Evaluation of the Effects of the 15-day Odd-Even Scheme in Delhi: A Preliminary Report

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Introduction

The Odd-Even rule was implemented in Delhi from 1st January 2016 to 15th January 2016. During this period only odd numbered passenger cars were allowed to ply on odd days and even numbered cars on even days between 08:00 and 20:00 hours. The rule did not apply on Saturdays and Sundays and the following vehicles were exempted: all taxis, passenger cars operating on CNG and electric power, cars with only women passengers, and all motorized two wheelers. All schools were closed during this period.

The study

1. This report summarises the results of the following surveys:

- Traffic speed data
- Proportion of odd and even cars on the roads
- Car occupancy
- Volume of car and motorised two-wheeler traffic

The surveys were done before, during, and after the odd-even experiment.

2. A summary of observations on pollution Delhi obtained from DelhiAirQuality.info authored by Dr. Sarath Guttikunda (http://www.delhiairquality.info).

Traffic Speed Data

Speed data were extracted for 38 origin-destination pairs using Google Maps Distance Matrix API (List of locations in Appendix 1). The API provides real time travel time between a given pair of locations, from which speeds are calculated. These data were extracted using the API every half an hour from 7AM to 10PM from 28th December 2015 to 22nd January 2016. The period covered four days before the odd-even implementation, 15 days during the implementation,

and a week after the implementation. These speed estimates are free of observer bias and allow us to present data for roads representing different traffic types and in different locations of the city.

It is more realistic to compare the speeds before and during the experiment as schools were closed during both the periods. By classifying the roads into four groups—arterial roads, inter-city roads, commercial roads, and ring roads we obtained a better idea of where the effects of the experiment were the most significant. The results of these data are shown in Figures 1-7 and Table 1.

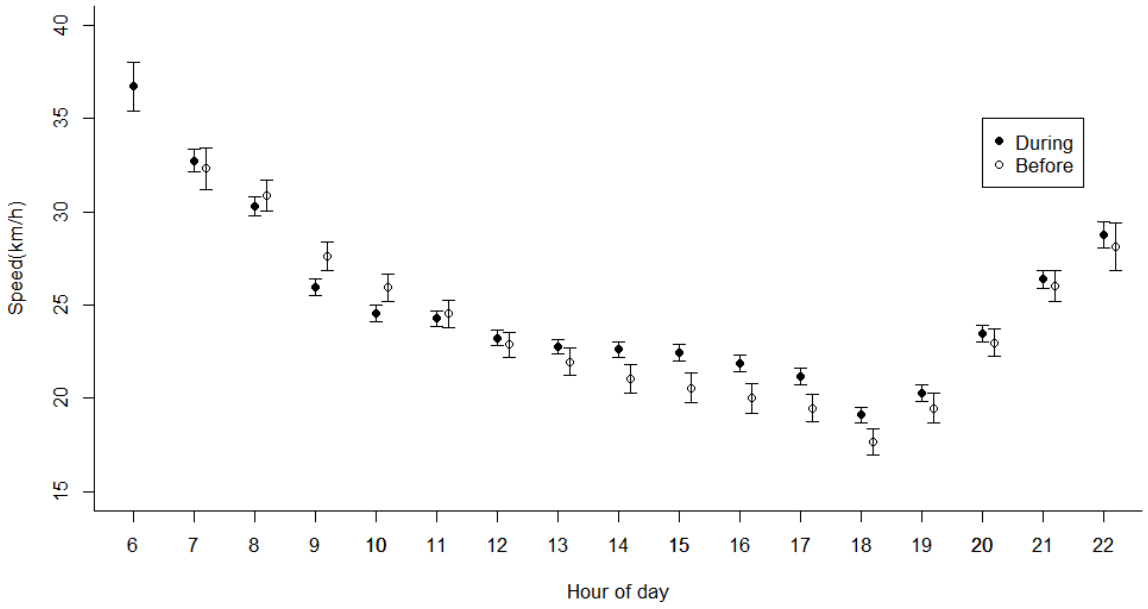

Figure 1: Hour-specific average speed showing 95% confidence intervals for speeds before and during the odd-even experiment (When the interval bars for each hour overlap, it means that the speeds are not different statistically with 95% confidence limits)

