Sources of air pollution: Estimating the Diwali effect

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A winter morning in Delhi

Policy measures on pollution

- Delhi is one of the world's most polluted cities
- The winter of 2016 was a public health emergency
- Long-term policy changes
  - Introduction of BS IV fuel and vehicles in April this year
  - Gradual reduction in sales of private diesel vehicles
- Graded Response Action Plan (GRAP) kicked in on October 2017 (Narain, 2017: Business Standard, October 22.).
  - Closure of the Badarpur thermal power plant
  - Shut down brick kilns (in the National Capital Region) that have not converted to new technology
  - Shut down the use of generator sets
  - Watch on contributors to air pollution - construction and road dust, garbage burning, polluting vehicles
- Measuring the causes and consequences of pollution important for policy design

Diwali

- Important festival for the Hindu's
- Celebrated by bursting crackers
- Heavy emphasis on educating people to not burst crackers, and a SC ban on sale of fire-crackers in Delhi in 2017

Research on impact of Diwali

- PM 2.10 concentration 2.49 times higher on the day of Diwali relative to one day before (Barman, Singh, Negi, Bhargava 2008: Environmental Monitoring and Assessment)
- Metal concentrations in ambient air were observed to be very high as compared to background values on previous days (Kulshrestha, Rao, Azhaguvel and Kulshrestha, 2004: Atmospheric Environment)
- Does Diwali have an impact upon air quality? If so, by how much?

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Data

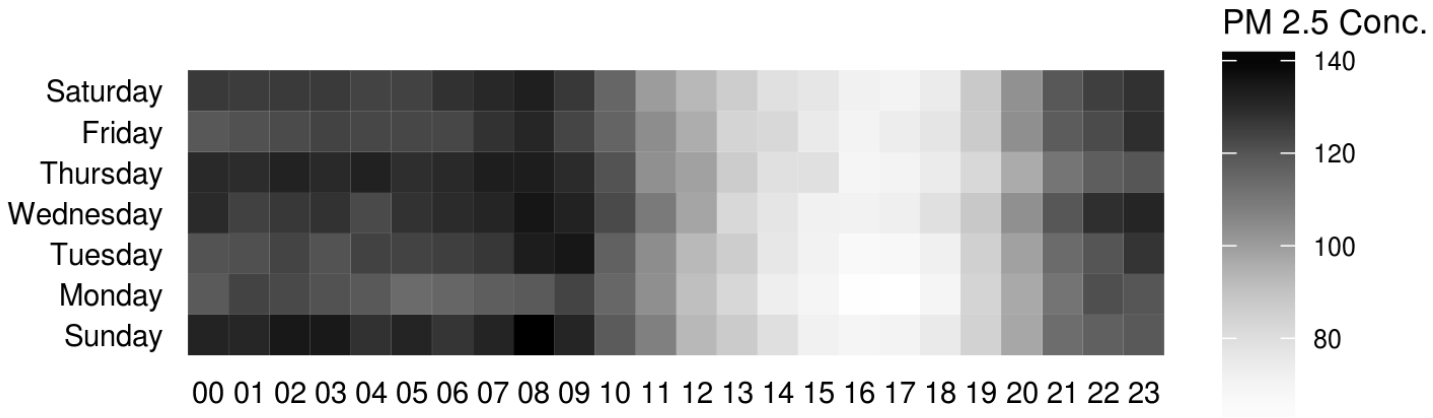
- Central Pollution Control Board: Anand Vihar, Mandir Marg, Punjabi Bagh, R. K. Puram
- US Consulate in Chanakyapuri
- Period: January 2013 to October 2016
- Winsorise the data at 1% level
- Focus only on the PM 2.5 variable

