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Supplementary Materials for

Citywide effects of high-occupancy vehicle restrictions: Evidence from "three-in-one" in Jakarta

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Citywide Effects Of High-Occupancy Vehicle Restrictions:
The Elimination Of "Three-In-One" In Jakarta

Supplementary Materials for Online Publication

Rema Hanna, Gabriel Kreindler, and Benjamin A. Olken

Materials and Methods

1. Additional Information on Policy Setting

Rising incomes in many developing and emerging nations has led to a dramatic increase in car ownership: in Jakarta, the number of registered passenger cars doubled between 2004 and 2014, from 1.64 to 3.26 million vehicles (*21*). Much of the travel throughout the city is on the roads, as the city has no subway or light rail system, and only a very limited commuter rail network. In particular, the commuter rail network carries 224 million passengers per year in the Jabodetabek region, compared to 961 million per year by the Delhi metro, 1.7 billion on the New York subway (*22-24*)

As incomes rise, cars are also more likely to carry fewer passengers. In Jakarta, from 1985 to 2000 the average private car occupancy rate went from 1.96 to 1.75 (*25*).

In response to heavy traffic, the Jakarta government instituted the "three-in-one" policy in March 1992. Initially, the policy only applied in the morning, between 6AM and 10AM between Monday and Friday. In December 2003, the Jakarta government changed the regulation to include the evening peak, the operating hours changed to 7-10AM and 4:00-7PM, cars henceforth required 3 or more passengers to be present in the car *at any point* on the restricted roads, and enforcement of the policy was improved (*26*). The evening hours were changed to 4:30-7PM in September 2004, and from 2004 to 2016 there were no changes in the system. Disobeying the three-in-one rule fell under disobeying road signs, with a maximum fine of IDR 500,000 (approximately USD

37.5) or 2 months in prison (*27-28*).

In late March 2016, the Jakarta government announced that the three-in-one policy would be temporarily lifted. This surprise announcement was motivated by an unrelated development, where the Jakarta police uncovered a ring of beggars that drugged children (*29*). The focus soon moved to mother jockeys and their infant children standing by the roadside, prompting Jakarta Governor Basuki Purnama (also known as Ahok) to denounce the three-in-one policy on March 29, 2016 and announce that it would be lifted effective 7 days later, for a one-week trial period. (*30*) The initial one week trial was first extended for another month and then the policy was permanently scrapped on May 10, 2016 (For the extension see *31;* regarding the permanent removal of three-in-one see *32*).

2. Additional Information on Data Collection

Our primary data on traffic congestion levels comes from Google Maps, specifically from repeated queries we made to the Google Maps Distance Matrix API. We obtain two types of data from the Google Maps system for our selected routes. The "live" data is obtained by setting the desired trip departure time to "now" at the time when the query is made through the Google Maps Distance Matrix API. This captures current travel conditions based on real-time reporting of traffic conditions from Android smartphone users, and is intended for real-time navigation. These queries were made every 10 minutes, with the exception of Thursday March 31, Friday April 1, and May 1-8, when the queries were made every 20 minutes.

The "predicted" data collected from the Distance Matrix Google Maps API captures typical travel time on a given day of the week and at a particular time of the day, based on historical data captured by Google. Specifically, for this type of query, we set the departure time on a particular time of day and day of the week, but on a distant date several weeks in the future. Since the date is far in the future, this estimate incorporates all historical averages, but no real-time data.

The "predicted" business-as-usual traffic numbers are indeed accurate forecasts of traffic conditions prior to the three-in-one lifting, and also appear to be very stable over time. In particular, this means that "predicted" queries made after the policy was lifted continue to accurately represent the pre-policy lifting counterfactual. Details of the timing of the "predicted" business usual queries are as follows. During the first stage of data collection, the departure date for predicted queries was chosen between April 18 and April 20 for weekdays, and May 21-22 for weekend. The queries themselves were made both before and after the lifting of the policy, between April 3 and April 12. During the second stage of data collection, the departure date for predicted queries was chosen between May 16 and 22. The queries were made on May 2, 3 and 4.

