Evaluating the Odd-Even Policy's Impact on Air Quality in Delhi

A CAUSAL STUDY

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INTRODUCTION

- Delhi's air quality crisis has led to innovative policy interventions, one of which is the odd-even traffic policy.
- Implemented from November 4th to 15th, 2019, this policy restricts vehicle usage based on the last digit of their license plates—odd-numbered vehicles on odd dates and even-numbered vehicles on even dates, active from 8 am to 8 pm.
- The efficacy of such policies is often debated, and this study aims to provide empirical evidence on their immediate impact on particulate matter ($PM_{2.5}$) levels.
- Understanding the policy's impact is pivotal for urban environmental planning and can guide future decisions on traffic regulation and pollution control.

METHODOLOGY

- To evaluate the policy's impact, a robust Difference-in-Differences (DiD) method, was employed.
- Our dataset comprises daily observations of PM2.5 from multiple monitoring stations across Delhi and its neighboring cities, including Ghaziabad, Noida, Faridabad, and Gurugram. The treatment group includes data from areas where the policy was enforced in Delhi, while the control group includes data from areas outside the policy’s scope in the neighboring cities.
- The model controls for both linear and non-linear time trends to capture the underlying pattern of PM2.5 levels. Interaction terms between treatment and post-policy indicators allow us to isolate the policy's impact from other temporal effects.
- Statistical analysis was conducted using robust standard errors to account for potential heteroskedasticity in the regression models.

ROBUSTNESS CHECKS

- Placebo Test Overview(Fake Treatment): To further validate the specificity of our findings, a placebo test was conducted using alternate regions where the odd-even policy was not implemented. Ghaziabad and Noida were treated as the 'fake treatment' group, while Faridabad and Gurugram formed the control group.

- The treatment interaction term was not statistically significant ($p = 0.953$), indicating that in regions not affected by the policy, no significant changes in PM2.5 levels were observed due to the fake treatment.

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	217.3775	8.757	24.823	0.000	200.214	234.541
treated	-0.8653	5.482	-0.158	0.875	-11.610	9.879
post	-48.5233	28.917	-1.678	0.093	-105.200	8.153
days	-3.3755	0.242	-13.923	0.000	-3.851	-2.900
days_squared	0.0212	0.002	13.650	0.000	0.018	0.024
treatment_interaction	1.4846	24.995	0.059	0.953	-47.504	50.473
post_days	14.9179	2.784	5.358	0.000	9.461	20.375
diwali	81.7725	18.625	4.390	0.000	45.268	118.277

