Air pollution, Information, Avoidance Behavior, and Health: Evidence from Korea

Geunsik Yoo

Outline

1. Introduction

2. Previous Research

3. Other Chapters of the Dissertation
    - 3.1. Chapter 1 – Leisure
    - 3.2. Chapter 2 – Labor

4. Data

5. Econometric Model

1. Introduction

<Figure 1> Seoul on a day of high PM pollution

Source: http://koreajoongangdaily.joins.com/news/article/article.aspx?aid=2999528

1. Introduction

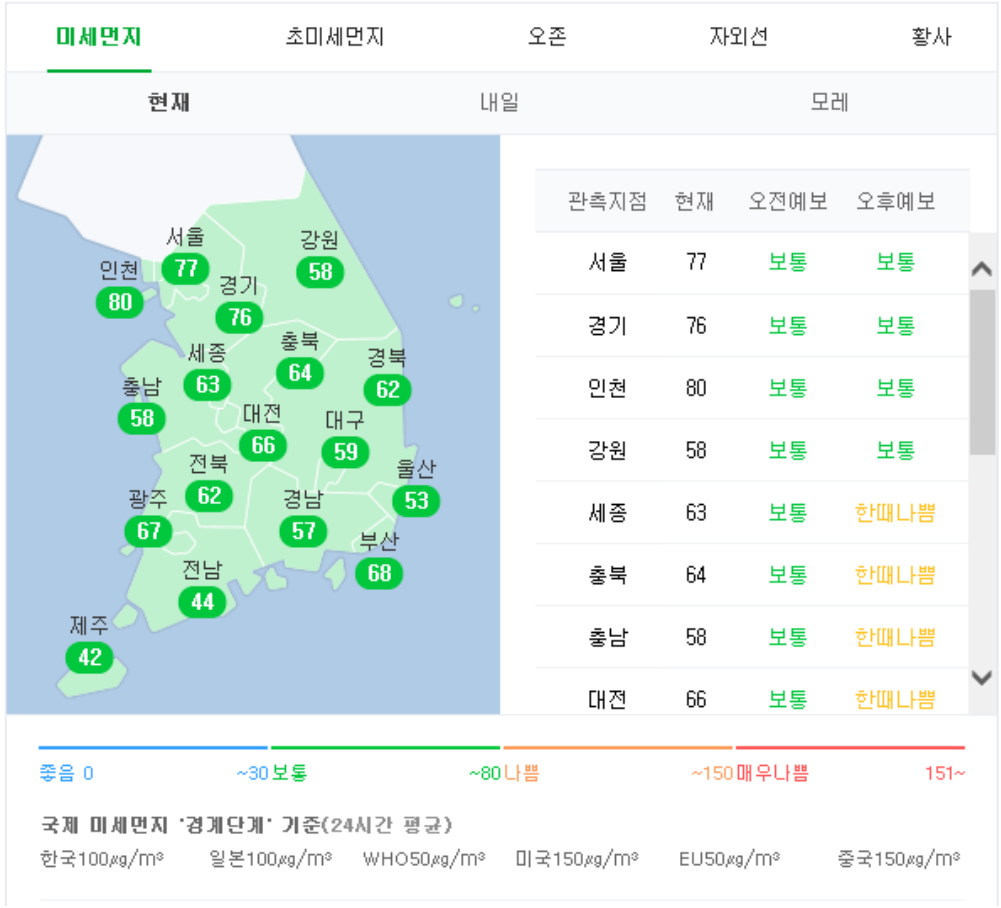
- The hazard of air pollution is popular in many studies.
- In particular, particulate matter (PM) air pollution is associated with morbidity and mortality from cardiovascular and respiratory diseases (Pope III and Dockery 2006, EPA 2014).
- International Agency for Research on Cancer (IARC) under WHO has classified PM as Group 1 carcinogen in 2013 (IARC 2013).
- Moreover, several studies have reported that PM negatively influences cognitive ability and human capital formation (Zweig et al. 2009, Levy et al. 2014).

1. Introduction

- Accordingly, countries have been implementing various policies to protect people from the threat of air pollution.
- These policies include providing information on air pollution levels with action guidelines.
- The information provision policy is based on the expectation that people will adjust their behavior on the basis of the information on air pollution.
- Certainly, certain studies have shown that information provision on air pollution causes avoidance behavior (Neidell 2009, Zivin and Neidell 2009, Janke 2014, Altindag et al. 2017).