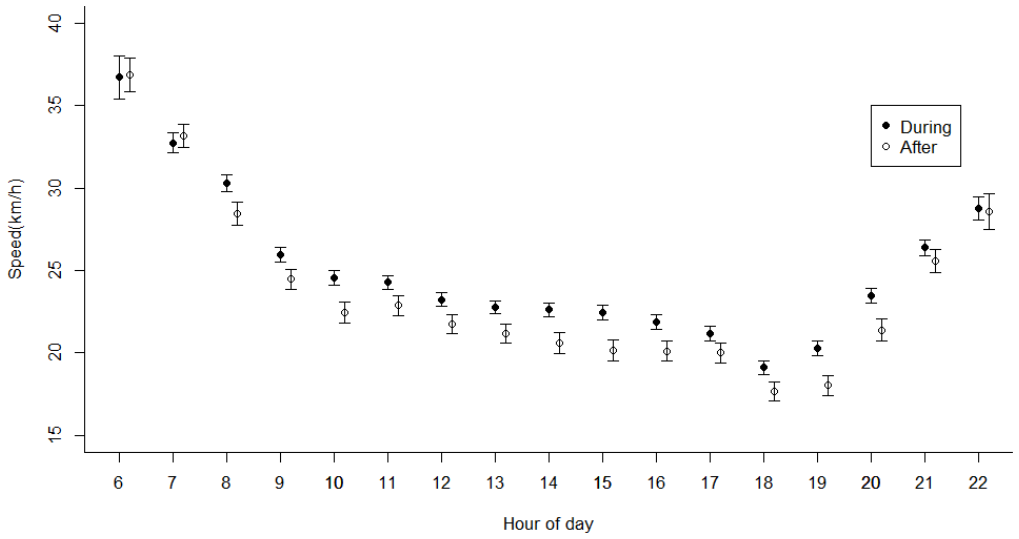

Figure 2: Hour-specific average speed showing 95% confidence intervals for speeds during and after the odd-even experiment (When the interval bars for each hour overlap, it means that the speeds are not different statistically with 95% confidence limits)

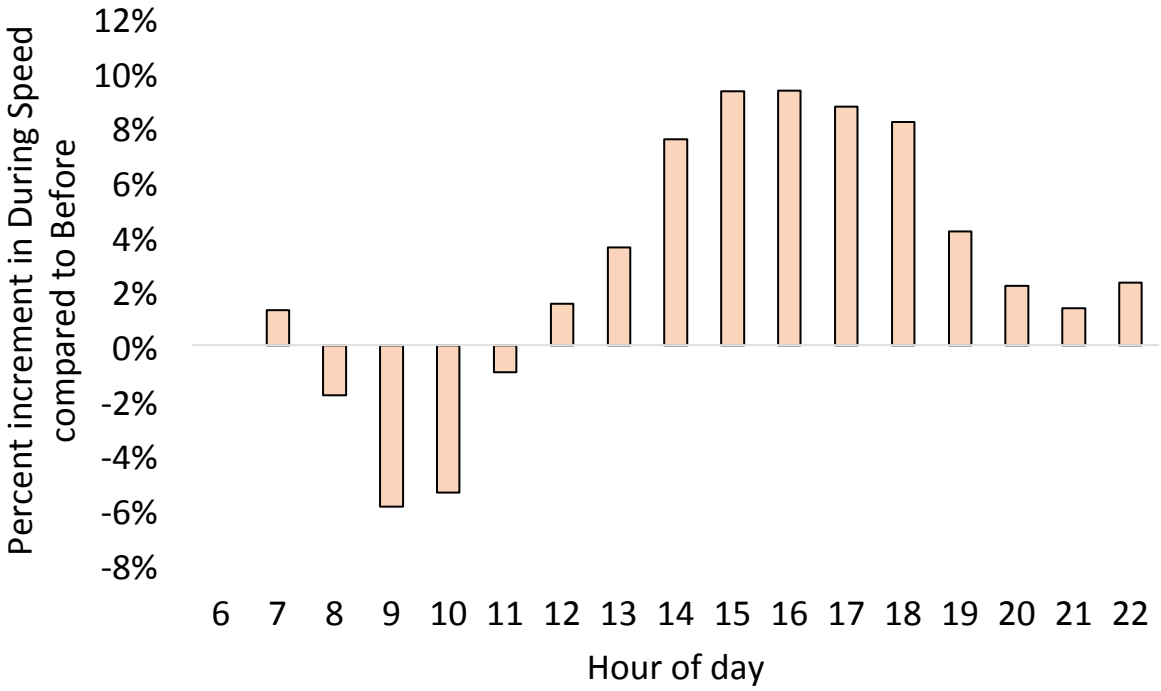

Figure 3: Percent change in average speeds during the experiment compared to speed before.

