambling based on either the AQI measure or the visibility factor. Rather, autumn and winter are the predominant seasons for both the visibility and AQI factors, while the effect is additionally present during spring under worsening visibility conditions only.

Overall, the seasonality regressions confirm the conventional wisdom about the relative impacts of air pollution by region and season, and show that the effect is regionally robust, while having greater concentration in the autumn and winter seasons.

[13] The red line shown in Figure 1 is also the dividing line above which publicly provided centralized heating is available, and below which heating is not available, demarking the traditional division between north and south which corresponds to the Huai River.

Table 4A: Regional Robustness Check

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
Ln Visibility	-0.058***	-0.063***		
	(-4.321)	(-5.780)		
Ln AQI			0.073***	0.061***
			(6.995)	(7.888)
Constant	16.044***	16.363***	15.601***	15.973***
	(222.835)	(295.501)	(221.806)	(236.825)
Observations	26,471	28,939	27,145	28,957
R-squared	0.177	0.145	0.194	0.145
# of Province ID	15	16	15	16
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Location	**North**	**South**	**North**	**South**

Table 4B: Seasonal Heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lnVisibility	-0.051***	-0.022	-0.036***	-0.042***				
	(-2.895)	(-1.494)	(-3.416)	(-4.008)				
lnAQI					0.005	0.012	0.060***	0.036***
					(0.391)	(1.047)	(8.377)	(3.720)
Constant	16.105***	16.061***	16.139***	16.141***	15.981***	15.970***	15.801***	15.899***
	(255.067)	(292.818)	(331.184)	(358.932)	(207.475)	(242.860)	(286.228)	(252.910)
Observations	13,988	14,017	13,875	13,530	14,165	14,198	14,040	13,699
R-squared	0.116	0.176	0.111	0.058	0.109	0.177	0.124	0.058
# of Province ID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Appendix B contains additional results decomposed by season and AQI components, but first we present the basic results on AQI components next in Section 3.

3. AQI compound components and visibility

With the baseline results of the previous section established, we now address the decomposition of the lottery-pollution effect across the components of AQI. Combined with the visibility data, our aim in this section is twofold: First, we are interested in assessing how much the visibility factor accounts for the positive effect of air pollution on lottery gambling. This is an important first step in understanding the mechanism for the lottery effect – can a substantial portion of the effect be explained by factors besides the purely chemical content of AQI, and thus potentially be attributed at least partially to psychological factors? Secondly, we are interested in which components of AQI are most responsible for the increase in lottery gambling. Prior literature on the effects of air pollution on human behavior has focused mainly on particulate matter (PM 2.5, and to lesser extent PM 10), or alternatively on total AQI. However, it is possible that some of the subtler aspects of human behavior, such as risk attitudes, may be attributed to an increase in one or more of the specific compounds in AQI.

To address this question, we implement a series of regression analyses in Table 5, which control simultaneously for visibility and the various components of AQI. Column (1) includes both AQI and visibility in the regression. While both explanatory variables maintain their statistical significance and direction of the coefficient, both coefficients are reduced compared to the baseline independent estimates of Table 1. This shows that there is significant overlap of the two factors in explaining variation in lottery gambling. In particular, the estimated marginal effect of an increase in AQI is lessened when controlling for the visibility factor. In other words, at least some of the increased lottery sales under polluted conditions are attributable to the influences of reduced visibility, such as darkened daylight conditions, hazy visuals, and the possible mood effects of such changes in the visual environment.[14]

Columns (2) through (7) include visibility as an explanatory variable, but instead of including the entire AQI in the aggregate, each component is considered separately as an explanatory variable. In this way, a comparison of the significance and direction of their effects can be made independently of the other AQI components. We can observe that for all AQI components except O_3 (ozone), the relationship between that component and lottery gambling is significantly positive. O_3 has a significantly negative relationship with lottery gambling, once controlling for visibility.[15]

Columns (8) through (13) show regression specifications that control for different combinations of the chemical and particulate compositions of AQI. Firstly, we notice that when controlling for the different components of AQI, the coefficient on PM 2.5 is either negative (columns 12 and 13) or insignificant (columns 8 and 9) in the regression. While PM 10 tends to have a positive coefficient once controlling for other AQI components, the coefficient is in some specifications (columns 10 and 13) insignificantly different than zero. The coefficient on ozone (O_3) is significantly negative for most of the specifications that control simultaneously for the different compounds of AQI. The one compound that is consistently positive and of consistent magnitude throughout all the regressions that control simultaneously for levels of other components of AQI, is sulfur dioxide (SO_2).

Appendix Section B provides results by individual components of AQI disaggregated by season (Tables B3 to B8), showing that while autumn and winter produce significant effects across all the components positively related to lottery sales, the effect also holds for PM2.5, PM10, NO_2 and CO in the spring, and SO_2 and NO_2 in the summer. Controlling for the components of AQI and visibility simultaneously in the regression shows that PM10 has a significantly positive effect in the spring, while SO2 has a significant positive effect in autumn (Tables B9 and B10). The significant results by seasons are well-reflected in the baseline results aggregated across seasons shown in Table 5.

The effects of sulfur dioxide (SO_2) on bodily and cognitive functioning has been previously studied and debated in the literature, which was originally driven by the prevalence of SO_2 in London's air pollution (Folinsbee, 1992). On the one hand, Andersen et al (1974) found only limited lung exposure to SO_2 when breathed in through the nose, while subjects reported discomfort after exposure. SO_2 has been statistically linked to various respiratory diseases, including bronchitis and asthma (see Shapiro, 1976 for discussion), and several studies examine the potential interaction effects between SO2 and other air pollutant components (ex. Bedi et al, 1979), as well as potential genetic consequences (ex. Meng et al, 2004). Chen et al (2012) found significant effects of SO_2 exposure on mortality rates in China. A potentially relevant line of research concerned with neurotoxicity, experimentally exposes mice to SO_2 and examines the effect on the rats' avoidance learning abilities, generally finding adverse effects (Kucukatay et al, 2005; Yargicoglu et al, 2007).

[14] Psychological studies have found effects of changes in lighting and visual stimuli on psychological well-being, such as Matsubayashi, Sawada, and Ueda (2013, 2014) which found reduction in train station suicides in Japan under blue lighting.

[15] Prior research on the harmful effects of ozone exposure found an association with reduced lung function, decline in oxygen uptake, and decline in exercise performance. Folinsbee (1992) provides a survey of the evidence.

The correlation between the chemical components of AQI in our data can be found in Section C of the Appendix. The table shows that the daily measurements of these compounds are generally positively correlated, except for ozone (O_3) which tends to be negatively correlated with the other components. This can partially explain the persistent negative coefficient found on the ozone variable in our regressions. PM 2.5 and PM 10 have the highest correlation with one another (0.87), while the correlations between components (NO_2 and CO) tends to be over 0.50. Sulfur dioxide (SO_2) has a high but relatively lower cross-correlation with the other components of AQI, which from a statistical standpoint, can explain its significant ability to explain lottery purchase variation in comparison to the other compounds.

By implementing a more detailed analysis on the components of AQI in this section, and their relationship to lottery gambling behavior, we can infer that other factors equal, sulfur dioxide significantly enhances lottery appeal while ozone decreases it. Particulate matter (PM 2.5 and PM 10), while being the focus of several previous studies, is correlated with, but appears to not be the underlying significant component through which pollution affects gambling.

Table 5: AQI and Components
Dependent Variable: log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales	(8) lnSales	(9) lnSales	(10) lnSales	(11) lnSales	(12) lnSales	(13) lnSales
Ln Visibility	-0.037***	-0.023*	-0.036***	-0.040***	-0.026**	-0.040***	-0.028**					-0.039**	-0.037*
	(-2.858)	(-1.758)	(-3.336)	(-4.717)	(-2.138)	(-2.937)	(-2.122)					(-2.168)	(-1.979)
Ln AQI	0.052***												0.037
	(5.774)												(0.599)
Ln PM2.5		0.052***						-0.059	-0.011			-0.086*	-0.096**
		(7.157)						(-1.622)	(-0.449)			(-2.013)	(-2.271)
Ln PM10			0.056***					0.059**		0.009		0.072***	0.053
			(9.365)					(2.483)		(0.503)		(2.806)	(1.543)
Ln SO_2				0.078***				0.057**	0.062**	0.058**	0.060**	0.065**	0.064**
				(7.970)				(2.353)	(2.525)	(2.367)	(2.524)	(2.438)	(2.390)
Ln NO_2					0.106***			0.048	0.051	0.041	0.046	0.048	0.049
					(7.977)			(0.908)	(0.973)	(0.812)	(0.963)	(0.894)	(0.927)
Ln O_3						-0.068***		-0.041***	-0.037**	-0.043***	-0.040***	-0.033**	-0.035*
						(-7.167)		(-2.871)	(-2.639)	(-3.311)	(-4.160)	(-2.091)	(-1.942)
Ln CO							0.086***	0.017	0.004	-0.008	-0.004	0.011	0.010
							(5.408)	(0.437)	(0.121)	(-0.263)	(-0.139)	(0.284)	(0.249)
Constant	15.931***	15.929***	15.908***	15.925***	15.764***	16.423***	16.134***	15.870***	15.905***	15.888***	15.897***	15.935***	15.893***
	(192.070)	(209.666)	(251.271)	(384.667)	(182.933)	(250.249)	(297.740)	(106.059)	(104.265)	(108.817)	(100.835)	(105.911)	(123.731)
Obs	55,158	50,887	50,882	50,887	50,887	23,612	50,887	23,869	23,870	23,869	23,870	23,611	23,547
# of ProvinceID	31	31	31	31	31	31	31	31	31	31	31	31	31
Adjusted R-squared	0.158	0.151	0.153	0.176	0.173	0.179	0.154	0.215	0.212	0.212	0.212	0.216	0.215
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4. Attention and Color Categories

So far, in order to understand the mechanism behind air pollution's effect on lottery gambling, we have identified which official chemical components of air quality drive the effect and controlled for the visual factor associated with pollution. If the pollution-lottery effect is not purely biological in nature as suggested by the visibility data results, a natural subsequent question is whether individuals' desire for lottery gambling is potentially manipulable by the information and/or the presentation of information given the actual level of air pollution.