Figure S6 shows using the first stage of data collection that predicted delay changes very slowly as a function of the date of the query. Predicted delay is virtually identical in queries made a few days before the lifting and one month after the policy lifting. Even during the evening peak on Jalan Sudirman, where "live" delay had been consistently higher for a period of a month, predicted delay after one month is only marginally higher than the other two lines. In other words, the algorithm used to predict typical travel times is only slowly influenced by recent developments.

For each route, we collect data on several segments along the route, and calculate delay as the total time in minutes to cover the entire route (summed up over all road segments) divided by the total length of the route in kilometers. During the second data collection phase, collected after April 28, we used route definitions recommended by the Jakarta Government Department of Transportation. During this phase, within each group of routes, namely former three-in-one routes and alternate routes respectively, we use the same procedure as above to compute the distanceweighted average delay across all routes in the group. For Jalan Sudirman, the revised route had slightly different start and end points relative to the first data collection phase. For the two alternate routes, Jalan Rasuna Said and Tentara Pelajar, the routes from the Department of Transport cover a subset of the segments that we have data for in the first phase. For consistency in the analysis, in the first phase we use the route definitions closest to the routes from the Department of Transport. If we instead use all available route segments from the first phase, we find similar results (results not shown). For the segments used in the main analysis, we also collected data on both the original and revised definitions for the three routes for an overlap period from April 28 to May 6. In Figure S7 we show that on the period of overlap, the two sets of queries agree for both the live and predicted values despite the small differences in exact origin and departure locations.

3. Validation of the Google Predicted Counterfactual

First, in Figure S1, we compare our "live" pre-period data for the former HOV road of Jalan Sudirman and its alternate roads with the predicted data. For Jalan Sudirman (Panel A), the live and predicted data track each other perfectly in the pre-period. For the alternate roads, the live and predicted data track each quite closely, except for a total of two time period-road pairs: the evening rush hour on Jalan Rasuna Said (Panel B) and the morning rush hour on Jalan Tentara Pelajar (Panel C), where in both cases the live data is slightly above the predicted.

Second, we can examine how our previous results would have looked had we used the predicted data. To do so, we can re-run Table 1, but use the predicted data rather than the live pre-data as our comparison group. Specifically, we run the regression

$$delay_{idhp} = \alpha + \beta \cdot \mathbf{1}(p = 1) + \gamma \cdot north_i + \varepsilon_{idh}$$

where $delay_{idhp}$ denotes delay on route i on date d for departure time h, and live or predicted for

$p = 0$ and $p = 1$, respectively. In the sample, we include all weekdays between April 28 and June 3 for the live data ($p = 0$), as well as the five weekdays of predicted data ($p = 1$). Once again, we restrict the departure time h in different columns of the table. Table S4 provides these results, and shows that our findings would be the same—the lifting of the three-in-one policy led to increased traffic both on the former HOV road during rush hours, but also at other hours and on the alternate roads. Altogether, this implies that the historical traffic prediction provides a valid counterfactual of the absence of the policy.

Additional Results: Robustness Checks

1. Results Disaggregated by Road Direction. In Figure S3, we disaggregate Figure 2 by North- and South-bound respectively. The results are very similar to the averaged figures. Traffic is worse after the policy is lifted in both the morning and evening rush hours on the former HOV road (Panel A), albeit the effect is most pronounced in the evening peak heading Southbound, which is consistent with slightly more residential areas being located south of the CBD than north of the CBD. Traffic is also higher in the non-rush hour periods on the former HOV road. For the alternative road of Jalan Rasuna Said (Panel B), traffic is worse in the midday period in the Northbound direction and in the midday, evening peak and evening in the Southbound direction, and otherwise the same. For the alternative road of Jalan Tentara Pelajar (Panel C), traffic is slightly worse in the evening rush hour, but clears up in the morning rush hour northbound, after the policy is lifted.

Similarly, Figure S8 shows the results from Figure 3 separately by direction. The results are similar, with a slightly more pronounced evening peak in the southbound direction.

Conversely, in the tables our main specification allows the data to be separate for North and South. Table S3 provides the same regression analysis, but using the average delay over both directions for each road. The results are virtually identical to Table 1.