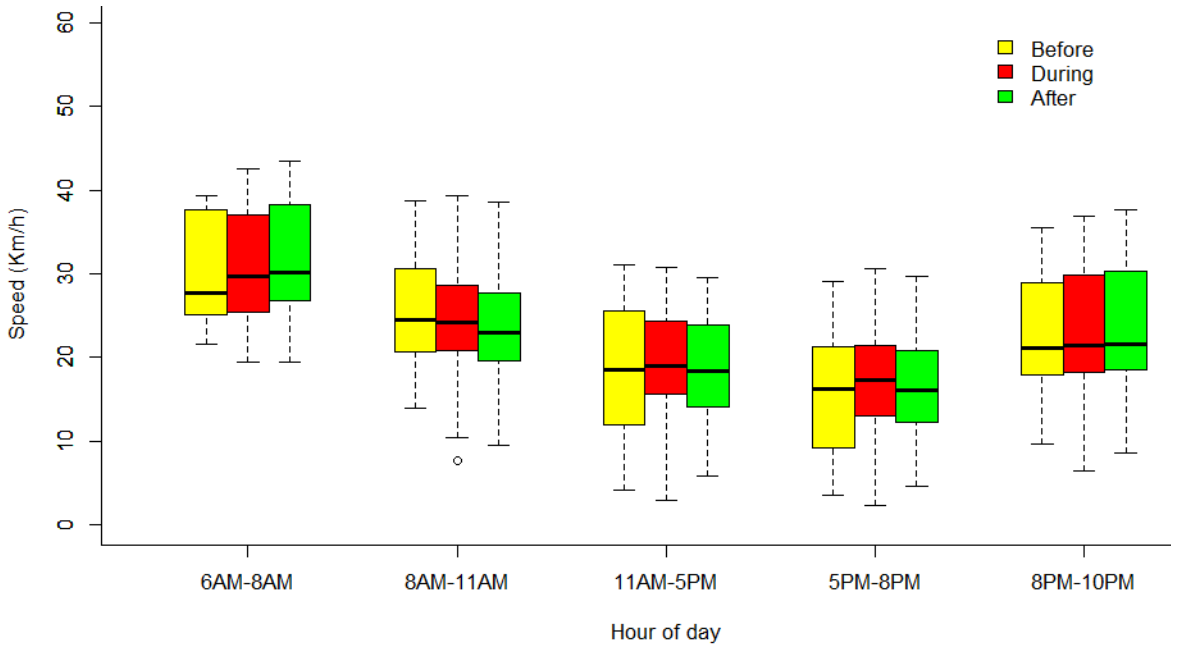

Figure 4: Box-and-whisker plots for speed during the three periods for Arterial road segments

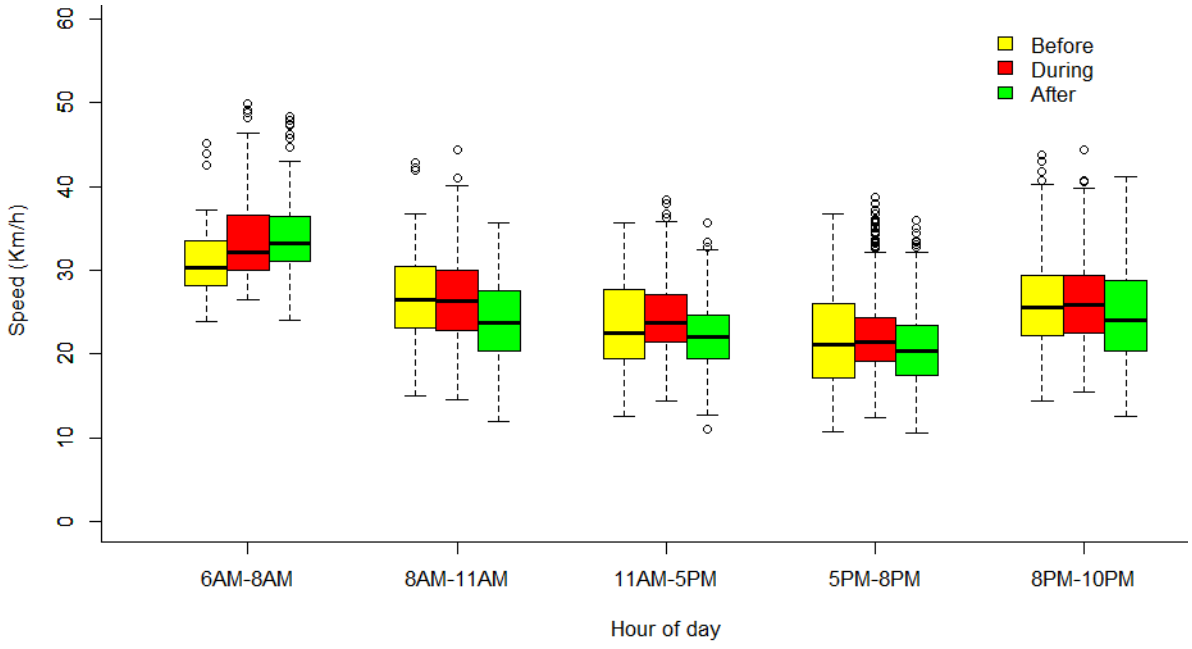

Figure 5: Box-and-whisker plots for speed during the three periods for Inter-city road segments