Since 2013, China's government has publicly released information about regional air pollution conditions through official AQI numbers, and additionally presented the public with color-coded categories to classify the degree of pollution severity. The official AQI information were released and widely disseminated starting from January 2013, as described in Barwick, Li, Lin and Zou (2019), which estimates the consumption and housing response to pollution.[16] Prior to this release date, AQI data existed nationwide, but was measured and reported by different entities, such as local governments and U.S. embassies. The AQI information was not as easily accessible, and importantly, the color-coded categorization of AQI levels was not in place at a national level prior to 2013.

Individuals typically obtain their information about AQI through an air pollution app on their cellular phones, highly popular in part, due to the concern about air quality over the sample period and beyond. In addition to manual checking of the pollution app, most cell phones automatically alert users to changes in air quality using push notifications. Therefore, there is good a priori reason to believe that most individuals follow the daily pollution levels to some extent. In regions of frequent high pollution levels, individuals may even need to prepare in advance for high pollution levels before leaving home, such as by wearing a particle filtration mask when going outdoors.

Figure 2: AQI Index Category Health Warning System (Wikipedia), translated from China's Official Ambient Air Quality Index Table)

AQI	Air Pollution Level	Air Pollution Category	Health Implications	Recommended Precautions
0–50	Level 1	Excellent(好极了)	No health implications.	Everyone can continue their outdoor activities normally.
51–100	Level 2	Good(良好)	Some pollutants may slightly affect very few hypersensitive individuals.	Only very few hypersensitive people should reduce outdoor activities.
101–150	Level 3	Lightly Polluted(輕度污染)	Healthy people may experience slight irritations and sensitive individuals will be slightly affected to a larger extent.	Children, seniors and individuals with respiratory or heart diseases should reduce sustained and high-intensity outdoor exercises.
151–200	Level 4	Moderately Polluted(中度污染)	Sensitive individuals will experience more serious conditions. The hearts and respiratory systems of healthy people may be affected.	Children, seniors and individuals with respiratory or heart diseases should avoid sustained and high-intensity outdoor exercises. General population should moderately reduce outdoor activities.
201–300	Level 5	Heavily Polluted(重度污染)	Healthy people will commonly show symptoms. People with respiratory or heart diseases will be significantly affected and will experience reduced endurance in activities.	Children, seniors and individuals with heart or lung diseases should stay indoors and avoid outdoor activities. General population should reduce outdoor activities.
>300	Level 6	Severely Polluted(嚴重)	Healthy people will experience reduced endurance in activities and may also show noticeably strong symptoms. Other illnesses may be triggered in healthy people. Elders and the sick should remain indoors and avoid exercise. Healthy individuals should avoid outdoor activities.	Children, seniors and the sick should stay indoors and avoid physical exertion. General population should avoid outdoor activities.

Note: Original AQI Index Category Table in Chinese provided in Appendix.

The categories are given as: Green (Excellent: AQI 0 to 50); Yellow (Good: AQI 51 to 100); Orange (Lightly Polluted: AQI 101 to 150); Red (Moderately Polluted: AQI 151 to 200); Purple (Heavily Polluted: AQI 201 to 300); Burgundy (Severely Polluted: AQI 301 to 500). The color/severity categories are discrete and are provided to give citizens an approximate assessment of the pollution situation locally. The categories intuitively label more severe pollution levels using more intense/darker colors.[17] By checking pollution levels fairly frequently, most individuals are at least approximately familiar with the meanings of the colors, at least in terms of the feature that darker color categories indicate higher pollution severity. However, the AQI index is essentially much more continuous in

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[16] Barwick, Li, Lin and Zou (2019) provide a detailed description of the motivations and rollout timeline of the AQI measure across cities, which was conducted in three waves from December 31, 2012 to November 20, 2014, prioritizing major population and economic centers of the country first. Thus, our use of January 1st, 2013 as the cutoff date for the policy change corresponds to the first instance at which the effects of the official information about AQI could start to be realized.

[17] The official color categories omit an additional category present on most cell phone apps which is the color black for AQI greater than 500 ("beyond index").

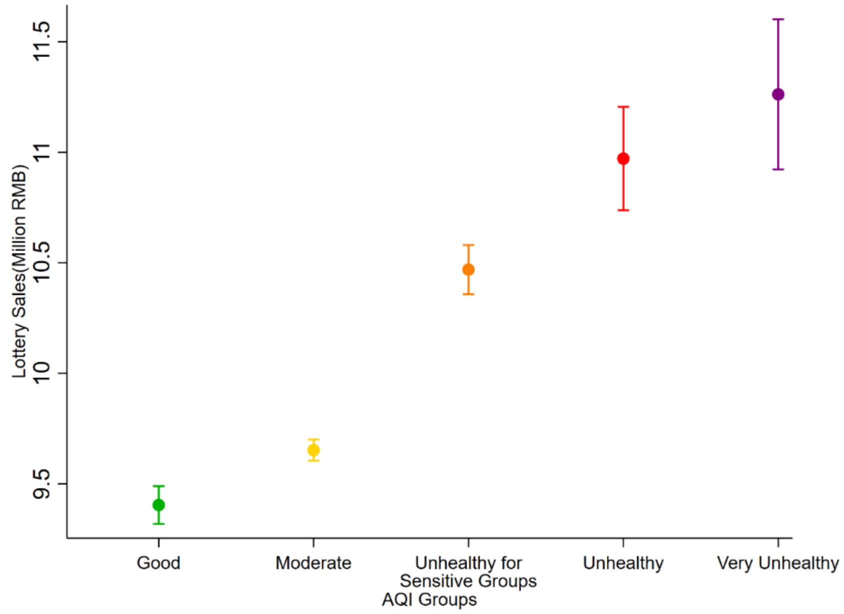
nature.[18] Under the fine distinctions between consecutive AQI points, a change from AQI 49 to AQI 50 should be an increase in pollution of similar magnitude as a change from AQI 50 to AQI 51, and hence should have a similar magnitude of behavioral response, if individuals pay attention to the meaning of each AQI value thoroughly.

However, prior research on pricing phenomena has shown that individuals often have limited attention in their processing of relevant information (see for example, Lacetera, Pope and Sydnor, 2011), and the same attentional limits may apply to the case of air pollution levels. If individuals pay more attention to the color category of pollution than the AQI level itself, an increase in AQI from 50 to 51 (for example) should correspond to a greater increase in lottery ticket purchase than an increase from AQI of 49 to 50, since the former increase involves a change in the color category, while the latter change does not.

Figure 3 shows the raw data of average lottery sales and color-coded pollution categories. While our empirical specification controls for the underlying average relationship between AQI, the basic message of our empirical specification can be seen clearly in the Figure. Average lottery sales are increasing across the color-coded AQI intensities, and there is a discontinuous increase across color categories, especially so for the levels of pollution designated from Moderate to Unhealthy. However, Figure 3 mainly shows the average values with the corresponding confidence intervals, but to more precisely test the marginal effect of crossing a color category, we utilize a regression approach.

Figure 3: Lottery sales by AQI color category

Average sales and 95% confidence intervals



We test for limited attention using the regression specification

$$\ln(Y_{it}) = \alpha + \beta_1 * \ln(AQI_{it}) + \beta_2 * \ln(AQI_{it})^2 + \beta_{3,j} * \mathrm{I}(\mathrm{AQI} = \mathrm{j}) + \rho W_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (2)$$

which controls for the general trend in the relationship between lottery sales and AQI allowing for non-linearity, but additionally tests for the marginal impact of each AQI value in a window range around the change in pollution severity category. Weather controls, time and regional fixed effects are included as in the previous specifications. The coefficients $\beta_{3,jj}$ reveal whether an AQI value of j specifically has a significantly higher or lower amount of lottery sales, than the overall linear and non-linear (squared term) relationships between lottery sales and AQI levels would suggest.

We implement the above specification over data from the beginning of China's AQI data in 2008 to 2018, for all color category crossing ranges (provided in Appendix, Section C), but we focus the discussion here on the 150 AQI threshold which yields the main significant result. The other AQI threshold which yields a similar

[18] The government document entitled *"Technical Regulation on the Ambient Air Quality Index"* (HJ 633- 2012) provides additional information about the introduction of China's AQI measure.

significant result to the one shown in Table 6A is the 100 AQI threshold, which implies that individuals are most sensitive to crossing the orange and red color category thresholds.

Recall that while the AQI data is on a daily basis, the lottery sales data is at the level of each lottery round, which occurs every two or three days. Since for the attention regression specification it is particularly important to preserve the numerical value of the daily AQI number, we divide the lottery-round sales data by the number of days since the previous lottery round in order to obtain daily sales figures. This approach essentially averages the sales levels across the days between lottery rounds, which serves as a noisy measure of the daily lottery ticket sales. Such a variable definition creates a situation in which it is more difficult to detect sharp discontinuities at the AQI category borderline, making our results more striking should a significant effect be found.[19]Thus, a significantly positive coefficient at or immediately above the candidate threshold should be a convincing indicator that consumers found lottery ticket purchase especially attractive at that specific AQI level.