2. Constraining results to comparable days. As soon as the policy experiment was announced, we began to collect data. However, this means we only have two full days of traffic data before the policy was lifted (the Friday and Monday before), as well as Thursday afternoon. This is a problem if traffic is significantly different on different days of the week, since we are comparing the pre-days of Monday and Friday with all potential weekday days after the policy change. We thus perform robustness checks holding the time periods constant.

First, for the figures, we can constrain our entire analysis to just Monday, Thursday afternoon and Fridays both pre and post the policy. As shown in Figure S9, the results are near identical. The sign and magnitude of impacts by road and time interval is very similar to Figure 2, with the exception of the mid-day off-peak on Jalan Sudirman, where we find no effect. This analysis implies that overall our findings are not driven by just having two days of pre-data.

Second, for the tables, in Table S5, we constrain the analysis to Mondays, Thursday afternoons, and Fridays (since we only have pre-data for these days and times). Again, the results are qualitatively similar—traffic is worse on the former HOV road during peak hours and is generally the same or worse at alternative times on the HOV road or on alternative roads—although we lose statistical precision in some cases due to the much smaller sample sizes. The one more substantive change in this specification is that we do not observe any impact during the mid-day off-peak on Jalan Sudirman.

3. Regression discontinuity specification

Table S6 replicates Table 1 using a regression discontinuity specification, restricting the sample to one week after the policy lifting, and including a linear control for the number of days relative to the lifting. Results are very similar to Table 1. Specifically, we use the specification

$$delay_{idh} = \alpha + \beta \cdot post_d + \gamma \cdot north_i + \delta since_d + \varepsilon_{idh}$$

where $delay_{idh}$ is the average travel delay in minutes per kilometer for segment i, on date d and for departure time h, $north_i$ is an indicator for whether segment i is northbound, $post_d$ is an indicator for dates after the lifting, and $since_d$ is the number of days since the lifting (equal to zero on April 5th 2016). β is the coefficient of interest, providing the jump in delay after the policy is lifted. The sample is restricted to dates between Thursday March 31st and Friday April 8th. Since we have fewer than 30 clusters at the level of date and road direction, we also report p-values for the coefficient on policy lifting calculated using the wild bootstrap cluster procedure (*33*). The results using this approach are similar to the results in Table 1.

4. Results in terms of Excess Delay

Our main metric focuses on *delay*, defined as the number of minutes required to move one kilometer. An alternative metric is *excess delay*, defined as the delay above and beyond the delay under free-flow condition. This alternative metric does not change the estimated treatment effects, but instead only affects the control means (and hence the percent increase). The logic of this measure is that the delay corresponding to free-flow is not affected by policies such as three-in-one. We approximate free-flow conditions using night-time delay, which is around 1.7-1.9 minutes per kilometer for all three roads. Using this metric, on Jalan Sudirman excess travel delay goes up 3.5 and 2.5 *times* during the morning and evening peak hours, respectively.

5. Estimates for another alternate route: Jalan Tentara Pelajar

In Figure S2 and Table S2 we show results for another alternate route, Jalan Tentara Pelajar, which is an artery leading into the CBD from the southwest. Note that traffic was smoother on this alternate road even during the three-in-one policy. We find a smaller but detectable increase during the evening peak and the time interval after the peak. During the morning peak, we find a decrease that is not statistically significant using the “live” counterfactual (Table S2) and a statistically significant and small increase using the “predicted” counterfactual (Table S4). Overall, these findings are in line with previously shown results, as well as the fact that we expect smaller impacts at lower baseline levels of travel delay.

6. Effects over time

We can also look more closely at how the effect changes over time. In Figures S4 and S5 we plot the average traffic delays each day, as well as the predicted travel delay, from April 28 to August 16th for the morning rush hour, the mid-day off-peak, the evening rush hour, and the hour after the evening peak. Figure S4 does so for the former HOV roads, while Figure S5 does so for the alternate routes.[1] The figures show that the effect of the policy persists over time on both the HOV and alternate roads, drops during the holiday of Lebaran (when many Jakarta residents travel to their native regions), and increases again relative to the predicted after the holidays, albeit smaller in magnitude after the holiday ends.

[1] Figures S10, S11 and S12 show the equivalent figures for Jalan Sudirman and its alternate routes from April 1 to August 16. They show similar patterns: a stark increase in traffic delays the day after the policy is lifted, followed by a continued increase in traffic, a decline in traffic during the holiday of Lebaran, and an increase again in the post period (although slightly lower in magnitude than before the holiday period).

