Journal of Environmental and Resource Economics at Colby

Volume 4 | Issue 1 Article 8

2017

How Individuals React to Smog Alerts in Beijing –Evidence from Beijing Subway Volume

Hanjing Shi
Colby College, hshi@colby.edu

Recommended Citation

Shi, Hanjing (2017) "How Individuals React to Smog Alerts in Beijing --Evidence from Beijing Subway Volume," *Journal of Environmental and Resource Economics at Colby*: Vol. 4 : Iss. 1 , Article 8.
Available at: https://digitalcommons.colby.edu/jerec/vol4/iss1/8

How Individuals React to Smog Alerts in Beijing --Evidence from Beijing Subway Volume

Cover Page Footnote

Professor Nathan Chan: My professor, whose perspective, direction and observations were insightful and objective. Thank you for his help. Dr. Qingpu Xu: Manager of Changzhou Environmental Research Institution, who helps me a lot to find the data. My classmates: Thank you for reviewing my draft and presentation.

I. Introduction

The smog is a comparably new concept in China, but it is a very severe issue especially in the Capital Beijing. When I was in China last winter break, almost every day there is a news saying about how bad the air quality in Beijing. Beijing Municipal Commission of Health published that long time exposure to heavy smog will increase the mortality risk, particularly for children and elders. To alert people and protect them away from the smog, Beijing Municipal Environmental Protection Bureau (BJEPB) issued Emergency Plan for Air Pollution in Beijing, and in the plan, there are criterions for issuing smog alerts. I am curious about how smog alerts issued by BJEPB affect individuals' outdoor activities.

BJEPB has issued two versions of Emergency Plan for Air Pollution in Beijing. The criterions are based on Air Quality Index(AQI). AQI is an index that reports daily air quality. AQI is calculated by five major air pollutants regulated by the Clean Air Act: ground level ozone, particle matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide[1]. The first Emergency Plan version was issued on the 27th, October in 2013. The second version was issued on the 20th November in 2016.

Table 1:

Alert Criterions (old and new version):

Alert Type	Old version	New version
Blue	AQI > 200 continue for 1 day	AQI > 200 continue for 1 day
Yellow	AQI > 200 continue for 2 days	AQI > 200 continue for 2 days
Orange	AQI > 200 continue for 3 days	AQI > 200 continue for 3 days Or AQI > 300
Red	AQI > 200 continue for 4 days and more	AQI > 200 continue for 4 days and more Or AQI>300 continue for 2 days Or AQI > 500

[1] "Air Quality Index (AQI) Basics." *AirNow*. N.p., 31 Aug. 2016. Web. 07 May 2017.

Table 1 shows the criterions for issuing alerts in old and new versions. There are four levels of alerts, the lightest one is blue alert, and the worst one is the red alert. The criterions for blue and yellow alerts are the same for two versions. When the daily average air quality index is larger than 200 and only continues for 1 day, then a blue alert will be issued. When it continues for 2 days, then a yellow alert will be issued. In the old version, when heavy smog continues for 3 days or 4 days and more, orange or red alerts will be issued. But in the new version, if the average AQI reaches more than 300, then orange alerts also will be issued, and if the average AQI reaches more than 300 and continues for 2 days, or reaches 500, then BJEPB will also issue red alerts. The smog alerts will show in the television programs and will be sent as a message to everyone's mobile phone.

In the emergency plans, BJEPB also provides suggestions and makes restrictions on individuals' outdoor activities. The blue alert suggests children, elders, and people with respiratory, cardiovascular and cerebrovascular diseases reduce outdoor activities. The yellow alert recommends children, seniors, and individuals with respiratory, cardiovascular and cerebrovascular diseases avoid outdoor activities, and normal people reduce time spends in outdoor. The orange and red alerts suggest people should try to avoid any outdoor activities.

This paper chooses daily subway volume as the representative of outdoor activities. The subway in Beijing has 19 lines, and it covers almost the whole city and sub-areas. Subway is a primary communication media for individuals to travel around Beijing. I hypothesis that the smog alerts will cause a decrease in passenger volume since the suggestion from BJEPB and people are not willing to go outdoors.