The PM 2.5 index

Breakdowns in PM 2.5 by the US Environmental Protection Agency

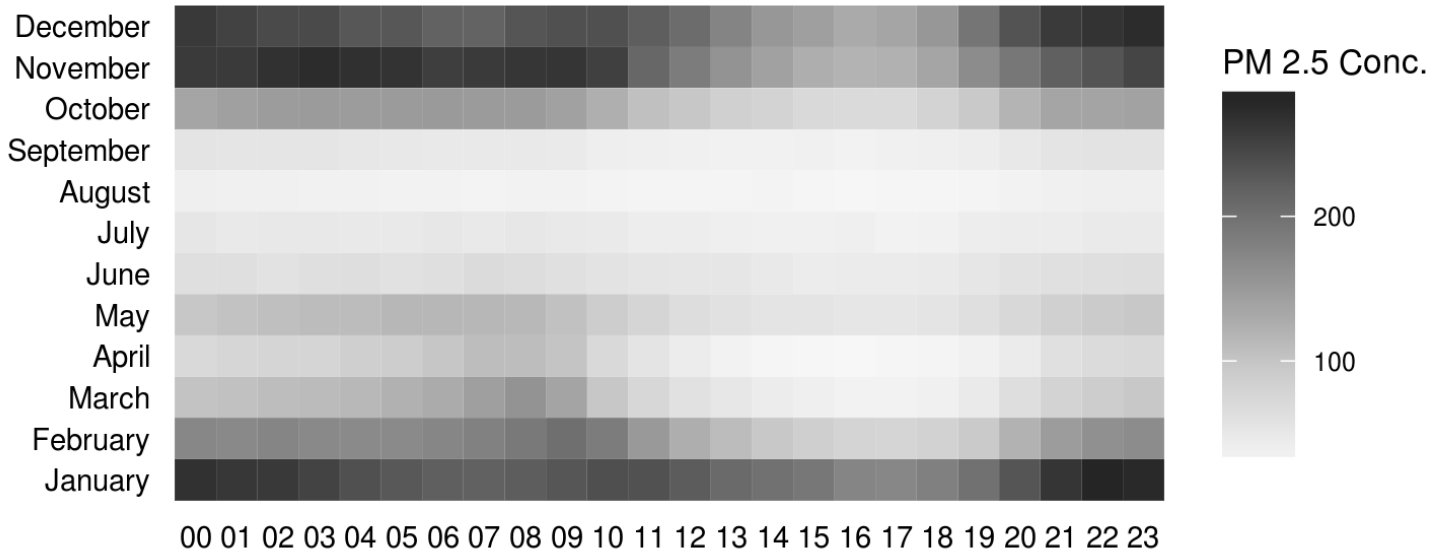
00.0-12.0	Good
12.1-35.4	Moderate
35.5-55.4	Unhealthy for sensitive groups
55.5-150.4	Unhealthy
150.5-250.4	Very Unhealthy
250.5-500	Hazardous

Summarising pollution in Delhi: Time effect



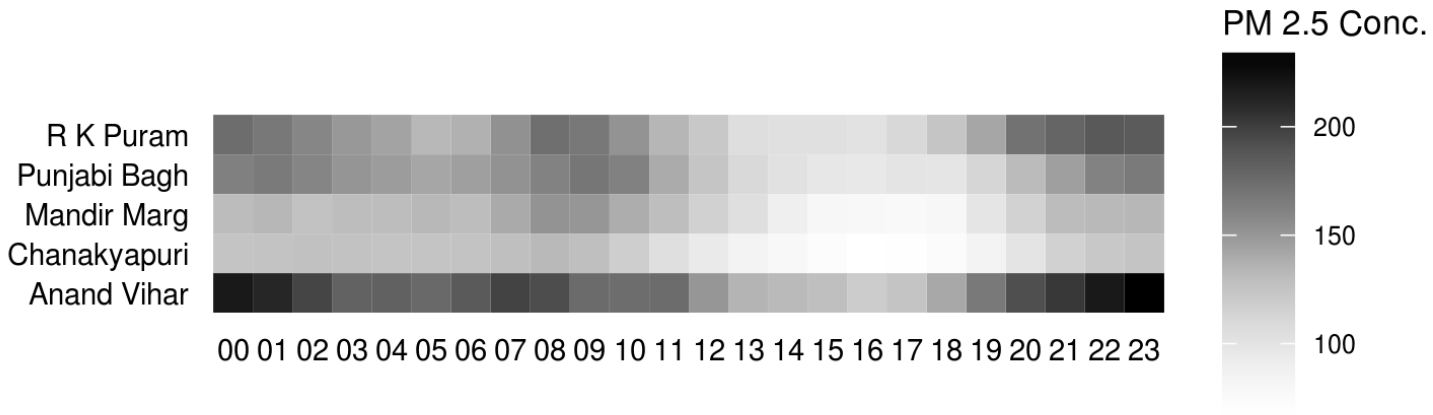
- Pollution low during the day.
- Starts increasing at 6PM.
- Remains high till 9AM the next day.