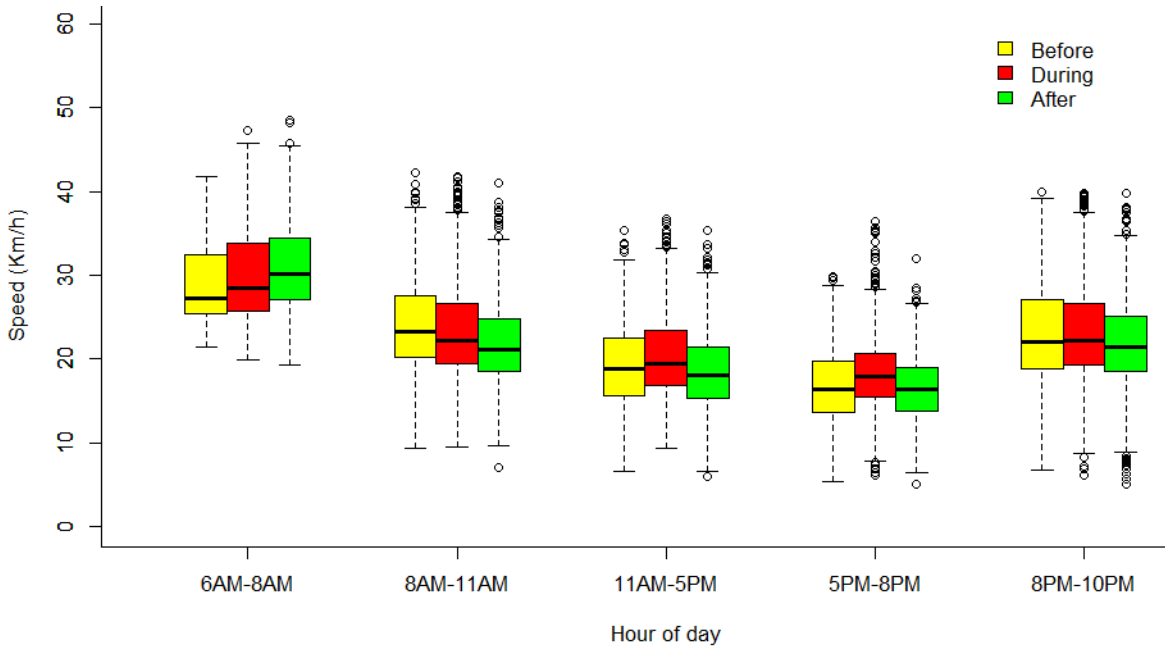

Figure 6: Box-and-whisker plots for speed during the three periods for Commercial road segments

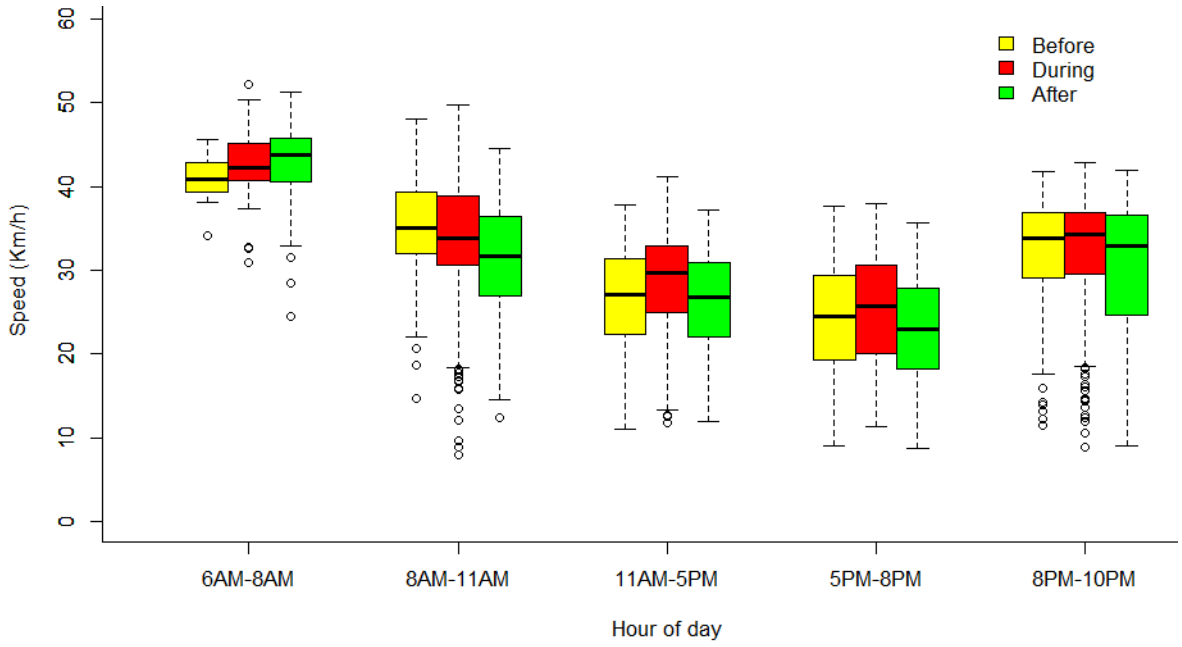

Figure 7: Box-and-whisker plots for speed during the three periods for Ring roads segments

Table 1: Average speed for the three periods

Time period	Before (Average Speed in km/h)	During (Average Speed in km/h)	After (Average Speed in km/h)	% increment in during speed compared to before	% increment in during speed compared to after
Arterial Road segments					
6AM-8AM	29	30	31.3	3%	-4%
8AM-11AM	24.3	23.1	21.9	-5%	6%
11AM-5PM	19.3	20.4	18.6	6%	10%
5PM-8PM	16.8	18.2	16.6	9%	10%
8PM-10PM	22.9	23.3	21.8	2%	7%
Inter-city Roads					
6AM-8AM	31.9	33.7	34.2	6%	-1%
8AM-11AM	26.7	26.5	23.9	-1%	11%
11AM-5PM	23.4	24.5	22.2	5%	10%
5PM-8PM	21.9	22.5	21	3%	7%
8PM-10PM	26.4	26.3	25	0%	5%
Commercial Road segments					
6AM-8AM	30.3	30.9	32	2%	-3%
8AM-11AM	25.6	24.9	23.9	-3%	4%
11AM-5PM	18.4	19.5	18.6	6%	5%
5PM-8PM	15.9	17.3	16.6	9%	4%
8PM-10PM	22.4	23.3	23.7	4%	-2%
Ring road segments					
6AM-8AM	41.2	42.6	43.2	3%	-1%
8AM-11AM	35.2	33.8	31.1	-4%	9%
11AM-5PM	26.7	28.6	26.2	7%	9%
5PM-8PM	23.9	25.4	22.8	6%	11%
8PM-10PM	32.1	32.4	30.4	1%	7%