Table 6A displays the results of this regression around the cutoff level of 150 AQI, which corresponds to the transition AQI between “lightly polluted” (orange) and “moderately polluted” (red). The columns of the table differ based on the range of AQI-related control variables included in the regression. The results show that controlling for the general relationship between AQI and lottery gambling, having an AQI of 151 in the days leading up to a lottery draw (compared to adjacent AQI values), results in significantly higher ticket sales. The result can be seen from the row “AQI 151” showing a significant positive coefficient across all the columns. The same significant relationship does not exist for AQI 150, one row upward in the table. The different specifications shown in Table 5 indicate that controlling for linear and squared terms for AQI, having an AQI of 151 is the only robust value across columns for which individuals increased their lottery sales. In other words, precisely at the transition between “lightly polluted” (orange) and “moderately polluted” (red) as determined by the government designated category, significantly more lottery tickets are being sold - beyond what is generally expected from the already established positive relationship between pollution and lottery gambling.

The analogous regressions around the borderline of other color categories show a similar effect at the AQI 101 mark (the transition between “good” and “lightly polluted”), although not for the transitions of AQI 51 or AQI 201. In other words, the behavioral responses are along the transitions for moderately serious air pollution categories, but not for particularly light or especially heavy pollution categories. This is intuitive given that the orange and red AQI categories are those which are meant to indicate to households a significant amount of pollution warranting caution, hence it is understandable that AQI crossing over into these categories yields the most significant marginal impacts. When adding the visibility variable to the regressions in Table 6A, the significance and magnitude of the results are unchanged. The regressions with visibility included are provided in Appendix C.

[19] A potentially intuitive alternative empirical approach to test our hypothesis could be to implement a traditional regression discontinuity (RD) design. We utilize the current approach instead, for a few key reasons. For one, our running variable (AQI) takes on strictly discrete values, which generally reduces the value added of a traditional RD approach compared to the specification we propose here. In addition, due to the relative proximity of attention threshold candidates (each 50 AQI values apart), we are examining the changes in lottery sales around a relatively narrow range of the running variable, which further places a limitation on the relative informativeness of a broader RD specification over our current approach. Finally, our approach, by including dummy variables for every single value of AQI in a window surrounding the local threshold, provides a high level of flexibility in terms of the relationship between lottery sales and specific AQI values.

Table 6A: AQI Categories, 150

Dependent variable: Log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales	(8) lnSales
lnAQI	0.051***	-0.104***	0.051***	-0.102***	0.051***	-0.102***	0.050***	-0.101***
	(37.209)	(-7.246)	(36.774)	(-7.143)	(36.481)	(-7.120)	(36.060)	(-7.020)
AQI_144							0.038**	0.032**
							(2.481)	(2.066)
AQI_145							0.010	0.003
							(0.544)	(0.167)
AQI_146					0.012	0.005	0.012	0.006
					(0.700)	(0.315)	(0.720)	(0.331)
AQI_147					-0.000	-0.007	-0.000	-0.007
					(-0.027)	(-0.414)	(-0.009)	(-0.398)
AQI_148			0.034**	0.027	0.035**	0.027	0.035**	0.028*
			(2.054)	(1.635)	(2.062)	(1.637)	(2.082)	(1.654)
AQI_149			-0.007	-0.014	-0.007	-0.014	-0.006	-0.013
			(-0.369)	(-0.751)	(-0.361)	(-0.750)	(-0.342)	(-0.734)
AQI_150	0.008	0.001	0.009	0.001	0.009	0.001	0.009	0.002
	(0.483)	(0.064)	(0.502)	(0.079)	(0.510)	(0.080)	(0.530)	(0.097)
AQI_151	**0.047****	**0.039****	**0.047****	**0.039****	**0.047****	**0.039****	**0.047****	**0.040****
	(2.445)	**(2.053)**	**(2.462)**	**(2.067)**	**(2.470)**	**(2.068)**	**(2.488)**	**(2.083)**
AQI_152	0.020	0.012	0.020	0.013	0.020	0.013	0.021	0.013
	(0.991)	(0.618)	(1.007)	(0.631)	(1.014)	(0.632)	(1.032)	(0.647)
AQI_153			0.020	0.012	0.020	0.012	0.020	0.012
			(1.046)	(0.633)	(1.054)	(0.634)	(1.073)	(0.650)
AQI_154			0.026	0.018	0.026	0.018	0.026	0.018
			(1.438)	(0.989)	(1.446)	(0.990)	(1.466)	(1.008)
AQI_155					0.000	-0.008	0.001	-0.008
					(0.008)	(-0.422)	(0.027)	(-0.406)
AQI_156					0.024	0.016	0.024	0.016
					(1.187)	(0.776)	(1.205)	(0.791)
AQI_157							-0.011	-0.020
							(-0.533)	(-0.959)
AQI_158							0.037*	0.028
							(1.758)	(1.346)
$lnAQI^2$		0.018***		0.018***		0.018***		0.018***
		(10.873)		(10.740)		(10.701)		(10.571)
Constant	15.327***	15.654***	15.328***	15.652***	15.329***	15.652***	15.330***	15.649***
	(2,268.759)	(507.512)	(2,259.319)	(506.679)	(2,250.678)	(505.934)	(2,242.285)	(505.094)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The threshold crossing phenomenon we document above should only exist if individuals have access to fairly precise AQI information through the public release of such statistics. In other words, we should expect that the previous results in Table 6A are attributed to the time period *after* which the government released AQI and the color-coded intensity categories to the public. After the policy of releasing such information to the public, citizens can access AQI information in their region very easily through air quality apps on their smart phone, or other online sources.

Table 6B adds to the previous regression a dummy variable for 2013 and beyond (the year that the government formally introduced the AQI and color coding system), as well as an interaction term between this time dummy variable and the category threshold of AQI 151, which tells us whether the post-2013 period accounts for the jump in sales occurring at AQI 151. The results show that indeed, the period from 2013 and afterward accounts for the entire phenomenon documented in Table 6A. That is, when including the "after 2013" variable and its interaction with AQI of 151, all statistical significance is obtained by the coefficients for these variables, leaving the AQI 151 variable no longer significant. This result confirms that information about AQI and the color-coded categories helps drive the increase in lottery gambling.

Note that analogous Table in Appendix Section C for the AQI 101 threshold shows an insignificant interaction term between AQI 101 and "after 2013". However, the presence of the "after 2013" variable and the interaction term with AQI 101 causes the significance coefficient on AQI 101 to disappear. This indicates that the main interaction between discrete AQI categories and the availability of AQI information after 2013 is at the AQI 151 threshold, corresponding to the transition into the red ("Unhealthy") color category, while some similar yet less obvious effect exists for the AQI 101 threshold.

Table 6B. Color Evidence AQI 150 (Interaction)

Dependent variable: Log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales	(8) lnSales
lnAQI	0.051***	-0.104	0.051***	-0.103	0.051***	-0.102	0.050***	-0.101
	(5.025)	(-0.995)	(4.954)	(-0.982)	(4.930)	(-0.977)	(4.902)	(-0.965)
AQI_144							0.038**	0.032**
							(2.471)	(2.269)
AQI_145							0.010	0.003
							(0.442)	(0.135)
AQI_146					0.012	0.005	0.012	0.006
					(0.596)	(0.264)	(0.609)	(0.275)
AQI_147					-0.000	-0.007	-0.000	-0.007
					(-0.014)	(-0.208)	(-0.004)	(-0.200)
AQI_148			0.034	0.027	0.035	0.027	0.035	0.028
			(1.344)	(1.109)	(1.347)	(1.108)	(1.357)	(1.117)
AQI_149			-0.007	-0.014	-0.007	-0.014	-0.006	-0.013
			(-0.348)	(-0.712)	(-0.339)	(-0.707)	(-0.319)	(-0.688)
AQI_150	0.008	0.001	0.009	0.001	0.009	0.001	0.009	0.002
	(0.523)	(0.076)	(0.542)	(0.094)	(0.550)	(0.096)	(0.569)	(0.116)
AQI_151	-0.008	-0.016	-0.008	-0.016	-0.008	-0.016	-0.007	-0.016
	(-0.292)	(-0.585)	(-0.282)	(-0.573)	(-0.278)	(-0.573)	(-0.267)	(-0.564)
AQI_152	0.020	0.012	0.020	0.013	0.020	0.013	0.021	0.013
	(1.190)	(0.859)	(1.209)	(0.880)	(1.218)	(0.884)	(1.237)	(0.907)
AQI_153			0.020	0.012	0.020	0.012	0.020	0.012
			(0.871)	(0.519)	(0.875)	(0.517)	(0.887)	(0.528)
AQI_154			0.026*	0.018	0.026	0.018	0.026*	0.018
			(1.697)	(1.147)	(1.695)	(1.137)	(1.709)	(1.150)
AQI_155					0.000	-0.008	0.001	-0.008
					(0.008)	(-0.384)	(0.026)	(-0.369)
AQI_156					0.024	0.016	0.024	0.016
					(1.133)	(0.757)	(1.152)	(0.774)
AQI_157							-0.011	-0.020
							(-0.476)	(-0.833)
AQI_158							0.037	0.028
							(1.342)	(1.102)
After2013	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***
	(15.459)	(15.477)	(15.457)	(15.475)	(15.457)	(15.474)	(15.458)	(15.475)
AQI_151* After2013	**0.069***	**0.070***	**0.069***	**0.070***	**0.069***	**0.070***	**0.069***	**0.070***
	(1.840)	**(1.863)**	**(1.842)**	**(1.864)**	**(1.842)**	**(1.864)**	**(1.844)**	**(1.865)**
$lnAQI^2$		0.018		0.018		0.018		0.018
		(1.521)		(1.504)		(1.494)		(1.480)
Constant	14.981***	15.307***	14.982***	15.305***	14.982***	15.304***	14.984***	15.302***
	(244.973)	(67.929)	(243.811)	(67.865)	(243.545)	(67.643)	(243.738)	(67.610)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.705	0.705	0.705	0.706	0.705	0.706	0.705	0.706
# of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5. Regional Economic Variables

Finally, we consider whether regional economic conditions also play a role in the appeal of lottery gambling under pollution. Lottery games are characterized by a low-cost entry fee, combined with a very small probability of an extremely high payout. Such gambles, which carry a tiny chance of a huge jackpot, may hold special appeal under either adverse or positive economic conditions (see Ng 1965, which proposes a 'hope' hypothesis for lottery demand). The interaction with those economic conditions and AQI could be another driving force behind the relationship between air pollution and lottery gambling.