Summarising pollution in Delhi: Month effect



- Monsoon months have the lowest levels
- Winter months have the highest - on account of low wind speed and humidity

Summarising pollution in Delhi: Location effect



- Anand Vihar has the highest levels of PM 2.5
- Chanakyapuri has the least levels of PM 2.5

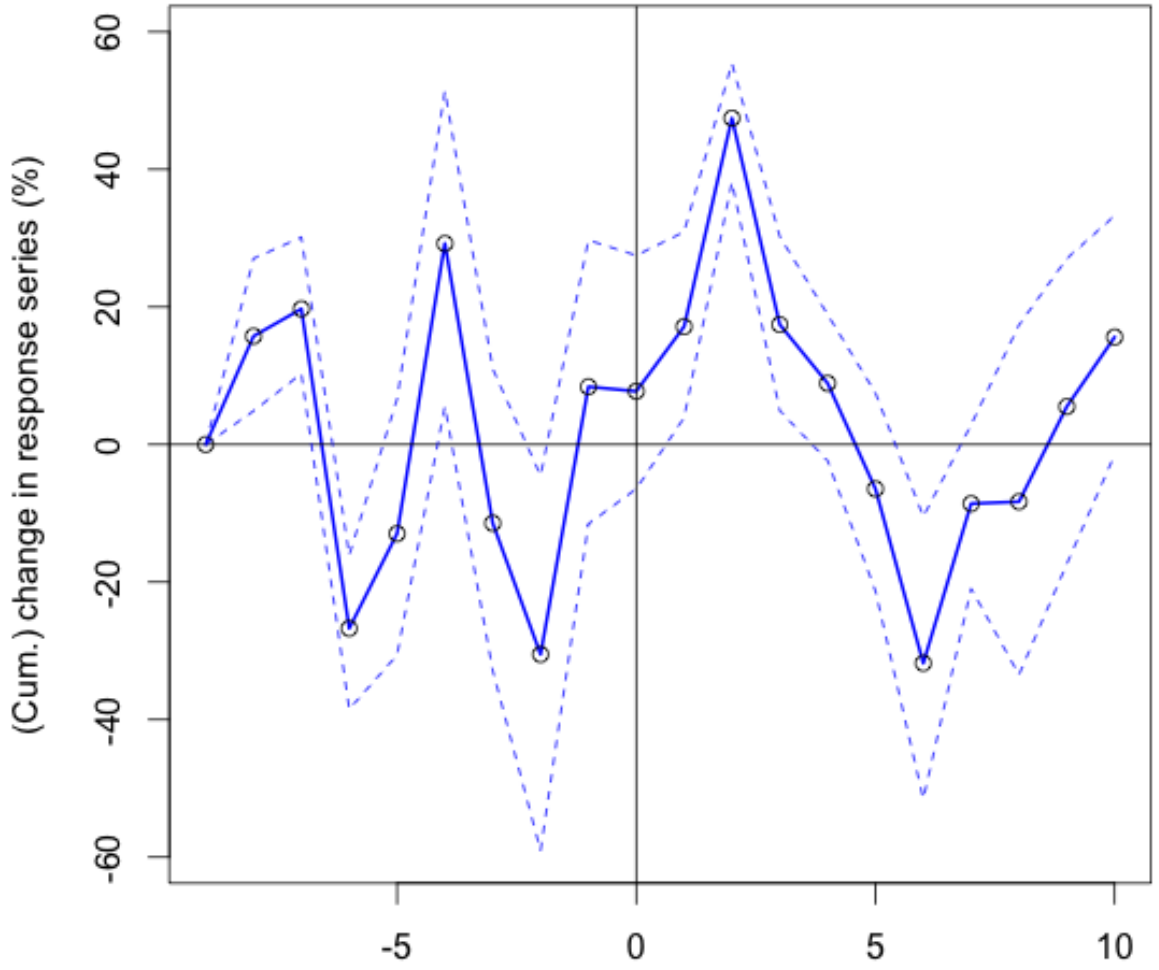
Issues in estimating the Diwali effect

- Effect not uniform throughout the day
- Variation in ambient pollution by location
- Ambient pollution higher during the Diwali period of 17th October and 15th November every year.
  - 3 November 2013
  - 22 October 2014
  - 11 November 2015

Event study on the Diwali date

- We aggregate the hourly concentration of PM2.5, at each location, to arrive at the daily numbers.
- The day of the "Lakshmi Puja" is the event date
- We calculate the percentage change in PM2.5 concentration levels by differencing the logarithm of PM2.5 values.
- We re-index these to show the cumulative change over a 20 day period

Event study results



- Pollution levels start increasing one day before Diwali
- Increase till two days after Diwali.

Regression: Set up