Stylized Theoretical Models Consistent with Empirical Findings

There are several reasons why eliminating HOW restrictions could lead to a city-wide increase in congestion. Here, we formally explore two potential explanations in brief by providing simple stylized models.

1. More Cars on the Road

The most parsimonious explanation is that more people are induced to drive once the HOV restrictions are eliminated: once these people have their cars at work, they drive them at other times of day, creating more traffic. The influx of drivers on formerly restricted roads may also lead other drivers to switch away from those roads to alternate roads. The following stylized model formalizes the latter intuition in a setting where drivers optimize over travel time.

Some form of heterogeneous preferences over routes is necessary to rationalize the findings. Suppose that there was a single origin O and destination D, with two identical routes connecting them. In this setting, if drivers care in the same way about travel time on the two routes, then travel time on both routes cannot be worse after the policy lifting than travel time on the unrestricted route while the policy was in place, since the unrestricted route was always an option for all drivers. However, empirically, we find that travel times on both routes after the lifting are higher than time on the unrestricted route before the lifting; hence some type of heterogeneity is important for a change in the number of drivers to explain the results.

We therefore sketch a simple example with heterogeneity in terms of relative distances to the entry points to the two routes to show how such a model can potentially generate the results we observe. A similar argument would go through for other types of heterogeneity, for example if single car users have an idiosyncratic taste for the formerly HOV route.

Consider a configuration of roads given by Figure S13. In the model, let A_1B represent the previously restricted three-in-one road, and A_2B represents the alternate road. Commuters live uniformly distributed along the A_1A_2 line, they have a benefit $W > 0$ of commuting to B. If they travel, they decide whether to commute via A_1 or A_2 to minimize travel time. There are equal mases of two types of commuters: *carpoolers* can travel on any highway, and *single car users* can only go via A_1 if there is no restriction. (Types are fixed: we assume in this simple example that single car users cannot become carpoolers, nor vice versa.) Travel times are as follows. The time to reach A_1 or A_2 is the distance from home to each point (assume the road A_1A_2 is always uncongested). Travel time on A_iB is $T(x_i)$ where x_i is total usage of route $i = 1,2, T' > 0$. Assume without loss of generality that the distance between A_1 and A_2 is 1, and label a particular commuter by their distance to A_2.

Without restrictions, for every sufficiently large benefit W, the only equilibrium is $a = b = 0.5$, with flows $x_1 = x_2 = 1$. Figure S13 depicts the model set-up under three-in-one, for intermediate values of W. Some single car users close to A_1 will not find it worthwhile to travel because they are too far away from the unrestricted road entry A_2. Carpoolers will divide between using A_1 and A_2, with commuter b indifferent. Total flows on the two routes are $x_1 = 1 - b$ and $x_2 = a + b$. The indifference conditions that determine the cutoff points a^* and b^* are:

single car users: $a^* + T(a^* + b^*) = W$

carpoolers: $b^* + T(a^* + b^*) = 1 - b^* + T(1 - b^*) > W$

In this model, it is possible to find a configuration of values such that flows may increase on both roads after the lifting. In particular, it is possible to find cost functions T and valuations W such that all people travel in the unrestricted states, only some people travel in the restricted states, and speeds are slower on both roads in the unrestricted state. For example, for $T(x) = x$ and $W = 19/12$, it is easy to verify that the unique HOV solution is given by $a^* = 52/84$ and $b^* = 29/84$, which satisfies $a^* + b^* < 1$, but on the unrestricted route, everyone travels since the maximum cost is $\frac{18}{12} < W$. Hence in this example, in the restricted case, traffic increases on both roads when the restriction ends.

2. Hypercongestion equilibrium

Another potential explanation is that the HOV restrictions prevented hyercongestion on the targeted roads. The basic idea is that on a road with hypercongestion, a high density of vehicles tends to clog up the road, which severely limits the throughput of the road. When this happens, drivers may use alternate routes and delays may go up throughout the system. Figure S14 illustrates the logic of a simple model that makes this point.[2] A point on the X axis represents a division of the total flow between the two roads. The Y axis represents delay (inverse speed). The red (dashed) curve represents the speed-flow relationship on the unrestricted road. The blue (solid) curve represents the delay-flow relationship on the HOV restricted road, and is backward bending, so the HOV road exhibits hypercongestion for sufficiently high values of delay.