1. Introduction

<Figure 2> Information on Air Pollution in Korea



Source: www.naver.com; www.daum.net

1. Introduction

- The current study investigates whether air pollution information, such as forecasts and real-time information, on particulate matter (PM) affects people's health in Korea.
- Previous studies only examined the effects of forecast; none have investigated the effect of real-time information.
- Therefore, examining the effects of real-time information is the main contribution of this study.
- In addition, the current study is worthwhile in that it is the first research to evaluate the health effects of information provision policy in Korea.

2. Previous Research

- As effectively summarized in Pope III and Dockery (2006), PM was found to be associated with morbidity and mortality due to respiratory and cardiovascular diseases.

- In addition, PM is related to human capital formation. Several recent studies have shown that PM negatively affects children's schooling and cognition (Zweig et al. 2009, Levy et al. 2014)

- Moreover, PM exposure in one's early life has worsened performances, such as test score and labor market outcome (Sander 2012, Isen et al. 2017).

- Research based on Korea has confirmed the negative effects of PM (Hong et al. 1999, Lee et al. 2000, Lee et al. 2002, Ha et al. 2003).

2. Previous Research

- Neidell (2009) found that smog alert in Southern California reduced the number of visitors to outdoor facilities and alleviated negative effect of ambient air pollution on asthma patients.

- Altindag et al. (2017) showed that exposure to PM, during pregnant, deteriorated infant health and information on air quality, such as Asian dust warning, mitigated the harmful effects.

- While, Janke (2014) reported that the positive effects of the information on health were limited and occurred only on asthma patients, although air pollution warnings reduced the daily visitors to an outdoor facility.

2. Previous Research

- Moretti and Neidell (2011) estimated the welfare costs of avoidance behavior by using daily boat traffic as an instrumental variable.

- Sheldon and Sankaran (2019) showed that bad air quality caused by Indonesian forest fire increase Singaporean domestic electricity demand.

- Some recent studies have shown that purchases of defensive products for air pollution, such as anti PM2.5 mask, increased in a day with high air pollution by using online purchasing data. (Zhang and Mu 2017, Liu et al. 2017)

3. Other Chapters of the Dissertation - Leisure

- The chapter 1 investigates whether real-time information on particulate matter affects people's behavior in Korea by using data on baseball game attendances.

- Results of this study show that people adjust their behavior in response to real-time information. The number of baseball game attendances decreases by approximately 7% when the real-time alert is issued.

- The effects of real-time alerts are different annually and to have increased significantly since 2014. This drastic change may be attributed to the increased accessibility and sensitivity of people.

- Moreover, the analysis results represent that dependency on real-time information is smaller than that of forecasts.