II. Literature Review

There are some papers studying the similar topics in America. The paper *Days of Haze: Environmental information disclosure and intertemporal avoidance behavior* (Zivin, Joshua Graff, and Matthew Neidell 2009), investigate the impact of smog alerts on consecutive days on discretionary outdoor activities in Southern California. They use daily aggregate measures of attendance at the Los Angeles Zoo and Botanical Gardens and Griffith Park Observatory. These two outdoor activities are both reactional. They find that when an alert is issued on one day only, attendance at the Zoo and Observatory decreases by a statistically significant 15% and 8%, respectively. The attendance on the second consecutive day falls to a statistically insignificant 5% and 0%. Furthermore, the response at the Zoo drops to zero for the third successive day. The response from children and the elderly is larger but there still exists a decreased response on the second day. Interestingly, if there is 1-day reprieve from smog alerts, the impact of the alert rebound to the level of the first day.

The paper named *Voluntary information programs and environmental regulation: Evidence from 'Spare the Air,'* (Bowman Cutter and Matthew Neidell 2009) assesses whether individuals change their transportation choices in response to 'Spare the Air' (STA) advisories. STAs are designed to elicit voluntary reductions in automobile trips by encouraging the public to increase ride-sharing and the use of public transit in San Francisco Bay Area. STA alerts are issued when the ozone forecast was predicted to exceed a certain level. By using an RD design that compares days where a STA was issued to days that were close to having an STA, they find that STAs reduce total daily traffic by 2.5-3.5%, with the largest effect during and just after the morning commuting periods. STAs have no statistically significant effect on total daily public transit use, but have statistically significant effect during peak commuting periods. In conclusion, individuals respond to STAs by reducing ozone-causing activities.

My study makes two main contributions to this literature. First, I assess the impact of smog alerts on daily subway volume in Beijing, China. There is no similar paper studying the impact of environmental alerts on individuals' behavior in China. Smog, in all, is a new topic in China, so that Chinese people may not have as much knowledge about the harm of air pollution as Americans, and Chinese government may not be as experienced as American government in the sense of issuing alerts. Due to these differences, this paper, to some extent, can show the distinction of reaction to the environmental alerts between Chinese people and American people.

III. Data

The original data set include 1180 observations. One observation includes the subway volume in one day, air quality index of that day, whether there is a red, orange, yellow or blue smog alert on that day, the highest and lowest temperature of that day, and whether it rains on that day. The data are from January 1st in 2014 to March 25th in 2017. The subway volume data are from the official website of Beijing subway. The air quality indexes are from BJEPB. I searched the website of BJEPB to find when they issued the smog alerts. The weather data are from *tianqi* website. The data set is time-serial.

From table 2, we can see that the standard deviation for the original subway volume data is very large. To exclude the extreme high and low volume data, I drop the variables if the subway volume is less than 1% percentile or more than 99% percentile. The higher air quality index means worse air quality. The mean of air quality index about 120, which means that the air quality in average is bad in Beijing during these years.

Table 2:
Summary statistics

	Number of observations	Mean	Medians	Std.Dev	Highest	Lowest
Original subway volume	1177	796.726	866.01	169.3808	1050.67	143.37
Original air quality index	1180	120.3017	100	76.8465	487	23
Subway volume after dropping	1132	802.6727	865.95	151.8301	1003.49	337.34
Air quality index after dropping	1131	119.863	100	75.99014	477	23

Note: the unit for subway volume is ten thousand.

Table 3:
Summary for rainy days, and alerts days.

	Number of dates
Rain	236
Red Alerts	13
Orange Alerts	16
Yellow Alerts	48
Blue Alerts	20

Table 3 shows that there are 13 days that were issued red alerts, there are 16 days that were issued orange alerts, there were 48 days that were issued yellow alerts, and there were 20 days that were issued blue alerts. Table 4 shows that the simple correlation between alerts and subway volume is negative. However, this simple comparison is confounded. For example, people will go out less if it is a rainy or snow day.