We examine this question in regressions which include economic variables and their interaction terms at the provincial level. The economic variables we consider are unemployment rate, to capture the limitations in economic opportunity at the regional level, and GDP per capita, as a general measure of regional economic activity.

Table 7a displays the results for the interactions with unemployment rate. The coefficient on the unemployment rate is always negative, which is indicative of adverse income effects of high unemployment on spending in general. However, the effect of pollution can be seen from the interaction terms with indicator variables for average AQI above particular thresholds. The interaction term coefficients show that the interaction terms between AQI above the threshold and unemployment are significantly positive, reaching the highest influence in the range of 150 AQI and above. In other words, regional unemployment promotes the positive relationship between AQI and lottery gambling. This is consistent with the "hope" hypothesis of lottery gambling proposed in Ng (1965).

Table 7b shows the analogous results for GDP per capita. The results show that while the stand-alone relationship between GDP per capita and lottery sales is positive, consistent with income effects, the interaction effects with pollution thresholds are also positive, reaching the greatest significant influence at the 200 AQI threshold. While at first this may seem counterintuitive to the hypothesis that lottery tickets provide the appeal of hope during adverse economic conditions, we point out that GDP growth in China has been accompanied by an increase in inequality and individuals at the right tail of the wealth distribution (see Tan, Zeng and Zhu, 2018).[20, 21]

The presence of individuals at the far-right tail of the wealth distribution could make lottery play more appealing for the population in general, as it includes a hope of becoming more similar to the highly wealthy individuals. While our study is limited in exploring the effect of local economic conditions because we only have regional level lottery and economic variables rather than more detailed micro-data, testing such hypotheses using more disaggregated data could be a direction for future work.

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[20] Lee (2013) finds that Chinese provinces with higher shares of business and property income have higher income inequality, while Garcia-Penalosa and Turnovsky (2006) provide a theoretical foundation for the positive relationship between economic growth and inequality.

[21] We use GDP per capita as a proxy due to the difficulty that inequality measures in China by province are not readily available using government statistics, and the calculations that exist in the literature are sometimes subject to debate. In general, measuring inequality precisely would require representative micro-level data, which is outside the scope of our current study.

Table 7a: Pollution and Regional Economic Conditions, Unemployment

Dependent variable: Log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales
Ln Unemployment Rate	-0.202***	-0.204***	-0.198***	-0.195***	-0.194***	-0.194***	-0.194***
	(-18.048)	(-20.370)	(-19.856)	(-19.527)	(-19.421)	(-19.393)	(-19.395)
AQI50	0.010						
	(0.911)						
AQI50*Ln UnemploymentRate	0.017*						
	(1.921)						
AQI100		0.005					
		(0.421)					
AQI100*ln UnemploymentRate		0.046***					
		(4.990)					
AQI150			-0.022				
			(-1.226)				
AQI150*ln UnemploymentRate			0.081***				
			(5.103)				
AQI200				-0.024			
				(-0.847)			
AQI200*ln UnemploymentRate				0.067***			
				(2.653)			
AQI250					-0.048		
					(-1.185)		
AQI250*ln UnemploymentRate					0.064*		
					(1.735)		
AQI300						0.029	
						(0.486)	
AQI300*lnUnemploymentRate						-0.012	
						(-0.207)	
AQI350							-0.069
							(-0.557)
AQI350*lnUnemploymentRate							0.031
							(0.270)
Constant	15.424***	15.447***	15.444***	15.441***	15.439***	15.439***	15.439***
	(1,054.232)	(1,160.713)	(1,162.279)	(1,160.476)	(1,160.256)	(1,160.245)	(1,160.263)
Observations	50,152	50,152	50,152	50,152	50,152	50,152	50,152
R-squared	0.716	0.718	0.716	0.715	0.715	0.715	0.715
Number of ProvinceID	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ProvinceID FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7b: Pollution and Regional Economic Conditions, GDP per Capita

Dependent variable: Log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales
lnGDPperCapita	0.394***	0.420***	0.414***	0.410***	0.409***	0.409***	0.409***
	(37.951)	(41.975)	(41.199)	(40.783)	(40.669)	(40.643)	(40.625)
AQI50	-0.280***						
	(-7.119)						
AQI50*lnGDPperCapita	0.029***						
	(7.899)						
AQI100		-0.084*					
		(-1.706)					
AQI100*lnGDPperCapita		0.014***					
		(2.971)					
AQI150			-0.333***				
			(-3.321)				
AQI150*lnGDPperCapita			0.038***				
			(4.048)				
AQI200				-0.614***			
				(-3.754)			
AQI200*lnGDPperCapita				0.061***			
				(4.066)			
AQI250					-0.378		
					(-1.550)		
AQI250*lnGDPperCapita					0.037*		
					(1.647)		
AQI300						-0.144	
						(-0.369)	
AQI300*lnGDPperCapita						0.016	
						(0.435)	
AQI350							0.404
							(0.589)
AQI350*lnGDPperCapita							-0.040
							(-0.627)
Constant	11.237***	10.977***	11.043***	11.079***	11.089***	11.091***	11.093***
	(107.413)	(109.220)	(109.470)	(109.641)	(109.695)	(109.725)	(109.749)
Observations	50,913	50,913	50,913	50,913	50,913	50,913	50,913
R-squared	0.718	0.720	0.718	0.717	0.717	0.717	0.717
Number of ProvinceID	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ProvinceID FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

6. Conclusions

Poor air quality in some of the world's rapidly expanding economies has inspired research on the influences of air pollution on economic behavior. These influences can be roughly categorized as biologically driven, economically driven and psychologically driven, perhaps in order of inevitability. In this study, we examine some of the potentially influential factors in each category with respect to lottery ticket purchase, one of the most popular forms of gambling in China, which has the features of low cost and high potential payoff.

The significantly positive relationship between pollution and lottery gambling is directly counter to the more general pollution avoidance effects on consumption found in Barwick, Li, Lin and Zou (2019), and more generally in terms of outdoor activity as in Neidell (2009). That is, rather than avoiding purchases and purchase related activities due to the presence of pollution, consumers in fact intentionally seek out the purchase of lottery tickets during high pollution periods. Given this arguably counterintuitive positive effect in the broader context of pollution avoidance behavior, it is important to understand what makes lottery tickets special in relation to local pollution levels.

Our analysis firstly indicates that the positive impact of air pollution on lottery gambling is in part biologically driven, and in part psychologically driven, as evidenced by the persistence of statistically significant effects when controlling for both AQI and visibility measures in the regressions. The robust chemical compound responsible for the gambling effect is sulfur dioxide, which has been previously discussed in some scientific studies as a main culprit in adverse health and psychological effects of air pollution. This helps to pinpoint the main AQI component that could be attributed to increased risk appetite and gambling tendencies, whereas prior studies on the effects of air quality on human behavior have tended to focus primarily on the consequences of particulate matter (PM 2.5).

While the reduced visibility associated with air pollution is one psychological factor that plausibly leads to the increased appeal of lottery tickets, we find that attention to the reported quality of local air is another key factor. We test for the attention factor induced by the Ministry of Environmental Protection's color-coded categories, which are comprised of discrete increments of 50 AQI points. While a purely biologically induced effect of air pollution on gambling should generally be insensitive to the exact AQI index value, paying full attention to the specific value of AQI rather than the discrete color category should yield smooth responses of lottery ticket sales to changes in AQI values, regardless of whether a color category is crossed.

However, contrary to what full attention predicts, we find that consumers discontinuously respond to AQI values that have just exactly crossed the threshold into the next color-coded intensity level of pollution by buying disproportionately more lottery tickets, reminiscent of the left digit bias found in Lacetera, Pope and Sydnor (2011). In this setting, rather than using left digits as the heuristic for pollution intensity, lottery buyers use the officially provided color category, particularly for the transition in color from orange to red, which also corresponds to a particularly salient "alert" level. Such an effect is driven entirely by the time period after the Ministry of Environmental Protection's public release of the AQI statistics and color categories, which were subsequently incorporated into cellular phone apps and websites, making such information readily available to consumers. What this implies is that consumers are making a conscious decision to buy lottery tickets after noticing that local AQI has crossed over into the red ("Unhealthy") range. Alongside our analyses on visibility versus chemical components, the color-coded evidence supports that the pollution effect on gambling is significantly cognitive in nature.