Assume that the two roads have equal length, and total flow is fixed. In equilibrium, delay on the two routes is equalized, and the flow on the two routes must sum to the total fixed flow. Under X_{HOV}, delay is low on both routes. Under the X_2 equilibirum, the HOV road has higher car density, so much so that it leads to lower flow than before, as well as higher delay. This is the hypercongestion aspect of the HOV road. The alternate road has a higher flow, and thus higher delay. In this setting, it is possible that the lifting shifted the traffic equilibrium from the low-

[2] We thank Matthew Turner for suggesting this explanation and the attached model.

congestion X_{HOV} to the high-congestion X_2.

While intuitively plausible, this type of static analysis has been questioned by some transportation economists, who argue that the speed-flow curves from Figure S14 represent relationships that holds instantaneously, but do not describe a stable steady state (*34*-*36*). In particular, Verhoef (*34*) shows that points on the backward-bending part of the curve cannot be stable to both quantity and cost perturbations. These authors argue that hypercongestion is a transient, dynamic response to a spike in travel demand. This interpretation is consistent with our setting, where we observe large increases in travel delay during the morning and evening peaks. The basic logic of the above model may go through in a micro-founded model that explicitly accounts for travel demand throughout the day and an explicit congestion technology, such as those introduced by Small and Verhoef (*36*). However, that exercise is beyond the scope of this paper.

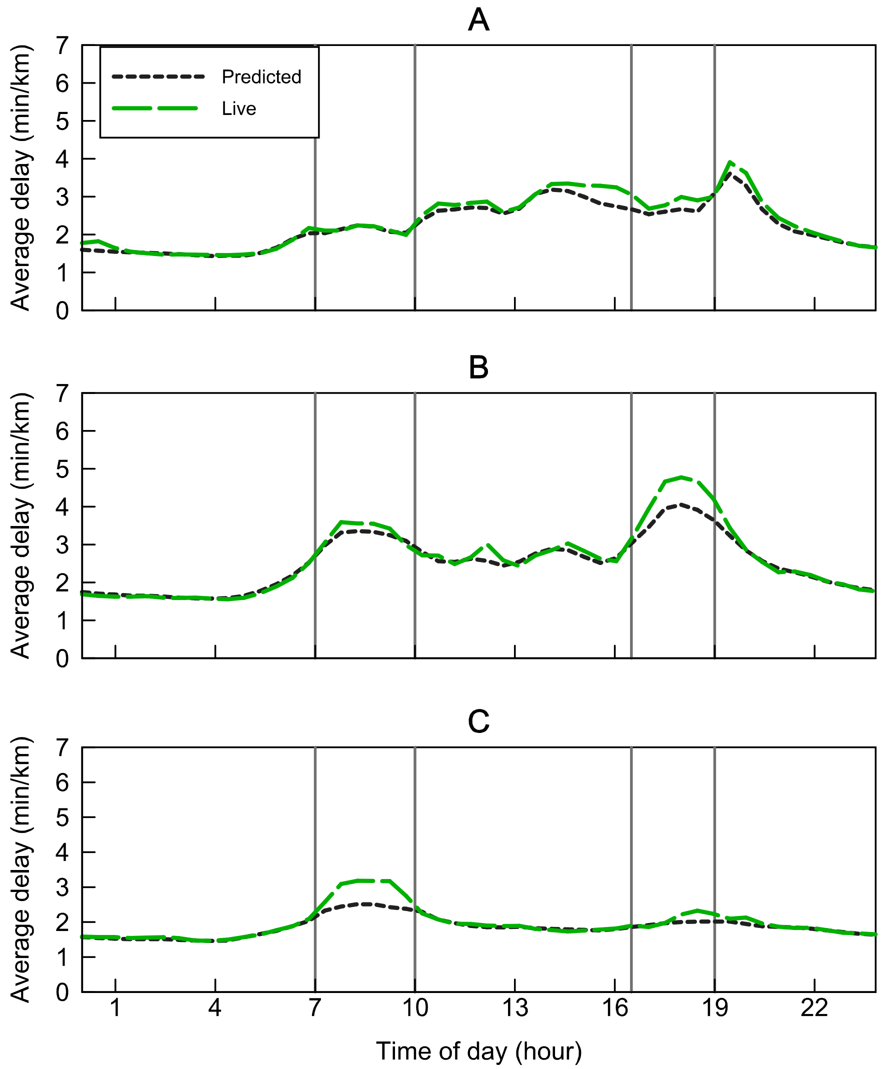

Figure S1.