Table 4:
Correlation between alerts and the subway volume:

	Alert	Subway Volume
Alert	1	
Subway Volume	-0.0382	1

IV. Empirical methods and results:

To avoid confounding, I make some fixed effects. The subway volume during weekend and break is much less than during working days, especially during the Spring Festival break, so that I make two dummy variables to represent weekends and breaks, and Spring Festival break. The first is the weekend dummy variable, which equals to 1 it is a weekend or a break. The second is the Spring Festival dummy variable, which equals to 1 when it is in spring festival.

Figure 1:
Distribution of subway volume

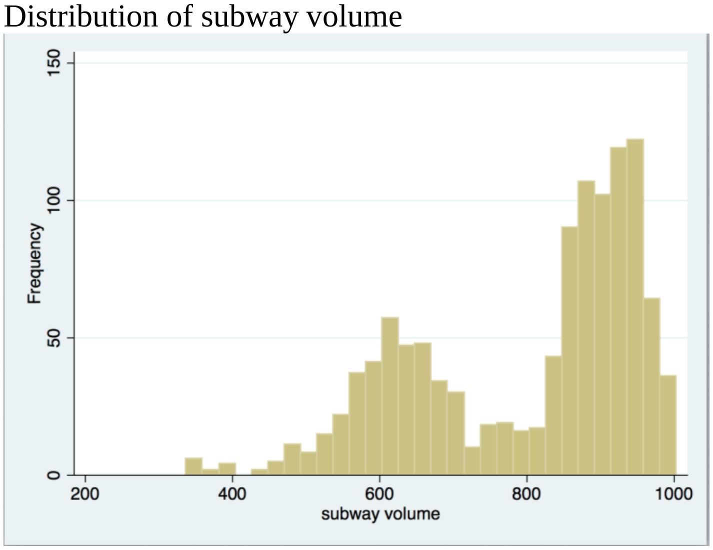

Figure 1 shows that the distribution of subway volume is not normal, so that in the dependent variable in the regression equation will be log form.

Equation 1 is the primary regression I will run. $volume_t$ is the subway volume

$Equation(1)$: $\log(volume_t) = Alert_t\alpha_1 + AQI_t\alpha_2 + Weekend_t\alpha_3 + Springfestival_t\alpha_4 + X_t\theta_0 + \alpha_0 + \varepsilon_t$

in date t. Since the subway volume i $Alert_t$ is a dummy variable showing whether there is an alert at date t. If there is an alert, then there will be 1 for that day. AQI_t is the air quality index at date t. X_t are potential confounding variables, including meteorological variables – average temperature and whether it is a rainy or snowy day. The unit of temperature is degree centigrade. $Weekend_t$ is the dummy variable to show whether it is a weekend day, and $Springfestival_t$ is another dummy variable to show whether it is in Spring Festival. α_0 is the intercept, and ε_t is the error term. The coefficient of interest is α_1. If these coefficients are negative, then it means that the alerts will make people take less subway. I will use regression discontinuity to find out whether individuals are affected by the alerts or the smog that can be visualized. The cutoff AQI is 200. The interval will be ± 10. If the coefficient for AQI differs significantly between the regression with all observations and the regression with observations when AQI is larger than 190 but smaller 210, then it means people react to the alert rather than the visualized air quality condition.

Table 5 shows the regression result for equation 1. The first column illustrates the result of the regression with all observations. Surprisingly, the coefficient for alerts is positive, and it means that if there is a smog alert on that day, the subway volume will increase 1.52 percent, ceteris paribus. But the result is not statistically significant at 5% level of significant. The coefficients for weekend, spring festival, and rainy or snowy are all statistically significant negative at any percent level of significance. These results mean that people will take less subway when it is rain or snow or when it is weekend, or when it is in spring festival. The impact of temperature is statistically significant positive, which means that one degree centigrade increase in temperature will increase the subway volume by 0.58 percent, ceteris paribus. The effect by AQI is very small and not statistically significant neither. The second column shows the results of the for equation 1 either, but limit the range of AQI to between 190 and 210. There are 38 observations in this regression. The coefficient for AQI is much larger in column 2 than in column 1, but it is still not statistically significant. By comparing two coefficients, I find that people do react to alerts, but the direction is opposite to the direction in the null hypothesis. The third column presents the regression results with the observations before changing the criterion of issuing

Table 5:
Econometrics results for equation 1:

	(1)		(2)		(3)		(4)	
	Coef.	Std.Err.	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
alert	0.0152	0.0149514	0.117	0.0769	0.0163	0.0550	0.000586	0.0550
AQI	0.000000119	0.0000538	0.007	0.00524	0.000000667	0.000194	-0.0000479	0.000194
weekend	-0.3494***	0.0069336	-0.367***	0.00693	-0.349***	0.0295	-0.368***	0.0295
spring festival	-0.5591***	0.0229302	-0.696***	0.180	-0.555***	0.0518	-0.595***	0.0518
average temperature	0.0031***	0.0003189	0.00579***	0.0027	0.00355***	0.00322	0.0101***	0.00322
rainy or snowy	-0.0296***	0.0081602	-0.0969***	0.0602	-0.0306***	0.0472	-0.00150***	0.0472
Constant	6.748617		5.334		6.736		6.810	
Observations	1129		38		1042		87	
R^2	0.7456		0.6832		0.7504		0.7945	

Note:
The dependent variable in each regression is the log term of the total subway volume in each day.
***means the result is statistically significant at 1% level of significance.
**means the result is statistically significant at 5% level of significance.
*means the result is statistically significant at 10% level of significance.

alerts, while the fourth column shows the results for the new version of the criterion. The coefficients for alerts are both positive but not significant at 5% level of significance in these two columns. No matter for which version, people did not change their behaviors to alerts significantly according to subway volume.

There is no significant result for alerts in all, then I run some different regressions to try to find out significant results.

$$\begin{aligned} Equation(2)\colon \log(volume_t) &= blue_t\alpha_1 + yellow_t\alpha_2 + orange_t\alpha_3 + red_t\alpha_4 + AQI_t\alpha_5 \\ &+ Weekend_t\alpha_6 + Springfestival_t\alpha_7 + X_t\theta_0 + \alpha_0 + \varepsilon_t \end{aligned}$$

Equation 2 is like equation 1 except that I divide the alert term into four sub terms. The coefficient of interest is α_1, $\alpha_{2,}$ α_3, and $\alpha_{4.}$ If any of the coefficient is negative, then it means that level of alerts will make people ride less subway. The other variables are the same as those in equation 1.

$$\begin{aligned} Equation(3)\colon \log(volume_t) &= SevereAlert_t\alpha_1 + AQI_t\alpha_2 \\ &+ Weekend_t\alpha_3 + Springfestival_t\alpha_4 + Weekend_t \\ &* SevereAlert_t\alpha_5 + X_t\theta_0 + \alpha_0 + \varepsilon_t \end{aligned}$$

Since in the Emergency plan, Beijing Municipal Environmental Protection Bureau suggests all people should try to avoid outdoor activities if there is orange and red alerts, then I make a dummy variable named severe alerts in Equation 3. This dummy variable equals to 1 when there is an orange alert or red alert. I also make an interaction term that times severe alerts and weekend together.

Table 6
Regression results for equation 2 and 3:

	(1)		(2)	
	Coef.	Std.Err.	Coef.	Std.Err
blue alert	0.0205	0.0258		
yellow alert	0.0009	0.0181		
orange alert	0.0444	0.0297		
red alert	0.0387	0.0329		
severe alert			0.0674***	0.0279
severe * break			-0.0721*	0.0419
AQI	-0.00000724	0.0000541	0.00000036	0.00524
weekend	-0.3495***	0.00693	-0.347***	0.00693
spring festival	-0.5569***	0.0229	-0.558***	0.180
average temperature	0.0031***	0.00031	0.0031***	0.0027
rainy or snowy	-0.0295***	0.00817	-0.0294***	0.0602
Constant	6.7489		6.748	
Observations	1129		1129	
R^2	0.7462		0.7467	

Note:
*** means the result is statistically significant at 1% level of significance.
** means the result is statistically significant at 5% level of significance.
* means the result is statistically significant at 10% level of significance.

