Can Air Pollution Save Lives? Air Quality and Risky Behaviors on Roads

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Summary

- We study the impacts of air quality on accidents **caused bydriver violations** using administrative data from Taiwan between 2009 - 2015.
- We find that a 1 μg/m³ increase in $PM_{2.5}$ concentration leads to a 0.59% **decrease** in the total number of traffic accidents caused by violations with casualties.
- The cost of air pollution on cognitive performance and other associated health outcomes involving risk attitudes may be biased or underestimated.

Introduction

The socio-economic costs of air pollution have been widely documented. However, in this paper, we find a "benefit" of air pollution: **reducing road accidents caused by driver violations**.

Using administrative traffic accident records and high-resolution air quality data of Taiwan, we identify air quality as a new factor for changing life-threatening risky behaviors.

This study further explores the transmission channels through which air quality influences risk behaviors and in turn brings down the number of road accidents.

Hypotheses

- Air pollution can simultaneously affect road safety in two opposite ways:
  (1) decreasing traffic accidents through increased risk aversion and
  (2) increasing accidents through impaired cognition.
- If air pollution affects road risky behaviors through **respiratory channel**, the number of accidents caused by violations committed by non-enclosed vehicle drivers will decrease more than those by eclosed vehicle drivers.
- If air pollution affects road risky behaviors through **visual channel**, the effect would be stronger during times with ambient natural light, when air quality can be visually assessed, than during times without.

Data

- Administrative traffic accident data between 2009 and 2015
- Daily air quality ($PM_{2.5}$) data at district/township level, averaged from air quality data at 3km*3km grid resolution
  - Aerosol optical depth (AOD) retrievals from MODerate resolution Imaging Spectroradiometer (MODIS)
  - Land use data from National Land Surveying and Mapping Center
  - Real time ground PM2.5 measurement and long-term emission grid data from Taiwan EPA

The endogeneity between pollution and accidents

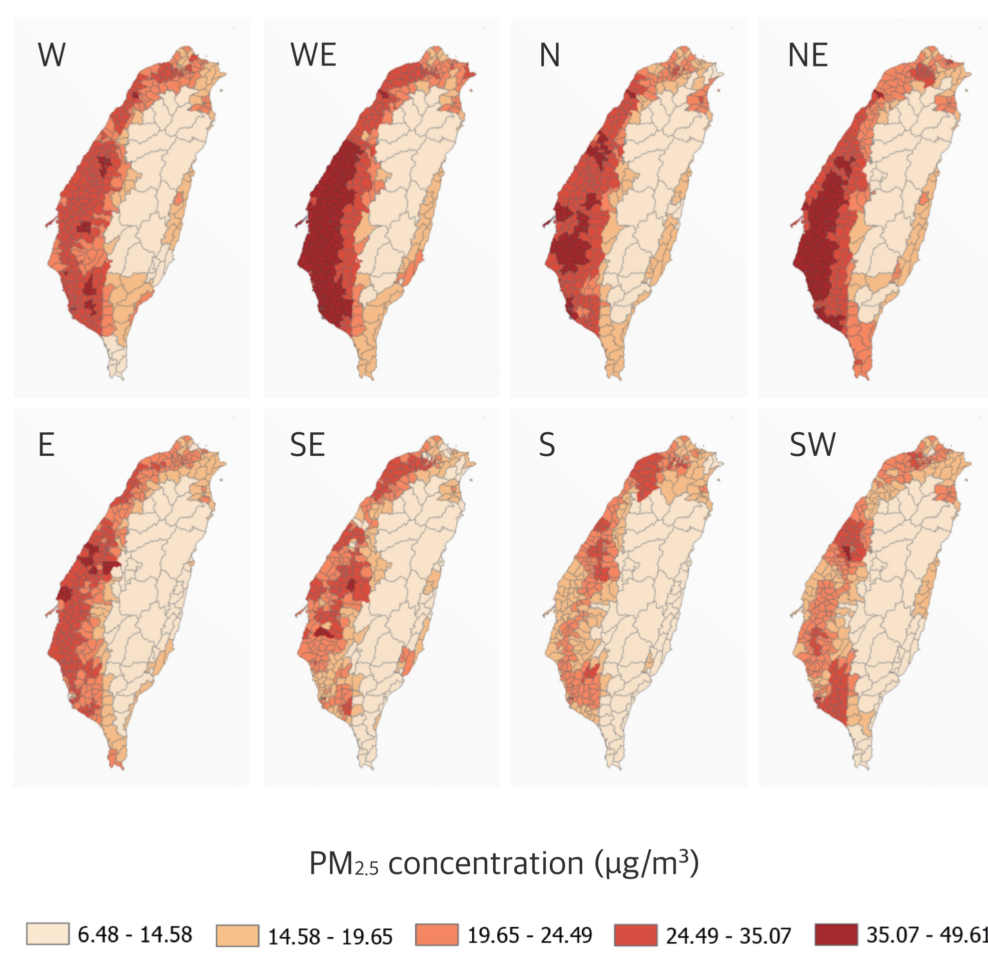
Taking into account the endogeneity betwee pollution and accidents, we use **wind directions** as instrumental variables to introduce exogenousvariation in air quality