While all of the above results help establish the importance of both biological and cognitive factors in the pollution and gambling relationship, they reveal relatively little about the deeper underlying reasons for the appeal of lottery tickets under polluted conditions. We then test whether the interaction between regional economic conditions and air quality can provide any suggestion. Consistently with the 'hope' hypothesis regarding the motives for purchasing lottery tickets (Ng, 1965), we find that high regional unemployment rates enhance the pollution-gambling relationship. Intuitively, regions of scarcer earnings opportunities (ex. unemployment) may inspire more activities which can give hope to residents, which is also consistent with sociological evidence on the significant motives for lottery play. Higher gross domestic product per capita, typically associated in China with increased inequality during the time period of our data, similarly promotes the necessity of hope among the less fortunate, which in fact comprise the great majority of the consumer base. Our empirical results are consistent with this line of reasoning.

In summary, the relationship between air pollution and lottery gambling is due to several factors with regard to poor air quality which seem to work together to promote the appeal of lottery tickets. In addition to the biologically-driven reaction towards the chemicals comprising air pollution, we show that lower visibility, knowledge about AQI levels, heuristic approaches to assessing the true air quality, and regional economic conditions all contribute significantly to this appeal. The interaction between regional economic conditions and the pollution-gambling link suggests that high air pollution could present a sense of bleakness in life that prompts the desire for hopeful gambles, pointing to the ex-ante psychological benefits of lottery play as a coping device. Furthermore, at least some of this effect is attributable to conscious decisions after having received detailed information and officially-suggested ways to understand air quality information.

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Appendix Section A: Summary Statistics and Robustness Checks with AQI and Visibility Measures

Table A1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Union Lotto Sales	56358	11000000.00	7087779.00	166072.00	89000000.00
Air Visibility	56777	9.78	4.29	0.15	18.60
Air Quality Index	56282	75.45	41.76	12.27	500.00
Pm 2.5	51796	45.01	32.12	4.10	471.28
Pm 10	51791	80.88	52.91	6.08	1067.61
So2	51796	19.93	17.96	1.94	270.06
No2	51796	30.47	15.07	3.93	176.22
O3	23870	57.09	24.68	2.20	173.57
Co	51796	1.01	1.07	0.20	124.30

Tables A2 and A3 show that the results of Tables 2 and 3 in Section 2.1 are robust to the inclusion of the AQI and Visibility variables in the regressions, respectively.

Table A2: Lottery Sales and Visibility Groups (adding LnAQI)

	Dependent variable: Log Sales							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top 1% Vis	-0.031**							
	(-2.522)							
Top 1% to 5% Vis		-0.023*						
		(-1.961)						
Top 5% to 10% Vis			-0.024**					
			(-2.503)					
Top 10% to 25% Vis				-0.026***				
				(-3.158)				
Bottom 1% Vis					0.009			
					(0.657)			
Bottom 1% to 5% Vis						0.022**		
						(2.106)		
Bottom 5% to 10% Vis							0.024**	
							(2.675)	
Bottom 10% to 25% Vis								0.026***
								(3.218)
lnAQI	0.068***	0.067***	0.065***	0.060***	0.069***	0.065***	0.063***	0.057***
	(12.501)	(11.440)	(10.661)	(9.312)	(11.967)	(10.564)	(9.673)	(8.294)
Constant	15.779***	15.786***	15.796***	15.822***	15.778***	15.791***	15.803***	15.822***
	(370.025)	(354.363)	(343.342)	(317.165)	(360.450)	(336.937)	(324.752)	(321.177)
Observations	55,158	55,158	55,158	55,158	55,158	55,158	55,158	55,158
R-squared	0.154	0.155	0.155	0.157	0.154	0.155	0.155	0.157
Number of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A3: Lottery Sales and AQI Groups (adding LnVisibility)								
	Dependent variable: Log Sales							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AQI_50 or less	-0.025***							
	(-2.832)							
AQI_100 or less		-0.039***						
		(-7.125)						
AQI_150 or less			-0.037***					
			(-3.769)					
AQI_150 or more				0.037***				
				(3.708)				
AQI_200 or more					0.012			
					(1.103)			
AQI_300 or more						-0.027		
						(-1.209)		
Good_Moderate							-0.039***	
							(-6.912)	
Unhealthy								0.039***
								(6.912)
lnVisibility	-0.058***	-0.048***	-0.056***	-0.056***	-0.062***	-0.064***	-0.048***	-0.048***
	(-5.366)	(-4.881)	(-5.753)	(-5.753)	(-6.418)	(-6.544)	(-4.909)	(-4.909)
Constant	16.207***	16.210***	16.233***	16.196***	16.213***	16.217***	16.211***	16.172***
	(333.194)	(345.400)	(335.936)	(360.088)	(349.476)	(343.485)	(345.525)	(353.157)
Observations	55,158	55,158	55,158	55,158	55,158	55,158	55,158	55,158
R-squared	0.152	0.154	0.151	0.151	0.149	0.149	0.154	0.154
Number of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Appendix Section B: Visibility and AQI Components by Season

Tables B1 and B2 show the seasonal regression results with Visibility and AQI as the main explanatory variables, respectively. The effect is mainly driven by the autumn and winter seasons.

Table B1: Baseline Visibility Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnVisibility	-0.050***	-0.021	-0.035***	-0.038***
	(-2.792)	(-1.453)	(-3.319)	(-3.654)
Constant	16.151***	16.114***	16.187***	16.182***
	(252.284)	(293.640)	(336.437)	(357.965)
Observations	13,988	14,017	13,875	13,530
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.186	0.249	0.177	0.111
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B2: Baseline AQI Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnAQI	0.002	0.011	0.059***	0.032***
	(0.163)	(0.982)	(7.908)	(3.401)
Constant	16.042***	16.028***	15.856***	15.965***
	(210.595)	(247.277)	(281.511)	(257.941)
Observations	14,165	14,198	14,040	13,699
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.179	0.250	0.189	0.112
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Tables B3 to B8 show the seasonal regressions for each AQI component separately. Individually, each AQI component with the exception of O_3 contributes positively to lottery sales in autumn and winter. Additionally SO_2 and NO_2 are significantly positive in the summer, while particulate matter (PM10), NO_2 and CO are significantly positive in the spring.

Table B3: Baseline PM2.5 Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
ln PM2.5	0.013	0.005	0.044***	0.042***
	(1.550)	(0.452)	(6.615)	(7.862)
Constant	15.968***	16.059***	15.945***	15.871***
	(258.517)	(251.456)	(297.063)	(436.001)
Observations	12,833	13,919	14,103	10,941
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.166	0.259	0.189	0.075
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B4: Baseline PM10 Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
ln PM10	0.021***	0.012	0.051***	0.049***
	(3.193)	(1.113)	(8.997)	(6.285)
Constant	15.926***	16.028***	15.888***	15.819***
	(284.308)	(248.710)	(320.237)	(396.292)
Observations	12,833	13,919	14,100	10,939
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.168	0.259	0.189	0.076
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B5: Baseline SO_2 Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnSo2	0.015	0.036**	0.085***	0.069***
	(1.123)	(2.097)	(7.089)	(4.393)
Constant	15.973***	15.977***	15.840***	15.813***
	(278.642)	(278.681)	(286.735)	(411.303)
Observations	12,833	13,919	14,103	10,941
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.166	0.263	0.217	0.084
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B6: Baseline NO_2 Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnNo2	0.034*	0.045*	0.084***	0.090***
	(1.997)	(1.779)	(6.352)	(6.106)
Constant	15.901***	15.930***	15.815***	15.734***
	(209.424)	(163.140)	(221.360)	(238.490)
Observations	12,833	13,919	14,103	10,941
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.169	0.263	0.196	0.089
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B7: Baseline O_3 Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lno3	-0.037**	-0.003	-0.036***	-0.098***
	(-2.646)	(-0.142)	(-2.882)	(-4.835)
Constant	16.173***	16.093***	16.252***	16.410***
	(204.381)	(210.201)	(331.026)	(190.257)
Observations	7,130	5,425	5,704	5,611
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.197	0.319	0.252	0.081
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B8: Baseline CO Results, by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnCo	0.036**	0.021	0.066***	0.055***
	(2.500)	(1.055)	(4.420)	(3.750)
Constant	16.018***	16.080***	16.113***	16.030***
	(391.598)	(385.377)	(381.061)	(575.410)
Observations	12,833	13,919	14,103	10,941
Number of ProvinceID	31	31	31	31
Adjusted R-squared	0.168	0.259	0.186	0.071
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B9 provides the seasonal regressions which include the decomposition of AQI components, omitting the aggregated AQI. These specifications are useful for determining which components of AQI account positively for lottery sales by season. We can observe that holding other AQI components constant, while PM10 is influential in the spring, SO2 is influential in the winter. Table B10 additionally includes visibility as an explanatory variable, and finds results similar in significance and magnitude to Table B9.