Column 1 in Table 6 shows the regression results of equation 2, but unfortunately, there is no any significant result for any type of alert. Column 2 shows the regression results for equation 3. The coefficients for severe alerts alone, weekends alone, and the interaction term of severe alerts and weekends are all statistically significant at least at 10% level of significance. The coefficient for severe alerts alone shows that if there is a severe alert in a non-weekend day, the subway volume will increase 6.74%, ceteris paribus. By adding the coefficients of severe alerts alone and the interaction term, if there is a severe alert in a weekend day, the subway volume will decrease 0.47% ceteris paribus. These results illustrate that the subway volume increases when there is a severe alert on a non-weekend day, and decrease on a weekend day.

V. Conclusion

The impacts of alerts in all and different types of alerts are not statistically significant. However, when I combine the red alerts and orange alerts together, the results significantly show that people will take more subway when there is an orange or red alert on a non-weekend day, and will take less subway when the orange or red alert is on a weekend day. The insignificant results for all alerts may because people care less about the blue and yellow alerts.

One explanation for these significant results is that Beijing Transportation Bureau will issue private cars restrictions when there is orange alert or red alert. If the number of the date is even, cars with the even number on the license are forbidden, and if the final number of the date is odd, cars with the odd licenses are forbidden. This restriction may force people who normally drive to take the subways. The other explanation is that individuals may recognize subway as a relevantly safe transportation tool with less exposure to the air since it is underground. On the working days, people need to go to work, but on the weekend, people can choose to stay at home. Thus, the subway volume increases when there is a severe alert on non-weekend days, and decrease on weekends.

There are still some shortcomings of my research. First, there are only 26 sever alerts, the sample size is relevantly small so that bias may exist. Secondly, even though the two versions of Emergency Plan for Air Pollution in Beijing both ask BJEPB to release the alert 24 hours before the alert day, when I searched for the official document for alerts, I found that a lot of alerts were still released on the day when the alert began rather than the day before the alert began. Some alerts were even issued in the afternoon or the evening of the day, and some alerts increased to a higher level after one day. It is hard for individuals to reschedule their outdoor activities if alerts are not issued at least one day before the heavy smog begins. If BJEPB can issue alerts on time, the result will be more robust. Thirdly, if there exits more detailed data, further researches can be done. For example, if there exists hourly subway volume, I can separate the commuting volume and recreational volume by time. And since children and elderly are more susceptible to smog, if there exists daily or hourly subway volume data for different age groups, I can do more detailed research.

This study still has some suggestion to policy makers in China. Since it will take long a time to enhance the air quality and to reduce the smog, it is important to optimize the alert mechanism under this bad situation. Simply increasing the level of AQI which an alert should be issued to reduce the amounts of alerts is only a self-deception way. To enhance people's welfare and to decrease the harm of the heavy smog to the lowest level, the related organizations should try to enhance the speed and the accuracy of predicting smog. It is significant to issue the smog alerts at least one day before the starting date of the heavy smog, because people can have time to reschedule their plans. Furthermore, it is urgent to educate people about the harm of smog to increase people's attention to the alerts.

References:

1.Cutter, W. Bowman, and Matthew Neidell. "Voluntary information programs and environmental regulation: Evidence from ‘Spare the Air.'" *Journal of Environmental Economics and Management* 58.3 (2009): 253-65. Web. 19 Apr. 2017.

2. Zivin, Joshua Graff, and Matthew Neidell. "Days of haze: Environmental information disclosure and intertemporal avoidance behavior." *Journal of Environmental*

4."Health Effect of Smog." Beijing Municipal Commission of Health and Family Planning, 14 Dec. 2016. Web. 07 May 2017. <http://www.bjchfp.gov.cn/54doctor/jkzs/qt/201612/t20161222_207237.htm>.

3. "Air Quality Index (AQI) Basics." *AirNow*. N.p., 31 Aug. 2016. Web. 07 May 2017.

4. "Emergency Plan for Air Pollution in Beijing." *Beijing Municipal Environmental Protection Bureau*. N.p., 27 Oct. 2013. Web. 18 Apr. 2017.

5."Emergency Plan for Air Pollution in Beijing (new version)." *Beijing Municipal Environmental Protection Bureau*. N.p., 20 Nov. 2016. Web. 18 Apr. 2017.

6. "Transportation Restrictions in Smog Alert Days." Beijing Government, 26 June 2015. Web. 30 Apr. 2017.