3. Other Chapters of the Dissertation - Leisure

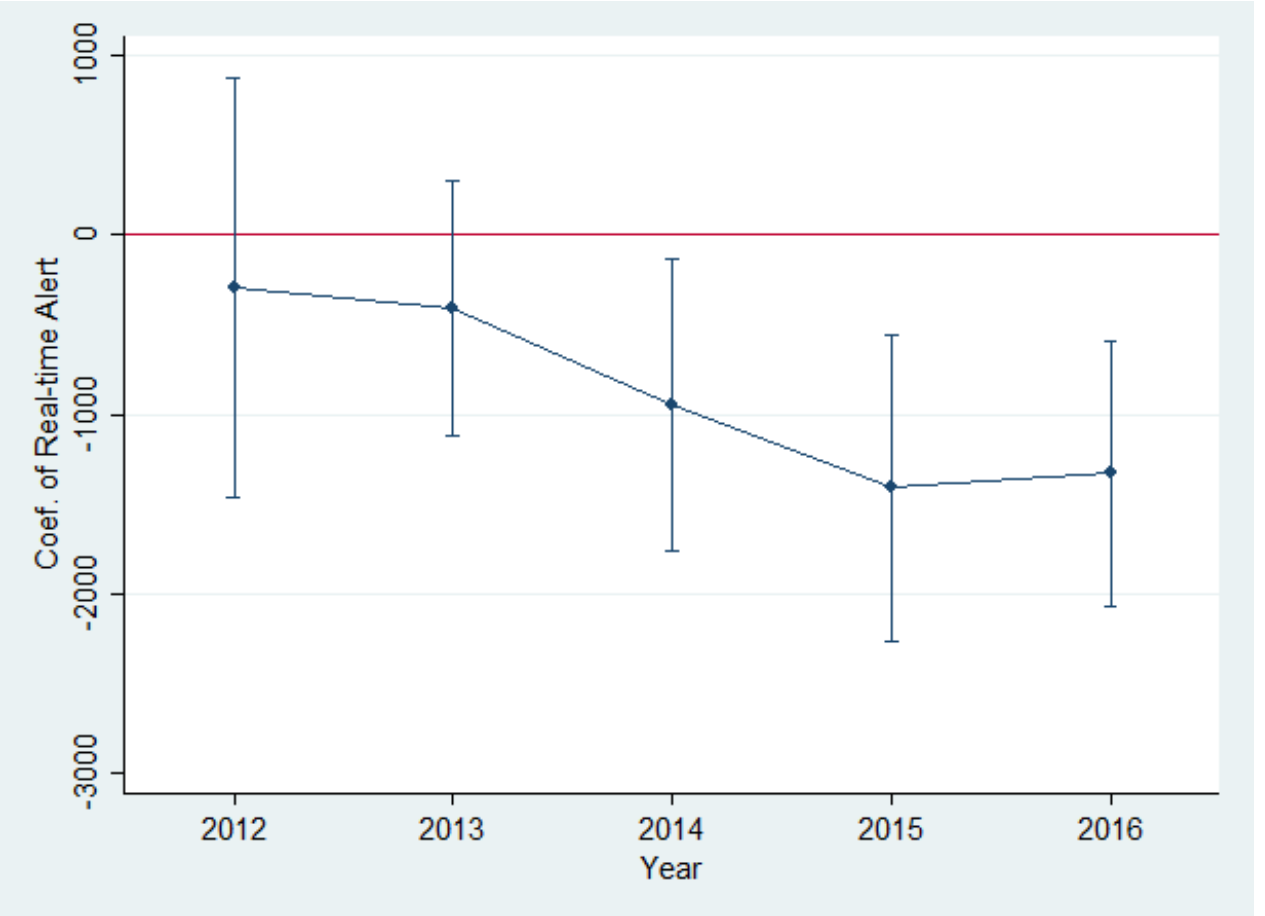
<Table 1> The Effects of Real-time Alerts on Baseball Game Attendances

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Attendance	Attendance	Attendance	Attendance	Attendance	ln(Attendance)
Real-time Alert	-1,949***	-1,849***	-1,369***	-923.0***	-902.7***	-0.0678**
	(516.0)	(507.2)	(376.1)	(281.4)	(280.2)	(0.0270)
Weather		○	○	○	○	○
Team Fixed Effects			○	○	○	○
Time Fixed Effects				○	○	○
Forecast alerts					○	○
R-squared	0.009	0.100	0.587	0.759	0.760	0.728
Observations	3,004	3,004	3,004	3,004	3,004	3,004

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3. Other Chapters of the Dissertation - Leisure

<Figure 2> The Effects of Real-time Alerts on Baseball Game Attendances



Note: The vertical bar of a point represents 90 percent confidence intervals

3. Other Chapters of the Dissertation - Leisure

<Table 2> Comparison of the Effects of Real-time Alerts with the Forecast Alerts

VARIABLES	(1) Baseline	(2) Including Interactions	(3) w/o FA days	(4) w/o RA days
RA	-941.0*** (327.7)	-1,186*** (363.1)	-1,048** (431.6)	
FA	-661.5** (333.9)	-1,284*** (392.1)		-1,253*** (445.3)
RA * FA		1,392** (592.5)		
Observations	1,951	1,951	1,841	1,774
R-squared	0.736	0.736	0.727	0.736

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3. Other Chapters of the Dissertation - Labor

- The chapter 2 estimates the effects of information such as forecast and real-time alerts, on working hours.
- Results suggest that outdoor workers reduce their working hours when forecast and real-time alerts are given.
- The workers respond to information by adjusting work start or end time, while they cannot immediately react to real-time alerts while working.
- The effects of information are chiefly derived from the agriculture, forestry, and fishing industries.
- Furthermore, only workers who can modify their work start and end time and employers react to the information on PM10.