Table B9: AQI Component Results by Season

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
LnPM 2.5	-0.160***	-0.100	0.036	-0.030
	(-2.912)	(-1.259)	(0.417)	(-0.512)
Ln PM10	**0.138*** **	0.005	-0.033	0.054
	(3.973)	(0.053)	(-0.547)	(1.620)
lnSo2	0.018	0.068	**0.084*** **	0.064
	(0.408)	(1.024)	**(3.492)**	(0.929)
lnNo2	0.015	0.101	-0.021	0.089
	(0.259)	(0.983)	(-0.360)	(1.278)
lnO3	-0.022	0.027	-0.030	-0.080**
	(-1.433)	(0.778)	(-1.362)	(-2.296)
lnCo	0.037	-0.005	-0.043	-0.071
	(1.102)	(-0.072)	(-0.772)	(-1.225)
Constant	16.156***	15.956***	15.963***	15.659***
	(66.735)	(73.786)	(136.810)	(109.257)
Observations	7,049	5,381	5,647	5,534
Number of ProvinceID	0.149	0.295	0.219	0.082
Adjusted R-squared	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B10: Baseline Results by Season, with Visibility term

	Dependent variable: Log Sales			
	(1)	(2)	(3)	(4)
lnVisibility	-0.098**	-0.107***	0.008	0.001
	(-2.180)	(-3.132)	(0.307)	(0.023)
LnPM 2.5	-0.160***	-0.100	0.036	-0.030
	(-2.912)	(-1.259)	(0.417)	(-0.512)
LnPM 10	**0.138*** **	0.005	-0.033	0.054
	(3.973)	(0.053)	(-0.547)	(1.620)
lnSo2	0.018	0.068	**0.084*** **	0.064
	(0.408)	(1.024)	**(3.492)**	(0.929)
lnNo2	0.015	0.101	-0.021	0.089
	(0.259)	(0.983)	(-0.360)	(1.278)
lnO3	-0.022	0.027	-0.030	-0.080**
	(-1.433)	(0.778)	(-1.362)	(-2.296)
lnCo	0.037	-0.005	-0.043	-0.071
	(1.102)	(-0.072)	(-0.772)	(-1.225)
Constant	16.156***	15.956***	15.963***	15.659***
	(66.735)	(73.786)	(136.810)	(109.257)
Observations	7,049	5,381	5,647	5,534
Number of ProvinceID	0.149	0.295	0.219	0.082
Adjusted R-squared	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes
Season	Spring	Summer	Autumn	Winter

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Appendix Section C: Correlation between AQI Components

Table C1: Correlation matrix

	Visibility	AQI	Pm2.5	Pm10	So2	No2	O3	Co
Visibility	1							
AQI	-0.381	1						
Pm2.5	-0.476	0.950	1					
Pm10	-0.268	0.930	0.865	1				
So2	-0.174	0.508	0.503	0.493	1			
No2	-0.426	0.704	0.733	0.624	0.527	1		
O3	0.185	-0.071	-0.169	-0.074	-0.290	-0.295	1	
Co	-0.321	0.683	0.723	0.625	0.651	0.663	-0.356	1

Table C2: Pairwise correlation coefficients

	Visibility	AQI	Pm2.5	Pm10	So2	No2	O3	Co
Visibility	1							
AQI	-0.370***	1						
Pm2.5	-0.485***	0.949***	1					
Pm10	-0.259***	0.929***	0.842***	1				
So2	-0.158***	0.504***	0.510***	0.468***	1			
No2	-0.433***	0.685***	0.724***	0.584***	0.479***	1		
O3	0.185***	-0.069***	-0.168***	-0.073***	-0.290***	-0.294***	1	
Co	-0.165***	0.335***	0.376***	0.278***	0.284***	0.319***	-0.356***	1

Appendix Section D: Limited Attention, other AQI Categories and Placebo Tests

Figure 3 (Original): AQI Index Category Health Warning System (Original Chinese Table from the Technical Regulation on the Ambient Air Quality Index)

表 2　空气质量指数及相关信息

空气质量指数	空气质量指数级别	空气质量指数类别及表示颜色		对健康影响情况	建议采取的措施
0～50	一级	优	绿色	空气质量令人满意，基本无空气污染	各类人群可正常活动
51～100	二级	良	黄色	空气质量可接受，但某些污染物可能对极少数异常敏感人群健康有较弱影响	极少数异常敏感人群应减少户外活动
101～150	三级	轻度污染	橙色	易感人群症状有轻度加剧，健康人群出现刺激症状	儿童、老年人及心脏病、呼吸系统疾病患者应减少长时间、高强度的户外锻炼
151～200	四级	中度污染	红色	进一步加剧易感人群症状，可能对健康人群心脏、呼吸系统有影响	儿童、老年人及心脏病、呼吸系统疾病患者避免长时间、高强度的户外锻练，一般人群适量减少户外运动
201～300	五级	重度污染	紫色	心脏病和肺病患者症状显著加剧，运动耐受力降低，健康人群普遍出现症状	儿童、老年人和心脏病、肺病患者应停留在室内，停止户外运动，一般人群减少户外运动
>300	六级	严重污染	褐红色	健康人群运动耐受力降低，有明显强烈症状，提前出现某些疾病	儿童、老年人和病人应当留在室内，避免体力消耗，一般人群应避免户外活动

Limited Attention and Visibility

The Table below replicates the main result in the body of the paper for AQI level of 151, but includes Visibility as a controlling covariate. The results show that the main effects in the Tables of Section 4 are robust to controlling for Visibility. In other words, the effect of attention to AQI level is not confounded by visibility conditions.

Table D1. AQI Categories, 150

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.043***	-0.085***	0.042***	-0.084***	0.042***	-0.084***	0.042***	-0.083***
	(28.223)	(-5.869)	(27.933)	(-5.778)	(27.776)	(-5.775)	(27.505)	(-5.692)
AQI_144							0.034**	0.029*
							(2.244)	(1.920)
AQI_145							0.007	0.002
							(0.421)	(0.122)
AQI_146					0.008	0.003	0.008	0.003
					(0.468)	(0.160)	(0.486)	(0.175)
AQI_147					-0.003	-0.009	-0.003	-0.009
					(-0.176)	(-0.490)	(-0.160)	(-0.476)
AQI_148			0.034**	0.029*	0.034**	0.029*	0.035**	0.029*
			(2.029)	(1.689)	(2.033)	(1.688)	(2.050)	(1.702)
AQI_149			-0.012	-0.018	-0.012	-0.018	-0.012	-0.017
			(-0.668)	(-0.969)	(-0.663)	(-0.970)	(-0.646)	(-0.956)
AQI_150	0.006	-0.000	0.006	-0.000	0.006	-0.000	0.006	0.000
	(0.321)	(-0.015)	(0.337)	(-0.001)	(0.342)	(-0.003)	(0.359)	(0.012)
AQI_151	**0.046****	**0.040****	**0.046****	**0.040****	**0.046****	**0.040****	**0.046****	**0.040****
	(2.379)	**(2.072)**	**(2.394)**	**(2.084)**	**(2.398)**	**(2.082)**	**(2.414)**	**(2.096)**
AQI_152	0.016	0.010	0.016	0.010	0.016	0.010	0.017	0.010
	(0.783)	(0.488)	(0.797)	(0.499)	(0.801)	(0.498)	(0.816)	(0.511)
AQI_153			0.016	0.010	0.016	0.010	0.016	0.010
			(0.837)	(0.514)	(0.841)	(0.513)	(0.858)	(0.527)
AQI_154			0.024	0.018	0.024	0.018	0.025	0.018
			(1.342)	(0.977)	(1.347)	(0.976)	(1.364)	(0.991)
AQI_155					-0.004	-0.011	-0.004	-0.010
					(-0.214)	(-0.557)	(-0.197)	(-0.543)
AQI_156					0.019	0.013	0.020	0.013
					(0.961)	(0.636)	(0.976)	(0.649)
AQI_157							-0.015	-0.022
							(-0.736)	(-1.073)
AQI_158							0.034	0.027
							(1.617)	(1.279)
$lnAQI^2$		0.015***		0.015***		0.015***		0.015***
		(8.860)		(8.745)		(8.731)		(8.624)
lnVisibility	**-0.018*****	**-0.016*****	**-0.018*****	**-0.016*****	**-0.018*****	**-0.016*****	**-0.018*****	**-0.016*****
	(-10.627)	**(-9.245)**	**(-10.610)**	**(-9.251)**	**(-10.598)**	**(-9.248)**	**(-10.566)**	**(-9.241)**
Constant	15.396***	15.659***	15.397***	15.657***	15.397***	15.658***	15.398***	15.656***
	(1,742.099)	(505.025)	(1,738.852)	(504.210)	(1,735.871)	(503.484)	(1,733.251)	(502.653)
Observations	119,208	119,208	119,208	119,208	119,208	119,208	119,208	119,208
R-squared	0.960	0.960	0.960	0.960	0.960	0.960	0.960	0.960
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Results for other AQI thresholds:

The following Tables show the analogous regressions as in Section 4 (for AQI cutoff of 150), but for other color category cutoffs. The results show that besides the 150 threshold, a similar pattern holds for AQI of 100. That is, there is a significant positive effect of AQI of 101 on sales, but once accounting for the interaction term with the information policy change, the effect is statistically absorbed, indicating that the presence of information fully accounts for the effect (however unlike the 150 threshold regression, the interaction term itself is not significant). Other AQI category cutoff levels do not display the same significant pattern, which shows that perhaps intuitively, the gambling effect is influenced primarily by the transition into marginally significant (light and moderate) levels of pollution.