These results may be summarised as follows:

- **Average speeds decreased by a small amount during the experiment period in the 08:00-11:00 period in most locations.**
- **There was a slight increase in average speeds between 11:00-17:00 during the experiment period. The maximum increase in average speeds was 9 per cent during the experiment as compared to the before period in a few locations. However, in most locations the change in speeds was less than 5%.**
- **The effect on the experiment was less on the inter city roads**
- **Details indicate that the effect of increase in speeds was slightly more on South Delhi roads during the experiment.**

Proportion of odd and even cars

Observational surveys were carried out at four locations—Jia Sarai at Outer ring road (JAS), South-ex at Ring road (SOX), Sai Mandir at Khel Gaon Marg (SAM), and Income Tax Office at Vikas Marg (ITO). The surveys consisted of videography for traffic volume, manual observation for odd and even numbered cars (200 cars at each location), and manual observations for occupancy of cars (100 cars at each location).

Using observational surveys, we counted the number of cars under odd and even categories Table presents odd-even split for time periods classified as before (December), odd cars days (1, 3, 5, and 7 Jan) and even car days (2, 4, 6, and 8 Jan).

Table 2: Odd-even split

Location	Before			During Odd Car Days			During Even Car Days		
	Odd	Even	Total	Odd	Even	Total	Odd	Even	Total
JAS	49%	51%	100%	77%	23%	100%	25%	75%	100%
SOX	48%	52%	100%	71%	29%	100%	24%	76%	100%
SAM	51%	49%	100%	77%	23%	100%	23%	77%	100%
ITO	52%	48%	100%	81%	19%	100%	20%	80%	100%
AVERAGE	50%	50%	100%	76%	24%	100%	23%	77%	100%

The data in Table 2 show that:

- **On both odd and even days about 30% of the vehicles not with the appropriate number were on the roads probably due to exemptions and partly due non-compliance (the 30% value is equivalent in numbers to 24% presence of wrong numbered cars).**
- **These data show that the odd-even policy did not reduce car use by 50% but by 35%**

Car occupancy

The occupancy of cars (number of occupants in the car including the driver) was observed to evaluate the effect of car use during odd-even policy. Figure 7 presents time series of average car occupancy at the four locations and Table 3 the average occupancy of cars.

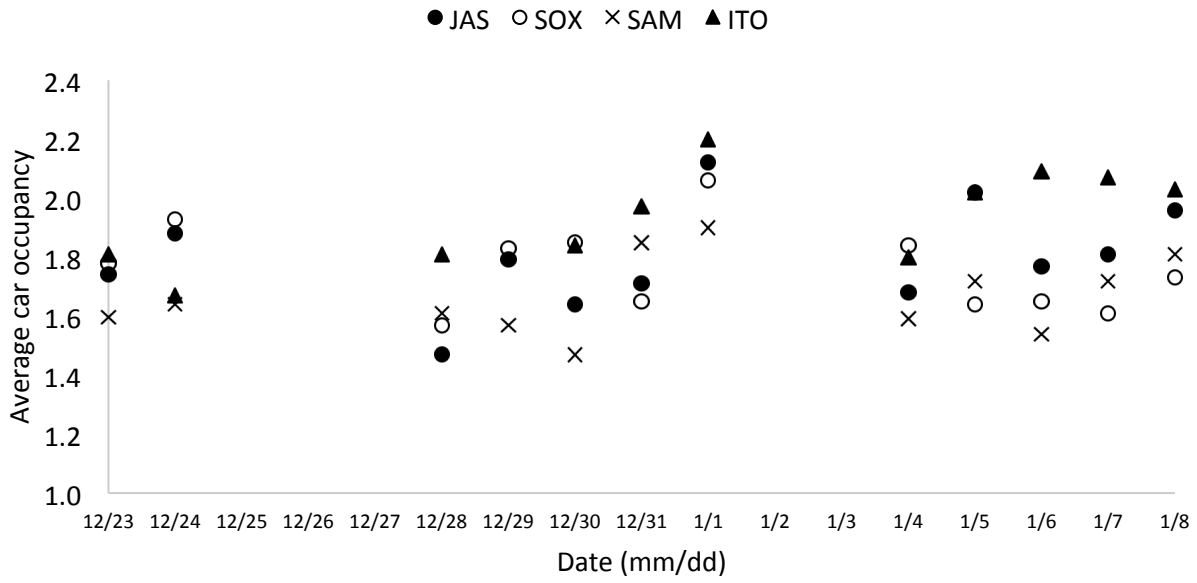

Figure 7: Time series of average car occupancy at the four locations

Table 3: Average occupancy of cars at four locations

Time period	JAS	SOX	SAM	ITO
Before	1.71	1.77	1.62	1.82
During	1.89	1.76	1.71	2.04

The above data show that car occupancy change varied from no change at one location to a maximum of 12 % increase at one location.