$$P_{it} = \beta_0 + \beta_1 D_t + beta_2 D_t L_i + m_t + h_t + l_i + \epsilon_{it}$$

- P is the PM2.5 measure
- i is the location, t is the time.
- D is an indicator for Diwali, L is an indicator for location
- m and h are month and hour respectively.
- Three models
  - t = 1 day (the day of Diwali)
  - t = 3 days (one day before Diwali, the day of Diwali, one day after Diwali)
  - t = 4 days (preceding day to two days after Diwali)

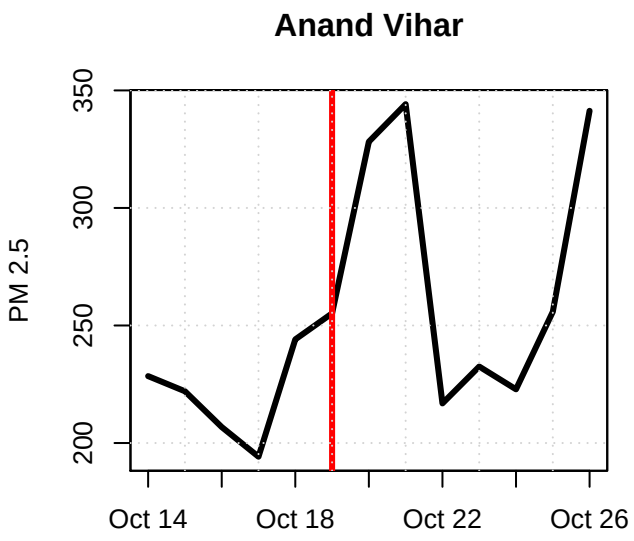
Results

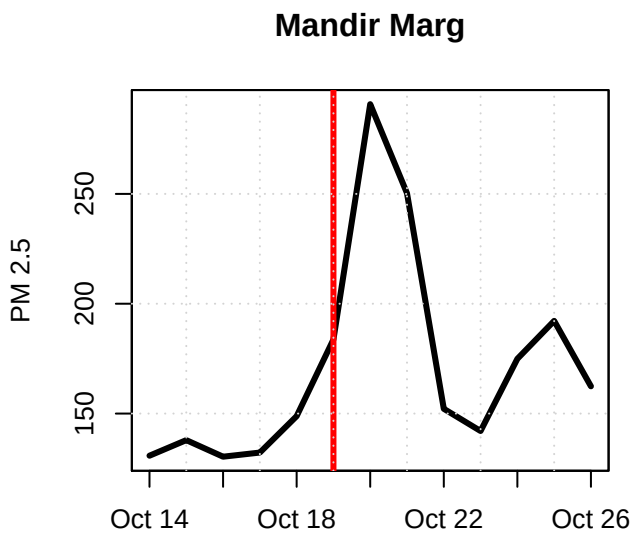
	PM2.5 Concentration		
	Diwali=t	Diwali=t-1:t+1	Diwali=t-1:t+2
	(1)	(2)	(3)
Diwali	-3.72	98.68	134.7
	[−0.177]	[8.469***]	[13.181***]
Chanakyapuri*Diwali	17.27	−75.878	−87.03
	[0.638]	[−5.10*]	[−6.69***]
Mandir Marg*Diwali	73.08	−67.94	−66.84
	[2.61***]	[−4.45***]	[−4.97***]
Punjabi Bagh*Diwali	65.63	-49.03	−52.25
	[2.37***]	[−3.25***]	[−3.94***]
R K Puram*Diwali	63.35	-54.23	-67.09
	[2.29**]	[-3.58***]	[-5.05***]
Month FE	Yes	Yes	Yes
Location FE	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes
Observations	118,847	118,847	118,847
R^2	0.26	0.26	0.27
Note:		*p<0.1; **p<0.05; ***p<0.01	