Table D2A: AQI Categories, 50

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.051***	-0.105***	0.051***	-0.103***	0.050***	-0.100***	0.049***	-0.098***
	(37.149)	(-7.306)	(36.304)	(-7.142)	(35.282)	(-6.906)	(34.157)	(-6.754)
AQI_44							-0.011**	-0.010**
							(-2.296)	(-2.109)
AQI_45							-0.010**	-0.009*
							(-2.120)	(-1.897)
AQI_46					-0.010**	-0.009**	-0.011**	-0.010**
					(-2.257)	(-1.999)	(-2.459)	(-2.155)
AQI_47					-0.007	-0.006	-0.008*	-0.006
					(-1.524)	(-1.243)	(-1.727)	(-1.401)
AQI_48			-0.004	-0.003	-0.005	-0.003	-0.006	-0.004
			(-0.930)	(-0.581)	(-1.131)	(-0.744)	(-1.336)	(-0.904)
AQI_49			-0.016***	-0.014***	-0.017***	-0.015***	-0.018***	-0.016***
			(-3.643)	(-3.273)	(-3.838)	(-3.429)	(-4.034)	(-3.582)
AQI_50	-0.006	-0.004	-0.007	-0.005	-0.008*	-0.006	-0.008**	-0.006
	(-1.469)	(-1.061)	(-1.626)	(-1.181)	(-1.828)	(-1.346)	(-2.032)	(-1.506)
AQI_51	**-0.004**	**-0.002**	**-0.005**	**-0.003**	**-0.005**	**-0.003**	**-0.006**	**-0.004**
	(-0.967)	**(-0.527)**	**(-1.121)**	**(-0.645)**	**(-1.320)**	**(-0.808)**	**(-1.521)**	**(-0.966)**
AQI_52	0.001	0.003	0.000	0.002	-0.001	0.001	-0.002	0.001
	(0.168)	(0.676)	(0.008)	(0.551)	(-0.201)	(0.378)	(-0.411)	(0.212)
AQI_53			-0.002	0.001	-0.002	-0.000	-0.003	-0.001
			(-0.409)	(0.164)	(-0.613)	(-0.006)	(-0.818)	(-0.168)
AQI_54			-0.007*	-0.005	-0.008**	-0.006	-0.009**	-0.006
			(-1.882)	(-1.271)	(-2.083)	(-1.439)	(-2.284)	(-1.597)
AQI_55					-0.009**	-0.006*	-0.010**	-0.007*
					(-2.365)	(-1.685)	(-2.565)	(-1.842)
AQI_56					-0.008**	-0.005	-0.008**	-0.005
					(-1.961)	(-1.247)	(-2.155)	(-1.401)
AQI_57							-0.009**	-0.007*
							(-2.435)	(-1.677)
AQI_58							-0.002	0.001
							(-0.632)	(0.146)
$lnAQI^2$		0.018***		0.018***		0.018***		0.017***
		(10.937)		(10.716)		(10.409)		(10.180)
Constant	15.327***	15.656***	15.330***	15.653***	15.334***	15.648***	15.338***	15.646***
	(2,260.412)	(507.585)	(2,239.287)	(506.651)	(2,213.121)	(505.301)	(2,182.885)	(503.608)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D2B: AQI Categories, 50 (Interaction)

Dependent variable: Log Sales

VARIABLES	(1) lnSales	(2) lnSales	(3) lnSales	(4) lnSales	(5) lnSales	(6) lnSales	(7) lnSales	(8) lnSales
lnAQI_M	0.051***	-0.105	0.051***	-0.103	0.050***	-0.100	0.049***	-0.098
	(5.002)	(-1.005)	(4.912)	(-0.986)	(4.807)	(-0.959)	(4.669)	(-0.942)
AQI_44							-0.011	-0.010
							(-1.402)	(-1.358)
AQI_45							-0.010*	-0.009
							(-1.815)	(-1.582)
AQI_46					-0.010	-0.009	-0.011	-0.010
					(-1.596)	(-1.387)	(-1.651)	(-1.420)
AQI_47					-0.007	-0.006	-0.008	-0.006
					(-1.109)	(-0.909)	(-1.180)	(-0.959)
AQI_48			-0.004	-0.002	-0.005	-0.003	-0.006	-0.004
			(-0.582)	(-0.363)	(-0.681)	(-0.446)	(-0.773)	(-0.520)
AQI_49			-0.016**	-0.014**	-0.017**	-0.015**	-0.018**	-0.016**
			(-2.549)	(-2.275)	(-2.570)	(-2.278)	(-2.593)	(-2.285)
AQI_50	-0.006	-0.004	-0.007	-0.005	-0.008	-0.006	-0.008	-0.006
	(-1.260)	(-0.935)	(-1.318)	(-0.981)	(-1.407)	(-1.057)	(-1.465)	(-1.108)
AQI_51	-0.006	-0.005	-0.006	-0.005	-0.007	-0.006	-0.008	-0.007
	(-0.762)	(-0.634)	(-0.822)	(-0.677)	(-0.911)	(-0.748)	(-0.994)	(-0.811)
AQI_52	0.001	0.003	0.000	0.002	-0.001	0.001	-0.002	0.001
	(0.169)	(0.717)	(0.007)	(0.545)	(-0.176)	(0.344)	(-0.333)	(0.178)
AQI_53			-0.002	0.001	-0.002	-0.000	-0.003	-0.001
			(-0.325)	(0.135)	(-0.459)	(-0.004)	(-0.574)	(-0.121)
AQI_54			-0.007*	-0.005	-0.008*	-0.006	-0.009*	-0.006
			(-1.784)	(-1.383)	(-1.872)	(-1.467)	(-1.915)	(-1.509)
AQI_55					-0.009**	-0.006*	-0.010**	-0.007*
					(-2.062)	(-1.719)	(-2.110)	(-1.766)
AQI_56					-0.008	-0.005	-0.008	-0.005
					(-1.592)	(-0.990)	(-1.649)	(-1.049)
AQI_57							-0.009*	-0.007
							(-1.779)	(-1.312)
AQI_58							-0.002	0.001
							(-0.526)	(0.120)
After2013	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***
	(15.472)	(15.490)	(15.471)	(15.486)	(15.470)	(15.486)	(15.473)	(15.489)
AQI_51*After2013	**0.004**	**0.005**	**0.004**	**0.005**	**0.004**	**0.005**	**0.004**	**0.005**
	(0.284)	**(0.409)**	**(0.283)**	**(0.406)**	**(0.284)**	**(0.404)**	**(0.285)**	**(0.400)**
$lnAQI^2$		0.018		0.018		0.018		0.017
		(1.531)		(1.507)		(1.471)		(1.446)
Constant	14.981***	15.309***	14.984***	15.306***	14.988***	15.301***	14.992***	15.300***
	(244.149)	(67.965)	(244.974)	(68.070)	(244.012)	(68.202)	(241.927)	(68.218)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.705	0.705	0.705	0.706	0.705	0.706	0.705	0.706
# of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D3A: AQI Categories, 100

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.051***	-0.106***	0.051***	-0.107***	0.050***	-0.108***	0.050***	-0.110***
	(37.105)	(-7.397)	(36.504)	(-7.493)	(36.072)	(-7.536)	(35.489)	(-7.658)
AQI_94							0.013**	0.015**
							(2.041)	(2.286)
AQI_95							0.015**	0.017**
							(2.241)	(2.474)
AQI_96					-0.003	-0.002	-0.003	-0.002
					(-0.473)	(-0.294)	(-0.422)	(-0.236)
AQI_97					0.014**	0.015**	0.015**	0.016**
					(2.075)	(2.241)	(2.125)	(2.297)
AQI_98			0.017**	0.018***	0.017**	0.018***	0.018**	0.019***
			(2.437)	(2.600)	(2.462)	(2.629)	(2.512)	(2.686)
AQI_99			0.014**	0.015**	0.014**	0.015**	0.015**	0.016**
			(1.991)	(2.109)	(2.017)	(2.140)	(2.066)	(2.195)
AQI_100	0.012*	0.013*	0.013*	0.014*	0.013*	0.014*	0.013*	0.014*
	(1.707)	(1.812)	(1.765)	(1.874)	(1.790)	(1.904)	(1.839)	(1.959)
AQI_101	**0.020****	**0.020*****	**0.020****	**0.021*****	**0.020*****	**0.021*****	**0.021*****	**0.021*****
	(2.511)	**(2.585)**	**(2.564)**	**(2.642)**	**(2.587)**	**(2.669)**	**(2.632)**	**(2.719)**
AQI_102	-0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.001
	(-0.048)	(0.026)	(0.005)	(0.083)	(0.028)	(0.110)	(0.072)	(0.160)
AQI_103			0.008	0.008	0.008	0.008	0.008	0.009
			(0.911)	(0.965)	(0.934)	(0.991)	(0.977)	(1.040)
AQI_104			0.002	0.002	0.002	0.003	0.003	0.003
			(0.244)	(0.282)	(0.266)	(0.308)	(0.310)	(0.357)
AQI_105					0.007	0.008	0.008	0.008
					(0.881)	(0.912)	(0.925)	(0.961)
AQI_106					-0.001	-0.001	-0.000	-0.000
					(-0.097)	(-0.092)	(-0.054)	(-0.045)
AQI_107							-0.004	-0.004
							(-0.456)	(-0.454)
AQI_108							0.003	0.003
							(0.321)	(0.298)
$lnAQI^2$		0.018***		0.019***		0.019***		0.019***
		(11.024)		(11.087)		(11.115)		(11.209)
Constant	15.327***	15.659***	15.329***	15.662***	15.329***	15.664***	15.331***	15.669***
	(2,267.734)	(507.961)	(2,258.292)	(507.742)	(2,247.815)	(507.402)	(2,235.527)	(506.987)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D3B: AQI Categories, 100 (Interaction)