- Omitted variables: e.g., the variations in traffic volumes not controlled by the fixed effects
- Avoidance behaviors: individuals decide not to travel because of a high level of air pollution
- Reverse causality: traffic accidents may lead congestion and more (exposure to) pollution

Assumptions for a valid instrument:

- Relevance: wind direction affects air quality in Taiwan
- Exclusion restriction: wind direction would only affect road risk behaviors and accidents through changing air quality, conditional on weather conditions
- Independence: wind direction is independent from the errors of accidents on air pollution
- Monotonicity: the effects of wind direction on air pollution are monotone

Wind directions and air quality in Taiwan



Empirical Strategy

THE FIRST STAGE

$$AQ_{it} = \gamma'_q AQZ_{iq} WD_{it} + \delta' X_{it} + \omega_{it} + \upsilon_{it}$$

- AQ_{it} : the air quality (pollutant) measure in district/township i in day t
- AQZ_{iq} = 1 if district/township i is in air quality zone q
- WD_{it} : the share of hours in the 24-hour period in which wind blows from a certain direction
- X_{it} : weather condition variables
- ω_{it} : spatial and temporal fixed-effects

First Stage (Air Pollution on Wind Directions)

Variables (WD by AQ Zone)	(1) OLS	(2) OLS	(3) OLS
South Wind x AQ Zone North	0.7096	3.7565**	-0.3776
	(1.9483)	(1.3526)	(1.4463)
South Wind x AQ Zone Central	-2.7817*	-3.3785***	-3.1097***
	(1.2435)	(0.7933)	(0.8555)
South Wind x AQ Zone South	-10.1895***	-4.1085***	0.2931
	(0.9363)	(0.9309)	(1.0165)
South Wind x AQ Zone East	-12.1673***	-0.5219	-5.8214***
	(1.2571)	(0.9196)	(0.7752)
West Wind x AQ Zone North	3.6997**	6.2390***	4.7087***
	(1.1534)	(0.7854)	(0.8303)
West Wind x AQ Zone Central	8.1869**	3.1903***	2.4498*
	(2.9403)	(0.7910)	(0.9891)
West Wind x AQ Zone South	15.7092***	2.1208*	4.9465***
	(1.4134)	(0.9456)	(1.0416)
West Wind x AQ Zone East	-1.7700	-7.4636***	-5.7200***
	(1.3314)	(0.9962)	(1.0923)
North Wind x AQ Zone North	1.0580	3.6321**	1.5687
	(1.0308)	(1.1696)	(1.3506)
North Wind x AQ Zone Central	16.9963***	-1.6744*	-5.2331***
	(1.3061)	(0.6817)	(0.8904)
North Wind x AQ Zone South	26.7380***	10.0435***	9.0299***
	(1.6625)	(1.0584)	(1.1472)
North Wind x AQ Zone East	-4.5505*	-4.1387***	-3.2284**
	(1.8290)	(1.0475)	(1.0639)
Observations	892,044	888,736	888,736
Weather Controls	N	Y	Y
Town FE	N	Y	N
Year-Month FE	N	Y	N
DoW FE	N	Y	N
Town-Year-Month FE	N	N	Y
Town-DoW FE	N	N	Y
K-P F-statistics	99.67	46.27	31.31
R-squared	0.221	0.617	0.656