The Diwali effect

- The average particulate matter is is 99 mg/m3 higher (2 day period), and 135 mg/m3 higher (3 day period)
- This is 28 percentage points higher on a mean of approx. 350
- The Diwali effect is lower in other other locations relative to Anand Vihar
- For instance, Diwali adds on an average 69.35 (73.07-3.72) mg/m3 PM2.5 particulate matter in air at Mandir Marg relative to Anand Vihar.

Diwali, 2017


Anand Vihar
PM 2.5
200
250
300
350
Oct 14
Oct 18
Oct 22
Oct 26


Mandir Marg
PM 2.5
150
200
250
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Oct 18
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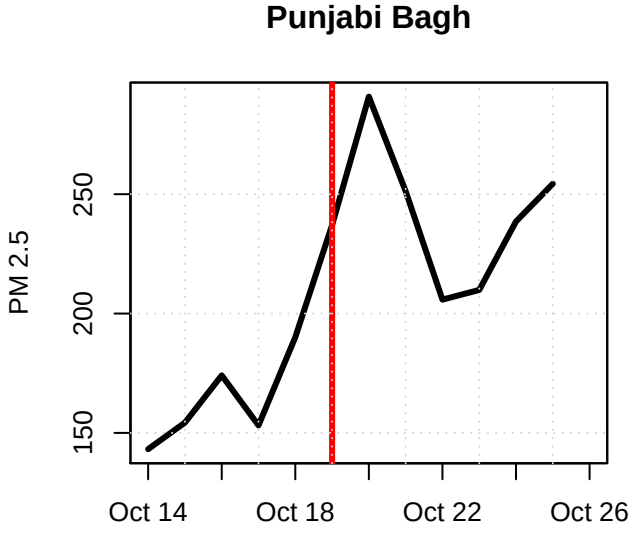
Oct 26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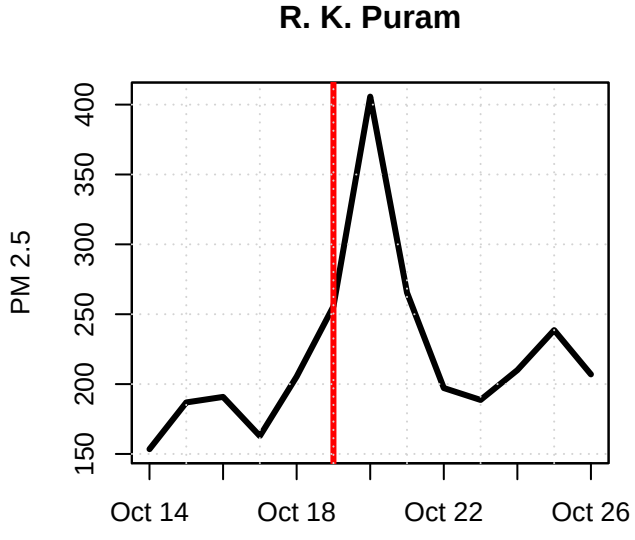
R. K. Puram
PM 2.5
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200
250
300
350
400
Oct 14
Oct 18
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Other sources

Thank you