3. Other Chapters of the Dissertation - Labor

<Table 3>Differential effects of Real-time Alerts depending on Provision Timing

VARIABLES	(1)	(2)	(3)
FA	6.220	6.790	6.662
	(8.816)	(8.898)	(8.927)
FA * OR	-65.69**	-71.91**	-66.49**
	(29.30)	(29.38)	(29.51)
RA (am)	0.659		0.452
	(0.985)		(1.169)
RA (am) * OR	-8.542**		-8.023*
	(3.587)		(4.268)
RA (pm)		-0.627	-0.405
		(1.039)	(1.232)
RA (pm) * OR		5.362	0.987
		(3.617)	(4.302)
Daily Avg PM10	○	○	○
Demographic Info.	○	○	○
Occupational Info.	○	○	○
Weather, Time	○	○	○
Observations	4,023	4,023	4,023
R-squared	0.193	0.192	0.193

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3. Other Chapters of the Dissertation - Labor

<Table 4> Analyses on Time Adjustment Path

VARIABLES	(1) Hours Worked	(2) Time in Work Place	(3) Work Start Time	(4) Work End Time	(5) Other Action in Work Place
FA	6.220	12.83	-5.325	7.503	6.608
	(8.816)	(10.36)	(7.509)	(9.011)	(5.380)
FA * OR	-65.69**	-86.96**	23.22	-63.74**	-21.27
	(29.30)	(34.43)	(24.95)	(29.94)	(17.88)
RA (am)	0.659	0.467	-0.650	-0.183	-0.192
	(0.985)	(1.157)	(0.839)	(1.007)	(0.601)
RA (am) * OR	-8.542**	-10.84**	6.980**	-3.860	-2.298
	(3.587)	(4.215)	(3.055)	(3.666)	(2.189)
Observations	4,023	4,023	4,023	4,023	4,023
R-squared	0.193	0.173	0.213	0.192	0.086

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3. Other Chapters of the Dissertation - Labor

<Table 5> Identification whether the Effects of Information are Concentrated in a Particular Industry

	(1)	(3)	(4)
VARIABLES	w/o ind#1	w/o ind#6	w/o ind#8
FA	-0.354	4.887	6.719
	(8.784)	(9.197)	(8.895)
FA * OR	0.880	-81.22**	-110.2***
	(39.26)	(31.72)	(32.90)
RA_am	0.335	0.700	0.840
	(0.983)	(1.017)	(0.989)
RA_am * OR	-4.426	-8.083**	-9.643**
	(4.754)	(4.019)	(4.035)
Observations	3,787	3,665	3,800
R-squared	0.183	0.204	0.194

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; ind#1 indicates agriculture, forestry and fishing, ind#6 indicates construction, ind#8 indicates transportation

3. Other Chapters of the Dissertation - Labor

<Table 6> Analyses on the Immediate Avoidance Possibilities

VARIABLES	(1) 1 hour	(2) 2 hour	(3) 3 hour
Panel A			
RA(Hourly)	0.0664	0.225	1.173
	(0.331)	(0.588)	(0.845)
RA(Hourly) * OR	-0.564	0.732	0.980
	(1.258)	(2.234)	(3.205)
Observations	42,950	42,907	42,765
R-squared	0.244	0.287	0.363
Panel B (PM10 b/w 60-100)			
RA(Hourly)	0.699	0.592	1.424
	(0.487)	(0.873)	(1.263)
RA(Hourly) * OR	-2.855	-2.660	-2.529
	(1.784)	(3.197)	(4.616)
Observations	17,646	17,629	17,573
R-squared	0.251	0.294	0.366

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3. Other Chapters of the Dissertation - Labor