Comparison of Google Maps "predicted" and "live" data. (A) Former three-in-one restricted road (Jalan Sudirman) (B) unrestricted alternate road (Jalan Rasuna Said), unrestricted alternate road (Jalan Tentara Pelajar). "Live" data are from before the policy lifting, from the evening of Thursday, March 31, Friday, April 1, and Monday, April 4. "Predicted" data were collected between April 3 and April 12.

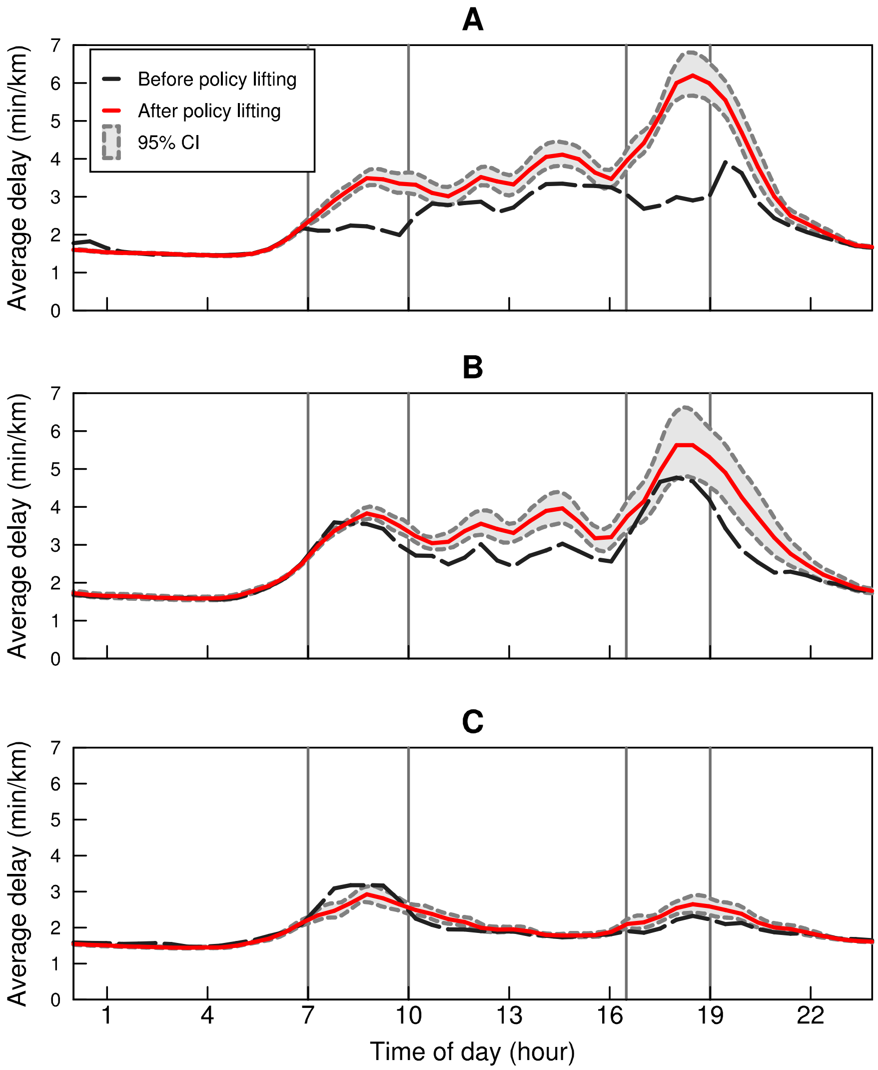

Figure S2.