ROBUSTNESS CHECKS

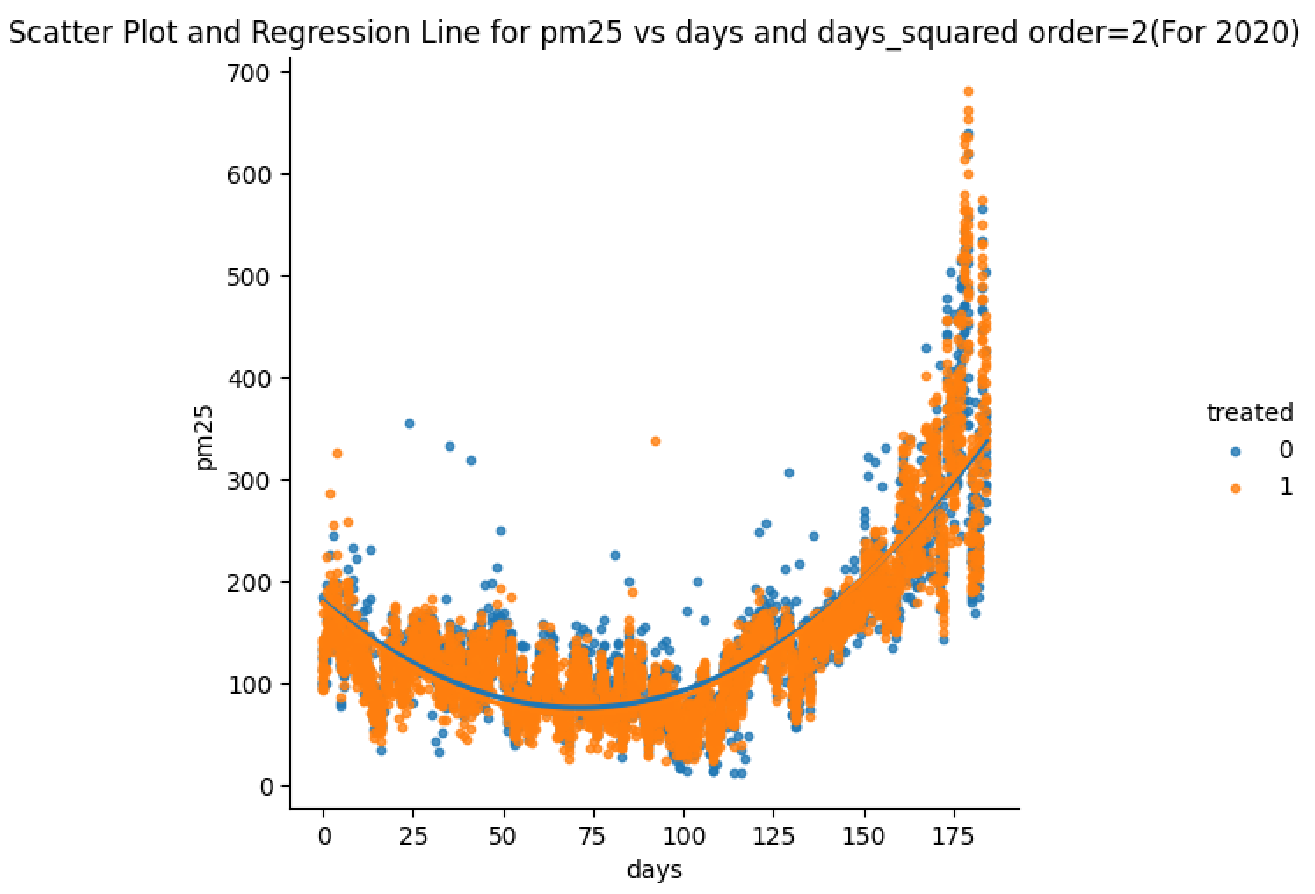
- Placebo Test Overview(Fake Outcome): A placebo test using data from the same period a year after the policy implementation showed significant effect.

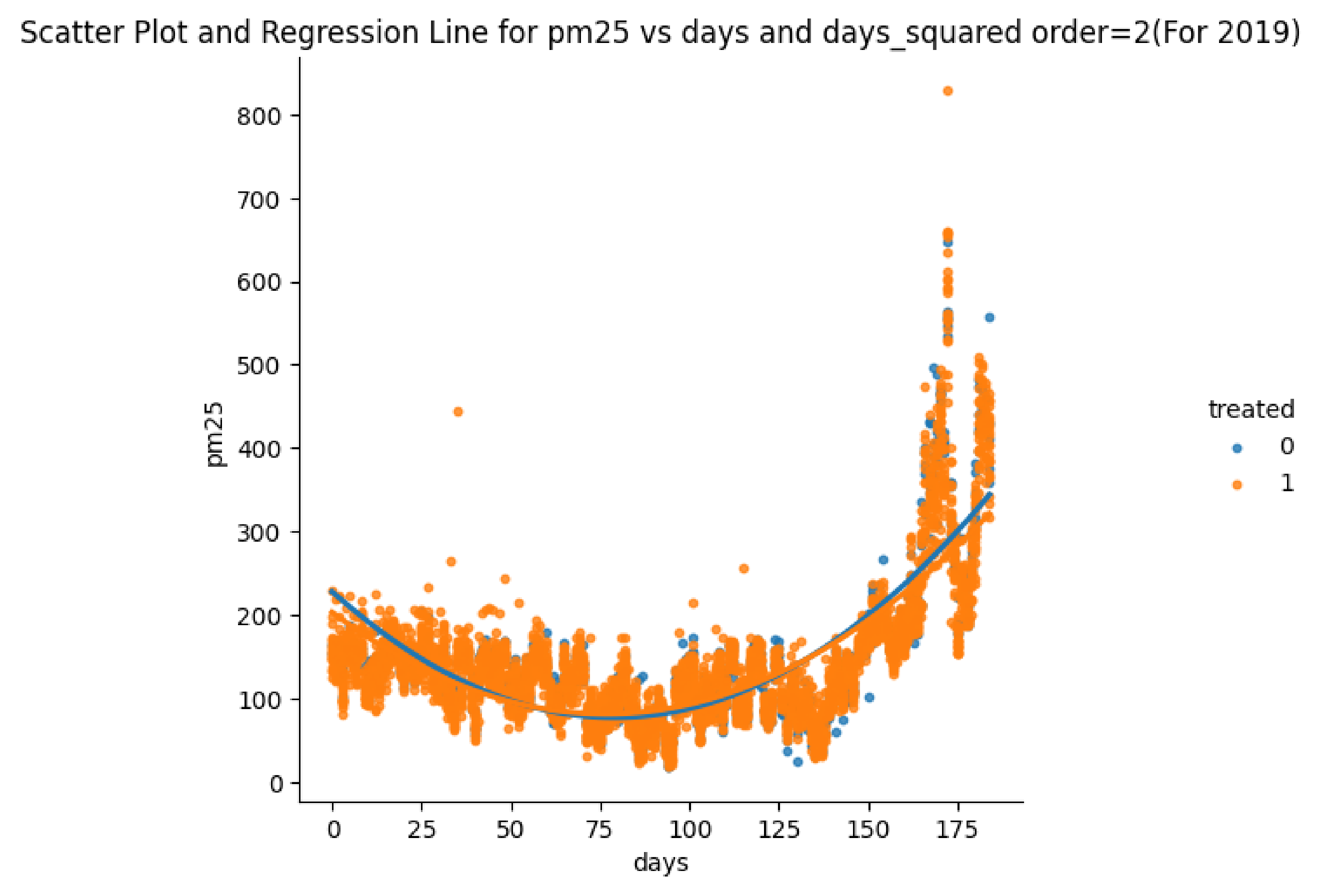
- The observed statistical significance during the placebo period could be influenced by increased cracker bursting in the treatment region (Delhi) during Diwali. This festival, known for its heightened use of fireworks, can significantly affect air quality, potentially explaining the overlap with significant treatment interaction effects.