Traffic volume on roads

Traffic was recorded on video cameras at four locations (Jia Sarai, Sai Mandir, South Extension and ITO) before and during the experiment. Videographic analysis was done to analyse traffic flow at the four locations.

Figure 8 shows the results. During the experiment:

a. Bus flow per hour increased by 16%,11% & 5 % for Sai Mandir, ITO & South Extension respectively, whereas it decreased by 5% at Jia Sarai.

b. Car flow per hour decreased by 9%, 12%, 9 % & 17% for Sai Mandir, ITO ,South Ex & Jia Sarai respectively.

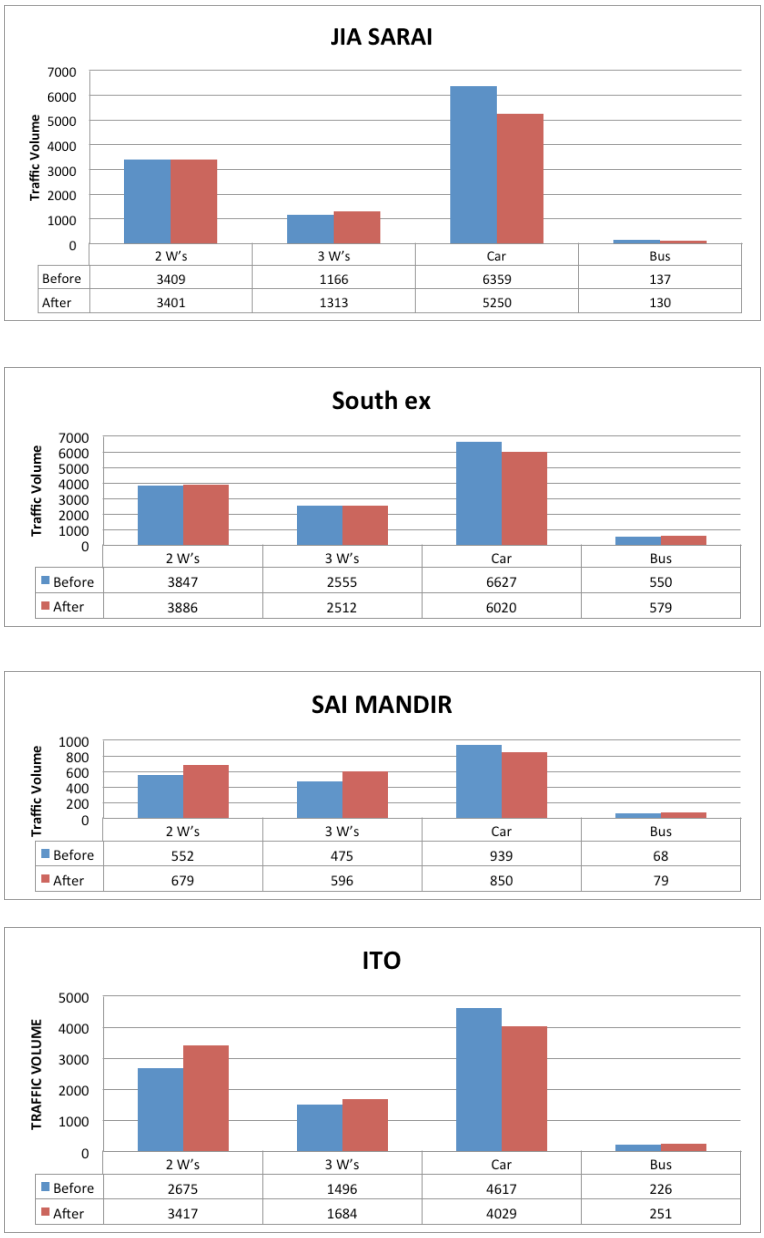

Figure 8. Traffic volume of motorized two-wheelers (2W's), auto-rickshaws (3 W's), cars and buses at four locations in Delhi before and during the odd-even experiment ('After' in figures represent volumes during the experiment)

c. 3 Wheeler flow increased by 25%, 12%, & 12 % at Sai Mandir, ITO, & Jia Sarai respectively. It decreased by 2 % at South Extension.

d. Motorised two-wheeler flow increased by 23%, 28% and 1% at Sai Mandir, ITO and South Extension respectively and decreased by 1% at Jia Sarai.