Impact of three-in-one policy lifting. (A) Former three-in-one restricted road (Jalan Sudirman), (B) unrestricted alternate road (Jalan Rasuna Said), and (C) unrestricted alternate road (Jalan Tentara Pelajar). Replicates Figure 2 adding the alternate road Tentara Pelajar. See Figure 2 for further details.

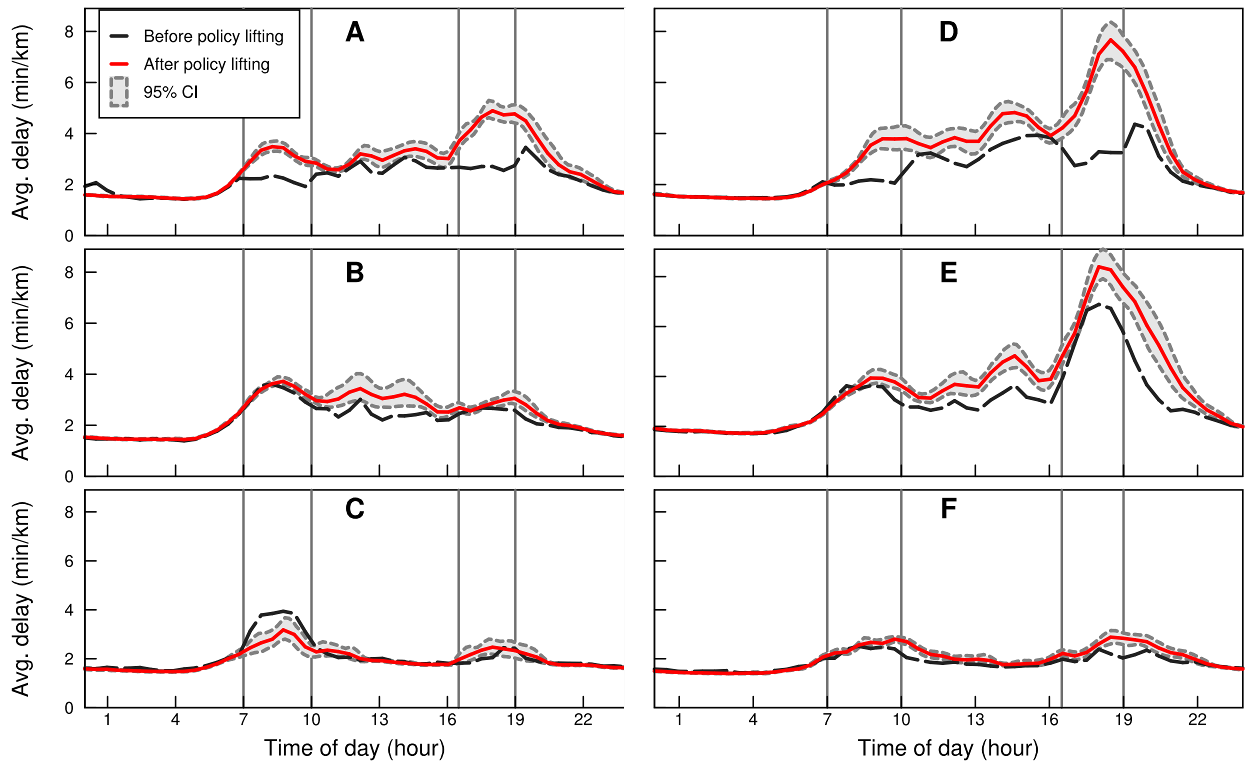

Figure S3.

Impact of three-in-one policy lifting by road direction. (A) and (D) Former three-in-one restricted road (Jalan Sudirman), (B) and (E) unrestricted alternate road (Jalan Rasuna Said), (C) and (F) unrestricted alternate road (Jalan Tentara Pelajar). Panels (A), (B) and (C) include only northbound road segments, panels (D), (E) and (F) include only southbound road segments. Replicates Figure 2 restricting to northbound or southbound road segments.