THE SECOND STAGE (a nonlinear stage with Poisson regression)

$$Acc_{it} = exp(\beta AQ_{it} + \gamma \widehat{\upsilon_{it}} + \theta' X_{it} + \omega_{it}) + \varepsilon_{it}$$

- Acc_{it} : the traffic accident related count in region i within a time period t
- $\widehat{\upsilon_{it}}$: the residual (AQ_{it}-$\widehat{AQ_{it}}$) from the first stage
- X_{it} : a vector of weather condition variables
- ω_{it} : spatial and temporal fixed-effects

Air Pollution and Accidents Caused by Violations

Variables	(1) IV PPML	(2) IV PPML	(3) IV PPML	(4) IV OLS	(5) IV PPML
$PM_{2.5}$ (μg/m³)	-0.0013	-0.0056***	-0.0059***	-0.0070***	-0.0059***
	(0.0065)	(0.0012)	(0.0012)	(0.0016)	(0.0012)
Semi-Elasticity				-0.0055	
$PM_{2.5}$ (1 day before)					0.0001
					(0.0002)
$PM_{2.5}$ (2 days before)					0.0000
					(0.0002)
$PM_{2.5}$ (3 days before)					0.0004*
					(0.0002)
Observations	892,044	886,182	820,358	888,736	820,355
Weather Controls	N	Y	Y	Y	Y
Town FE	N	Y	N	N	N
Year-Month FE	N	Y	N	N	N
DoW FE	N	Y	N	N	N
Town-Year-Month FE	N	N	Y	Y	Y
Town-DoW FE	N	N	Y	Y	Y
K-P F-statistics	99.67	46.27	31.31	31.31	31.31

Robustness checks

Are the negative effects driven by avoidance behaviors?

- Rush hours vs. non-rush hours
- Weekdays vs. Weekend
- District/Township by population density (lower vs. upper 50%)

Are the negative effects driven by increased risk aversion?

ROBUSTNESS

Variables	Rush Hours	Non-rush Hours	Weekdays	Weekend	Regions w/ Low Pop	Regions w/ High Pop	Mindless Errors
$PM_{2.5}$	-0.0068***	-0.0052***	-0.0060***	-0.0060**	-0.0064*	-0.0057***	-0.0032
	(0.0017)	(0.0013)	(0.0014)	(0.0023)	(0.0032)	(0.0013)	(0.0019)
Observations	763,893	789,956	568,466	211,482	375,139	445,219	776,785

Transmission Channels Test

- **RESPIRATORY AND VISUAL**
- A placebo test: the effect of ozone, which is generally found to have little effect on haziness of skies.

Respiratory and visual channels

Variables	(1) Enclosed Vehicle	(2) Non-enclosed Vehicle	(3) Natural Light	(4) No Natural Light
$PM_{2.5}$	-0.0057***	-0.0067***	-0.0079***	-0.0018
	(0.0016)	(0.0016)	(0.0015)	(0.0018)
Observations	781,092	762,527	807,090	698,196