- **The above data show that during the odd even experiment car flow rates per hour on different roads decreased by 9%-17% in parallel with approximately similar increases in bus flow and auto rickshaw rates and significant increases in motorised two wheeler flow rates.**
- **Increases in flow of all vehicles other than cars will offset the decrease in emissions form cars.**
- **Significant increase in motorised two-wheeler flow can have the effect of increase in deaths and serious injuries as these vehicles are much more hazardous for their occupants than all the other vehicle modes.**

Delhi Metro ridership

We obtained time series of daily ridership of Delhi metro for the period of 25th December to 7th January for 2014-2015 as well as 2015-2016 (see 4). During these time periods, no new lines were added. The two time series excluding Saturdays and Sundays as well as 1st of January are shown in Figure 9.

An average ridership of December 2014 excluding Saturdays and Sundays is 2,385,391 and January 2015 (also excluding 1st Jan) is 2,490,128. The latter is 4.3% higher than the former. An average ridership of December 2015 excluding Saturdays and Sundays is 2,653,245 and January 2016 (also excluding 1st Jan) is 2,764,872. The latter is 4.2% higher than the former, which is interestingly the same proportion as 2014-2015. Thus, there is almost no difference between the per cent growth in the ridership from 2015 to 2016 and that of 2014 to 2015. This indicates the increase in the ridership of metro during the first week of January 2016 can be independent of odd-even implementation.

Table 4: Daily ridership of Delhi metro

	2014-2015			2015-2016		
Date	**Year**	**Day**	**Daily Ridership**	**Year**	**Day**	**Daily Ridership**
25-Dec	2014	Thursday	1,959,439	2015	Friday	2,149,450
26-Dec	2014	Friday	2,356,548	2015	Saturday	2,278,019
27-Dec	2014	Saturday	2,178,984	2015	Sunday	1,924,321
28-Dec	2014	Sunday	1,729,736	2015	Monday	2,714,131
29-Dec	2014	Monday	2,405,278	2015	Tuesday	2,657,639
30-Dec	2014	Tuesday	2,400,452	2015	Wednesday	2,615,801
31-Dec	2014	Wednesday	2,379,287	2015	Thursday	2,625,408
1-Jan	2015	Thursday	2,507,332	2016	Friday	2,536,306
2-Jan	2015	Friday	2,141,105	2016	Saturday	2,402,183
3-Jan	2015	Saturday	2,235,931	2016	Sunday	1,927,761
4-Jan	2015	Sunday	2,060,970	2016	Monday	2,847,800
5-Jan	2015	Monday	2,679,465	2016	Tuesday	2,774,052
6-Jan	2015	Tuesday	2,621,409	2016	Wednesday	2,733,165
7-Jan	2015	Wednesday	2,518,532	2016	Thursday	2,704,472

Figure 9: Time series of daily metro ridership

These data indicate that implementation of odd-even experiment on its own may not have had any significant effect on metro ridership as there were similar increases for end of December 2014 to beginning January 2015.

Effect on Pollution

The data in this section and comments are obtained from DelhiAirQuality.info authored by Sarath Guttikunda (http://www.delhiairquality.info).

The estimated contribution of different category of vehicles to PM2.5 emissions is given below.

Estimated relative contribution to PM 2.5 emissions					
Motorised two wheelers	4-wheelers	3-wheelers	Buses	Light duty trucks	Heavy duty trucks
9%	16%	1%	10%	29%	34%

The modelled annual source contribution from all sources is given in Figure 10. These statistics suggest that the theoretical reduction in PM2.5 by the odd-even experiment cannot exceed 15% of 22.5%, that is less than 4% of PM2.5 emissions.

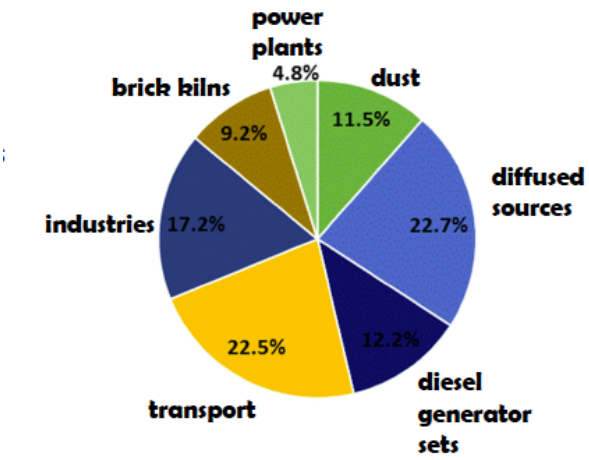

Figure 10. Modelled annual PM 2.5 source contribution in Delhi

The combined PM2.5 emissions of buses, three-wheelers and motorised two-wheelers is estimated to be 20% of the transport sector compared to cars that contribute an estimated 16%. In light of the fact that increase in flow of buses, three wheelers and motorised two wheelers seems to be of a similar magnitude as the decrease in car flow, the effect of decrease in PM2.5 emissions by cars would be even less. It is

possible that the decrease in emissions from cars may be offset by an increase in flow of other vehicles

Dr. Guttikunda sates that the benefits of the program on the day time air quality was not immediately apparent in the ambient measurements, with likely large interference from meteorology. Further, it appears that data from 6 DPCC stations is not enough to analyse the benefits of such interventions on air quality, and at least 20 stations are needed for reliable analysis.

Conclusions

Vehicle speeds

- Average speeds decreased by a small amount during the experiment period in the 08:00-11:00 period in most locations.