<Table 7> The differential effects of the Information by Groups

VARIABLES	(1) w/ Discretion	(2) w/o Discretion	(3) Regular Employee	(4) Temporal Employee	(5) Employer	(6) a2039	(7) a4059	(8) over60	(9) Woman	(10) Man
FA	9.104	1.418	-0.942	-10.09	47.34**	10.34	-5.047	10.95	-3.535	15.71
	(19.42)	(9.876)	(9.733)	(24.59)	(21.91)	(13.71)	(11.92)	(33.55)	(15.38)	(10.70)
FA * OR	-89.92*	-15.24	-23.58	-47.30	-109.5**	-51.59	19.21	-107.2	-158.6*	-48.48
	(49.84)	(40.03)	(56.72)	(86.10)	(48.01)	(97.18)	(47.72)	(66.31)	(94.80)	(30.66)
RA (am)	0.0269	0.851	1.364	-3.699	0.295	2.921*	-1.695	0.688	1.339	0.545
	(2.133)	(1.110)	(1.105)	(2.609)	(2.519)	(1.508)	(1.371)	(3.456)	(1.647)	(1.230)
RA (am) * OR	-14.09**	-1.527	5.515	7.820	-16.00***	-1.445	-2.586	-16.07*	-19.42	-8.171**
	(6.252)	(4.926)	(7.355)	(9.792)	(6.033)	(11.42)	(5.056)	(8.284)	(13.55)	(3.698)
Observations	1,202	2,821	2,161	800	1,062	1,300	2,095	628	1,495	2,528
R-squared	0.277	0.180	0.135	0.396	0.295	0.221	0.207	0.349	0.258	0.150

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4. Data

Health data

- National Sample Cohort data from National Health Insurance Service is used for health data.

- National Sample Cohort data is a panel data sampling approximately one million within individuals having national health insurance from 2002-2015.

- This data contains social& economic status, medical utilization record, health examination record.

4. Data

Real-time Pollution data

- Hourly ambient air pollution data was obtained from National Institute of Environmental Research (NIER) of Korea.

- Real-time PM information is provided numerically and categorically: 0–30 is classified as good, 31–80 moderate, 81–150 bad, and over 151 very bad.

- Moreover, each level has a color to intuitively express the risk, such as blue, green, amber, and red. Thus, the scheme will make people react to a category, not concentrate on a particular figure.

4. Data

Forecasts data

- Korean government has been operating air quality forecasts system since 2014 and this data could be obtained from the government operating web-site, www.airkorea.or.kr.

- The government announces forecasts on PM and ozone on the next day in four time schedules: 5 a.m., 11 a.m., 5 p.m., and 11 p.m.

- The 5 p.m. forecast was selected in this study because the information is released on the evening news.

- The forecast is only provided at four levels: good, moderate, bad, and very bad.

4. Data

Weather

- Weather variables, which may influence air pollution and working hours, are potential confounding factors in this analysis.

- Thus, weather data, obtained from the Korea Meteorological Administration, will be used in the analysis.

- Temperature, precipitation, relative humidity, and wind speed will be controlled in the form of a quadratic function.