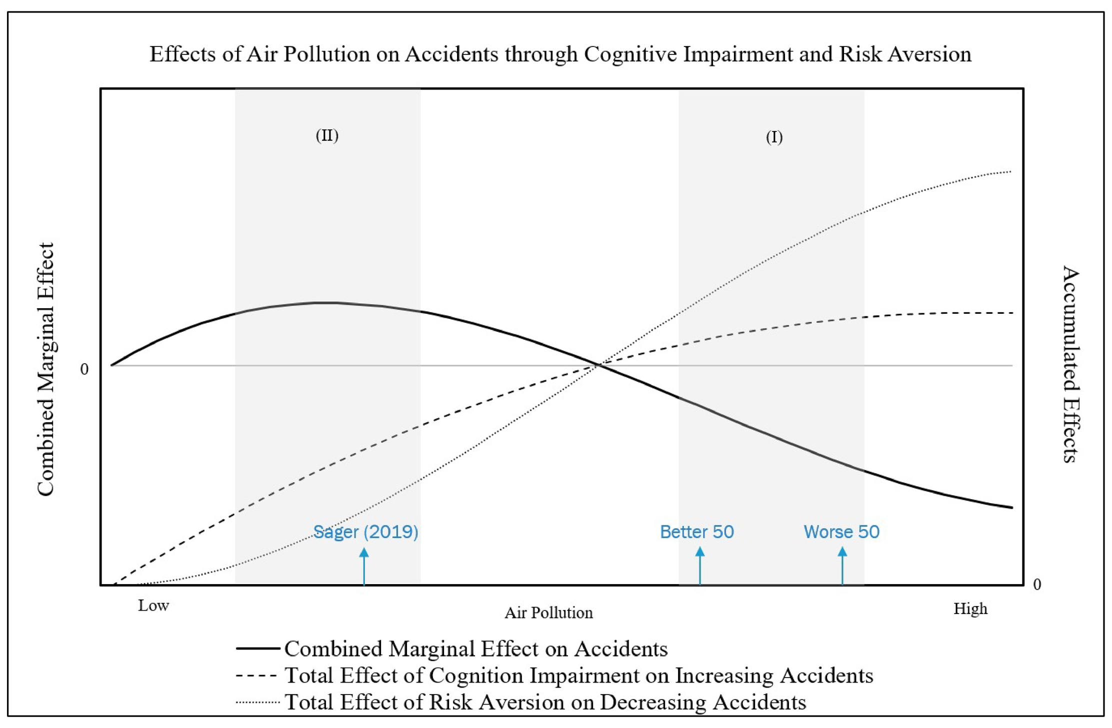
Variables	(1) All
Ozone (ppm)	-0.0003
	(0.0008)
Observations	820,345

The nonlinear effects of air pollution on risky behaviors

- Based on each region's average $PM_{2.5}$ concentration, we stratify all regions into two groups: the better and worse 50.
- Nonlinear second stage with linear splines.

Variables	(1) Better 50	(2) Worse 50	(3) $PM_{2.5}$ Splines
$PM_{2.5}$	-0.0026	-0.0062***	
	(0.0025)	(0.0014)	
$PM_{2.5}$ (0 – 10 μg/m³)			0.0060
			(0.0046)
$PM_{2.5}$ (10 – 20 μg/m³)			-0.0073***
			(0.0015)
$PM_{2.5}$ (20 – 30 μg/m³)			-0.0063***
			(0.0013)
$PM_{2.5}$ (30 μg/m³ and above)			-0.0054***
			(0.0012)
Observations	378,385	441,973	820,358

the nonlinear effects on Cognition and risk Preferences



Conclusion

- We find that a 1 μg/m³ increase in $PM_{2.5}$ concentration leads to a 0.59% decrease in accidents caused by driver violations.
- A nonlinear dose-response relationship between air pollution and risky behaviors: air pollution likely increases the degree of risk aversion at an increasing rate (or at a rate faster than that on reducing cognition).
- The cost of air pollution on cognitive performance and other associated health outcomes involving risk attitudes may be biased, if the effect on risk attitudes is not isolated.
- Air pollution can affect risk preferences through visual channel: the negative effects are only observed in times when air quality can be visually assessed.