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.051***	-0.106	0.051***	-0.107	0.050***	-0.108	0.050***	-0.110
	(4.992)	(-1.014)	(4.930)	(-1.029)	(4.896)	(-1.038)	(4.851)	(-1.058)
AQI_94							0.013	0.015
							(1.369)	(1.527)
AQI_95							0.015*	0.017**
							(1.927)	(2.175)
AQI_96					-0.003	-0.002	-0.003	-0.002
					(-0.289)	(-0.184)	(-0.253)	(-0.145)
AQI_97					0.014*	0.015*	0.015*	0.016**
					(1.863)	(2.026)	(1.889)	(2.057)
AQI_98			0.017**	0.018**	0.017**	0.018**	0.018**	0.019**
			(2.269)	(2.385)	(2.274)	(2.394)	(2.274)	(2.397)
AQI_99			0.014	0.015*	0.014	0.015	0.015	0.016*
			(1.580)	(1.699)	(1.574)	(1.695)	(1.587)	(1.713)
AQI_100	0.012	0.013	0.013	0.014	0.013	0.014	0.013	0.014
	(1.150)	(1.225)	(1.181)	(1.260)	(1.199)	(1.281)	(1.231)	(1.318)
AQI_101	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025
	(1.231)	(1.223)	(1.250)	(1.245)	(1.258)	(1.255)	(1.276)	(1.276)
AQI_102	-0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.001
	(-0.023)	(0.013)	(0.002)	(0.041)	(0.013)	(0.054)	(0.034)	(0.078)
AQI_103			0.008	0.008	0.008	0.008	0.008	0.009
			(0.733)	(0.792)	(0.744)	(0.807)	(0.777)	(0.845)
AQI_104			0.002	0.002	0.002	0.003	0.003	0.003
			(0.269)	(0.322)	(0.287)	(0.344)	(0.329)	(0.393)
AQI_105					0.007	0.008	0.008	0.008
					(0.678)	(0.712)	(0.703)	(0.742)
AQI_106					-0.001	-0.001	-0.000	-0.000
					(-0.096)	(-0.092)	(-0.053)	(-0.045)
AQI_107							-0.004	-0.004
							(-0.432)	(-0.436)
AQI_108							0.003	0.003
							(0.324)	(0.297)
After2013	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***
	(15.454)	(15.472)	(15.457)	(15.475)	(15.459)	(15.476)	(15.459)	(15.476)
AQI_101*After2013	**-0.007**	**-0.006**	**-0.007**	**-0.006**	**-0.007**	**-0.006**	**-0.007**	**-0.006**
	(-0.270)	**(-0.216)**	**(-0.270)**	**(-0.216)**	**(-0.270)**	**(-0.216)**	**(-0.270)**	**(-0.216)**
$lnAQI^2$		0.018		0.019		0.019		0.019
		(1.537)		(1.549)		(1.556)		(1.573)
Constant	14.981***	15.311***	14.983***	15.315***	14.983***	15.317***	14.985***	15.321***
	(244.144)	(67.944)	(244.477)	(68.096)	(244.547)	(68.240)	(244.304)	(68.423)

Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.705	0.706	0.705	0.706	0.705	0.706	0.705	0.706
# of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D4A: AQI Categories, 200

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.051***	-0.105***	0.051***	-0.104***	0.051***	-0.104***	0.051***	-0.107***
	(37.403)	(-7.314)	(37.185)	(-7.227)	(36.984)	(-7.178)	(36.997)	(-7.371)
AQI_194							-0.046	-0.062**
							(-1.479)	(-1.999)
AQI_195							0.040	0.023
							(1.246)	(0.736)
AQI_196					0.067*	0.051	0.067*	0.051
					(1.825)	(1.394)	(1.820)	(1.375)
AQI_197					0.027	0.010	0.027	0.010
					(0.953)	(0.369)	(0.945)	(0.344)
AQI_198			0.023	0.007	0.024	0.007	0.023	0.006
			(0.663)	(0.197)	(0.667)	(0.199)	(0.662)	(0.179)
AQI_199			0.128***	0.111***	0.128***	0.111***	0.128***	0.111***
			(3.231)	(2.819)	(3.236)	(2.821)	(3.230)	(2.803)
AQI_200	0.028	0.012	0.028	0.012	0.028	0.012	0.028	0.011
	(0.905)	(0.375)	(0.913)	(0.382)	(0.919)	(0.385)	(0.913)	(0.362)
AQI_201	**0.023**	**0.006**	**0.023**	**0.006**	**0.023**	**0.006**	**0.023**	**0.006**
	(0.667)	**(0.177)**	**(0.674)**	**(0.183)**	**(0.679)**	**(0.186)**	**(0.672)**	**(0.164)**
AQI_202	0.001	-0.016	0.001	-0.016	0.001	-0.016	0.001	-0.017
	(0.019)	(-0.425)	(0.025)	(-0.419)	(0.029)	(-0.417)	(0.024)	(-0.435)
AQI_203			-0.043	-0.060*	-0.043	-0.060*	-0.043	-0.061*
			(-1.234)	(-1.727)	(-1.228)	(-1.725)	(-1.235)	(-1.746)
AQI_204			0.044	0.027	0.044	0.027	0.044	0.026
			(1.253)	(0.762)	(1.258)	(0.764)	(1.252)	(0.743)
AQI_205					-0.033	-0.051	-0.034	-0.052
					(-0.804)	(-1.232)	(-0.809)	(-1.249)
AQI_206					0.018	0.000	0.018	-0.001
					(0.501)	(0.004)	(0.494)	(-0.017)
AQI_207							-0.067*	-0.085**
							(-1.737)	(-2.214)
AQI_208							-0.055	-0.074*
							(-1.404)	(-1.881)
$lnAQI^2$		0.018***		0.018***		0.018***		0.019***
		(10.949)		(10.839)		(10.768)		(10.961)
Constant	15.326***	15.656***	15.327***	15.654***	15.327***	15.653***	15.327***	15.660***

	(2,271.182)	(507.066)	(2,267.256)	(505.762)	(2,262.776)	(504.346)	(2,257.672)	(503.195)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D4B: AQI Categories, 200 (Interaction)

Dependent variable: Log Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales	lnSales
lnAQI	0.051***	-0.105	0.051***	-0.104	0.051***	-0.104	0.051***	-0.107
	(5.048)	(-1.005)	(5.024)	(-1.002)	(5.001)	(-0.997)	(4.993)	(-1.024)
AQI_194							-0.046*	-0.062**
							(-1.754)	(-2.273)
AQI_195							0.040	0.023
							(1.599)	(0.906)
AQI_196					0.067*	0.051*	0.067*	0.051*
					(1.985)	(1.771)	(1.976)	(1.746)
AQI_197					0.027	0.010	0.027	0.010
					(0.999)	(0.370)	(0.992)	(0.345)
AQI_198			0.023	0.007	0.024	0.007	0.023	0.006
			(0.705)	(0.237)	(0.709)	(0.239)	(0.702)	(0.215)
AQI_199			0.128	0.111	0.128	0.111	0.128	0.111
			(1.374)	(1.225)	(1.375)	(1.225)	(1.372)	(1.217)
AQI_200	0.028	0.012	0.028	0.012	0.028	0.012	0.028	0.011
	(0.983)	(0.440)	(0.987)	(0.445)	(0.991)	(0.448)	(0.984)	(0.422)
AQI_201	0.058	0.039	0.059	0.040	0.059	0.040	0.059	0.039
	(0.528)	(0.358)	(0.530)	(0.360)	(0.531)	(0.361)	(0.529)	(0.354)
AQI_202	0.001	-0.016	0.001	-0.016	0.001	-0.016	0.001	-0.017
	(0.020)	(-0.511)	(0.026)	(-0.503)	(0.031)	(-0.500)	(0.025)	(-0.522)
AQI_203			-0.043	-0.060**	-0.043	-0.060**	-0.043	-0.061**
			(-1.331)	(-2.098)	(-1.324)	(-2.096)	(-1.332)	(-2.126)
AQI_204			0.044	0.027	0.044	0.027	0.044	0.026
			(1.039)	(0.720)	(1.042)	(0.722)	(1.037)	(0.704)
AQI_205					-0.033	-0.051	-0.034	-0.052
					(-0.823)	(-1.379)	(-0.828)	(-1.399)
AQI_206					0.018	0.000	0.018	-0.001
					(0.520)	(0.004)	(0.512)	(-0.016)
AQI_207							-0.067**	-0.085**
							(-2.060)	(-2.525)
AQI_208							-0.055**	-0.074***
							(-2.132)	(-2.845)
After2013	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***	0.815***	0.813***
	(15.461)	(15.480)	(15.461)	(15.479)	(15.461)	(15.479)	(15.462)	(15.480)
AQI_201*After2013	**-0.039**	**-0.036**	**-0.039**	**-0.036**	**-0.039**	**-0.036**	**-0.039**	**-0.036**

	(-0.327)	**(-0.306)**	**(-0.327)**	**(-0.306)**	**(-0.326)**	**(-0.306)**	**(-0.327)**	**(-0.306)**
$lnAQI^2$		0.018		0.018		0.018		0.019
		(1.533)		(1.533)		(1.525)		(1.553)
Constant	14.980***	15.309***	14.981***	15.307***	14.981***	15.306***	14.980***	15.312***
	(245.276)	(67.934)	(245.188)	(68.270)	(245.073)	(68.135)	(244.355)	(68.034)
Observations	120,171	120,171	120,171	120,171	120,171	120,171	120,171	120,171
R-squared	0.705	0.705	0.705	0.706	0.705	0.706	0.705	0.706
# of ProvinceID	31	31	31	31	31	31	31	31
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WeekDay FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: For the regression with AQI values adjacent to 301, the interaction term with After2013 is omitted due to collinearity. Since this is the main variable of interest (together with the variable for AQI = 301) for these specifications, the Table is omitted out of space considerations.