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	169.0964	1.497	112.920	0.000	166.161	172.031
treated	-4.3501	0.896	-4.855	0.000	-6.106	-2.594
post	108.3834	8.201	13.216	0.000	92.309	124.457
days	-2.4610	0.038	-64.145	0.000	-2.536	-2.386
days_squared	0.0172	0.000	75.358	0.000	0.017	0.018
treatment_interaction	17.1370	9.555	1.793	0.073	-1.591	35.865
post_days	-6.2727	1.040	-6.034	0.000	-8.310	-4.235
diwali	7.9925	2.332	3.428	0.001	3.423	12.563

EVALUATING THE PARALLEL TRENDS ASSUMPTION

- The comparison of PM2.5 trends from 2019 (treatment year) and 2020 (non-treatment year) demonstrates a key prerequisite for our Difference-in-Differences approach. The quadratic regression lines for both years follow a similar trajectory before policy implementation, suggesting that the underlying trend in air pollution is consistent across treated and untreated groups. This visual similarity supports the parallel trends assumption, which is critical for attributing any post-treatment effects in PM2.5 levels to the odd-even policy impact.





DISCUSSION

- Policy Impact: The 'treatment_interaction' term, representing the effect of the odd-even policy, shows a marginally significant negative coefficient ($p = 0.074$). This suggests a potential reduction in PM2.5 levels due to the policy, although the significance is borderline.
- Temporal Trends: The coefficients for 'days' and 'days_squared' indicate a quadratic time trend, reflecting the non-linear nature of changes in PM2.5 levels over time.
- Diwali Effect: A substantial increase in PM2.5 levels during Diwali is observed, highlighting the significant impact of festival-related activities on air quality.

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	200.6505	3.141	63.880	0.000	194.494	206.807
treated	-2.3692	2.110	-1.123	0.262	-6.505	1.767
post	-37.1752	12.460	-2.984	0.003	-61.597	-12.754
days	-2.9135	0.090	-32.328	0.000	-3.090	-2.737
days_squared	0.0187	0.001	30.115	0.000	0.017	0.020
treatment_interaction	-17.0854	9.574	-1.785	0.074	-35.849	1.678
post_days	15.2703	1.207	12.649	0.000	12.904	17.636
diwali	70.6362	7.523	9.390	0.000	55.892	85.381

CONCLUDING OBSERVATIONS

- Summary of Findings: Our comprehensive analysis, utilizing a Difference-in-Differences (DiD) model, suggests a marginally significant reduction in $PM_{2.5}$ levels in Delhi attributable to the odd-even traffic policy. The analysis highlights the policy's potential effectiveness in mitigating air pollution. Key factors like the Diwali festival and temporal trends play a critical role in influencing air quality.

- Future Directions: To bolster the robustness of our conclusions, future work will involve exploring alternative model specifications. This includes addressing potential autocorrelation and multicollinearity, and incorporating additional control variables to account for other factors influencing air quality.

Thank you!

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