4. Data

<Table 8> Descriptive Statistics

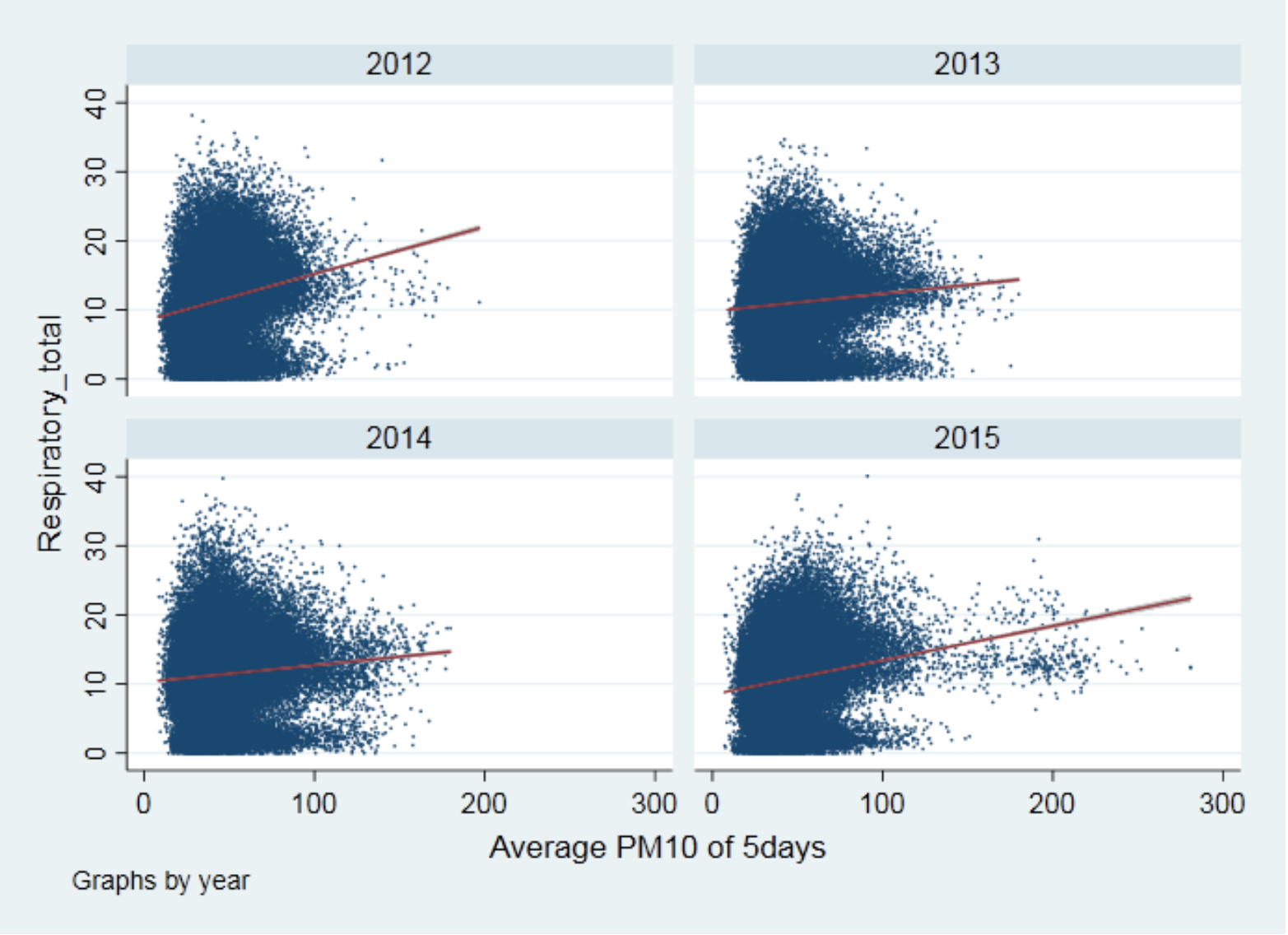
VARIABLES	Mean (Std. Dev.)
Population	6735.2 (4517.9)
Respiratory Diseases	75.85 (68.10)
Cardiovascular Diseases	26.33 (22.13)
Daily Average PM10	47.05 (27.09)
# of Real-time Bad	2.72 (5.49)
Forecast Alerts	0.035 (0.186)
Temperature	13.36 (10.08)
Precipitation	3.31 (12.11)
Wind Speed	2.32 (1.13)
Relative Humidity	65.31 (16.19)
N	206,001