- There was a slight increase in average speeds between 11:00-17:00 during the experiment period. The maximum increase in average speeds was 9 per cent during the experiment as compared to the before period in a few locations. However, in most locations the change in speeds was less than 5%.

- The effect on the experiment was less on the inter city roads

- Details indicate that the effect of increase in speeds was slightly more on South Delhi roads during the experiment.

Cars on the road

- On both odd and even days about 30% of the vehicles not with the appropriate number were on the roads probably due to exemptions and partly due non-compliance (the 30% value is equivalent in numbers to 24% presence of wrong numbered cars).
- These data show that the odd-even policy did not reduce car use by 50% but by 35%.

Car sharing

- The data show that car occupancy change varied from no change to a maximum of 11 % increase at one location.
- Therefore, it appears that there was a very small increase in car sharing.

Traffic volume on roads

- The above data show that during the odd even experiment car flow rates per hour on different roads decreased by 9%-17% in parallel with approximately similar increases in bus flow and auto rickshaw rates and significant increases in motorised two wheeler flow rates.
- Increases in flow of all vehicles other than cars will offset the decrease in emissions form cars.
- Significant increase in motorised two-wheeler flow can have the effect of increase in deaths and serious injuries as these vehicles are much more hazardous for their occupants than all the other vehicle modes.

Metro ridership

- Ridership in early January in 2015 was higher than December 2104 by a similar amount as the increase in early January 2016 as compared to late December 2015. This indicates the increase in the ridership of metro during the first week of January 2016 can be independent of odd-even implementation.

Emissions

- The benefits of the program on the day time air quality was not immediately apparent in the ambient measurements, with likely large interference from meteorology.
- Data from 6 DPCC stations is not enough to analyse the benefits of such interventions on air quality, and at least 20 stations are needed for reliable analysis.

- The combined PM2.5 emissions of buses, three-wheelers and motorised two-wheelers is estimated to be 20% of the transport sector compared to cars that contribute an estimated 16%. In light of the fact that increase in flow of buses, three wheelers and motorised two wheelers seems to be of a similar magnitude as the decrease in car flow, the effect of decrease in PM2.5 emissions by cars would be even less. It is possible that the decrease in emissions from cars may be offset by an increase in flow of other vehicles

Appendix 1

Details of road stretches for which speed data was extracted from Google Maps API

Stretch name	Road Name	Road type
Press Enclave to IIT Gate	Aurobindo Marg	Arterial
IIT gate to AIIMS	Aurobindo Marg	Arterial
AIIMS to Safdarjung Tomb	Aurobindo Marg	Arterial
Safdarjung Tomb to AIIMS	Aurobindo Marg	Arterial
AIIMS to IIT Gate	Aurobindo Marg	Arterial
IIT Gate to Press Enclave Road	Aurobindo Marg	Arterial
IIT Hostel to Bhikaji	Africa Avenue	Arterial
Bhikaji CAMA to IIT Hostel	Africa Avenue	Arterial
Safdarjung to Nila Gumbad	Lodhi Road	Arterial
Nila Gumbad to Safdarjung	Lodhi Road	Arterial
Outer ring to Sai Mandir	August Kranti Marg	Arterial
Sai Mandir to Outer Ring	August Kranti Marg	Arterial
Outer Ring to Teen Murti	Rao Tula Ram Marg	Arterial
Teen Murti to Outer Ring	Rao Tula Ram Marg	Arterial
Aurobindo Marg to BRT	Press Enclave Road	Arterial
BRT to Aurobindo Marg	Press Enclave Road	Arterial
Ring Road to Ghazipur Drain	Vikas Marg	Inter-city
Ghazipur Drain to Ring Road	Vikas Marg	Inter-city
Sarita Vihar to Ring Road	Mathura Road	Inter-city
Ring Road to Sarita Vihar	Mathura Road	Inter-city
Dhaula Kuan to 11 Murthi	Sardar Patel Marg	Inter-city
11 Murthi to Dhaula Kuan	Sardar Patel Marg	Inter-city
Kharak Singh Marg to State Entry road	Connaught Place (CP) Outer Circle	Commercial
State entry to Barakhambha	Connaught Place Outer Circle	Commercial
Barakhambha to Sansad	Connaught Place Outer Circle	Commercial
India Gate to Gole Dak Khana	Ashoka Road	Commercial
Gole Dak Khana to India Gate	Ashoka Road	Commercial
Ashoka road to Akbar road	India Gate Circle	Commercial
Mandi House to CP	Barakhambha Road	Commercial
CP to Mandi house	Barakhambha Road	Commercial
Capital Court to IIT Gate	Outer Ring Road	Ring roads
IIT Gate to Capital Court	Outer Ring Road	Ring roads
IIT Gate to Nehru Place	Outer Ring Road	Ring roads
Nehru Place to IIT Gate	Outer Ring Road	Ring roads
Dhaula Kuan to AIIMS	Ring road	Ring roads
AIIMS to Dhaula Kuan	Ring road	Ring roads
AIIMS to Mathura road	Ring road	Ring roads
Mathura road to AIIMS	Ring road	Ring roads