4. Data

<Figure 3> Locations of Monitoring Stations, and Analyzed Areas

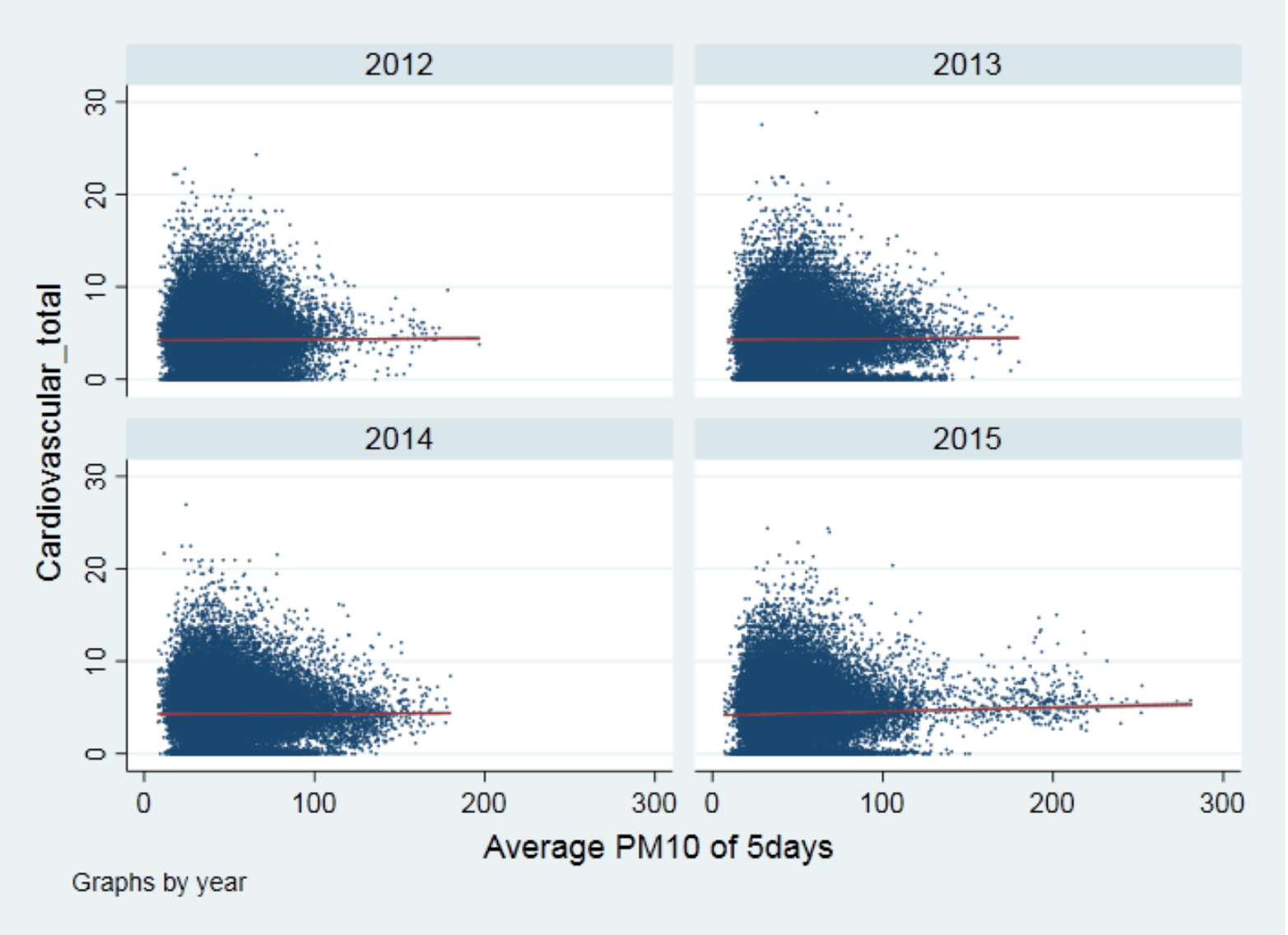
4. Data

<Figure 4> Relationship between PM10 and Respiratory Diseases



4. Data

<Figure 5> Relationship between PM10 and Cardiovascular Diseases



5. Econometric Model – Poisson Regression with County Fixed Effects

$$ln(Y_{ct}|X_{ct}) = \alpha + \sum_{j=0}^{4}\left[\beta_1 FA_{ct-j} + \beta_2 RA_{ct-j} + f\left(PM10_{ct-j}\right) + g\left(W_{ct-j}\right)\right] + \gamma_c + \delta_{time}.$$

- Y_{ct} is the number of hospital visits in county *c*, due to respiratory or cardiovascular diseases on day *t*.
- *FA* is a dummy variables indicating that forecast alert is given.
- *RA* is the number of real-time alerts in a day and has a value from 0 to 24.

5. Econometric Model – Poisson Regression with County Fixed Effects

$$ln(Y_{ct}|X_{ct}) = \alpha + \sum_{j=0}^{4}\left[\beta_1 FA_{ct-j} + \beta_2 RA_{ct-j} + f\left(PM10_{ct-j}\right) + g\left(W_{ct-j}\right)\right] + \gamma_c + \delta_{time}.$$

- PM10 is the daily average PM10 concentration, and W is the vector of the weather variables.
- Four lags of *FA*, *RA*, *PM10*, and *W* are included since previous air pollution and weather can affect hospital visit.
- County, and time (year, month, day of week, holiday) fixed effects are controlled in the model

5. Econometric Model – Individual Fixed Effects

$$Y_{ict} = \alpha + \sum_{j=0}^{4} \left[\beta_1 FA_{ct-j} + \beta_2 RA_{ct-j} + f\left(PM10_{ct-j}\right) + g\left(W_{ct-j}\right) \right]$$

$$+\pi_i + \gamma_c + \delta_{time} + \epsilon_{ict}.$$

- Y_{ict} is a dummy variable representing hospital visit of individual *i* who living in county *c*, due to respiratory or cardiovascular diseases on day *t*.

- Individual fixed effects π_i are controlled in the model.

Thanks.