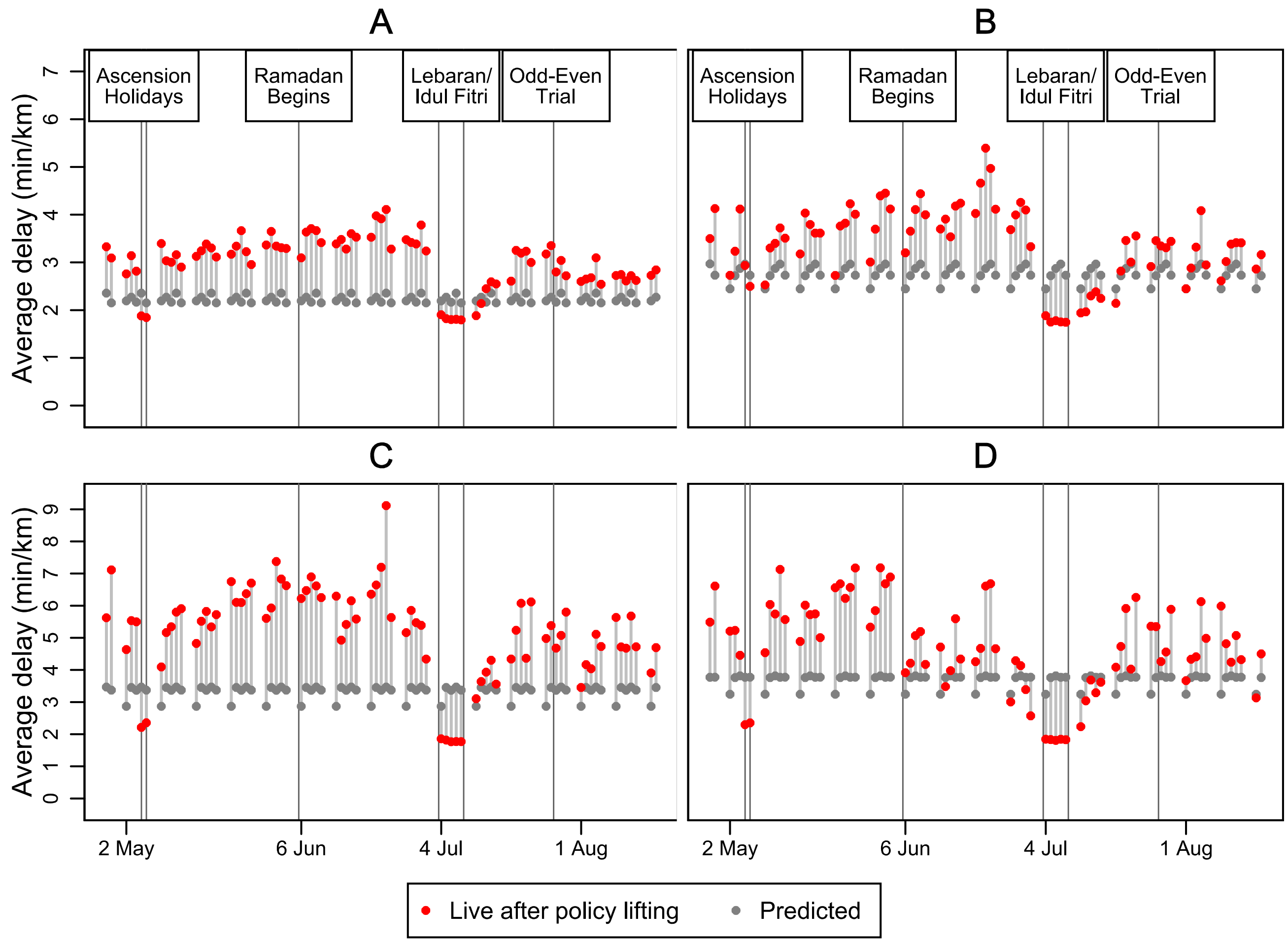

Figure S4.

Impact of three-in-one policy lifting over time on former three-in-one roads. (A) Morning peak (7-10am), (B) Mid-day off-peak (10am-4:30pm), (C) Evening peak (4:30-7pm), (D) Hour after evening peak (7-8pm). Roads and dates in the sample are as in Figure 3 (A). Red points represent the average delay calculated using “live” data on former three-in-one roads on a given date in the time interval for that panel. Gray points represent the same calculated using “predicted” data for the corresponding day of the week.

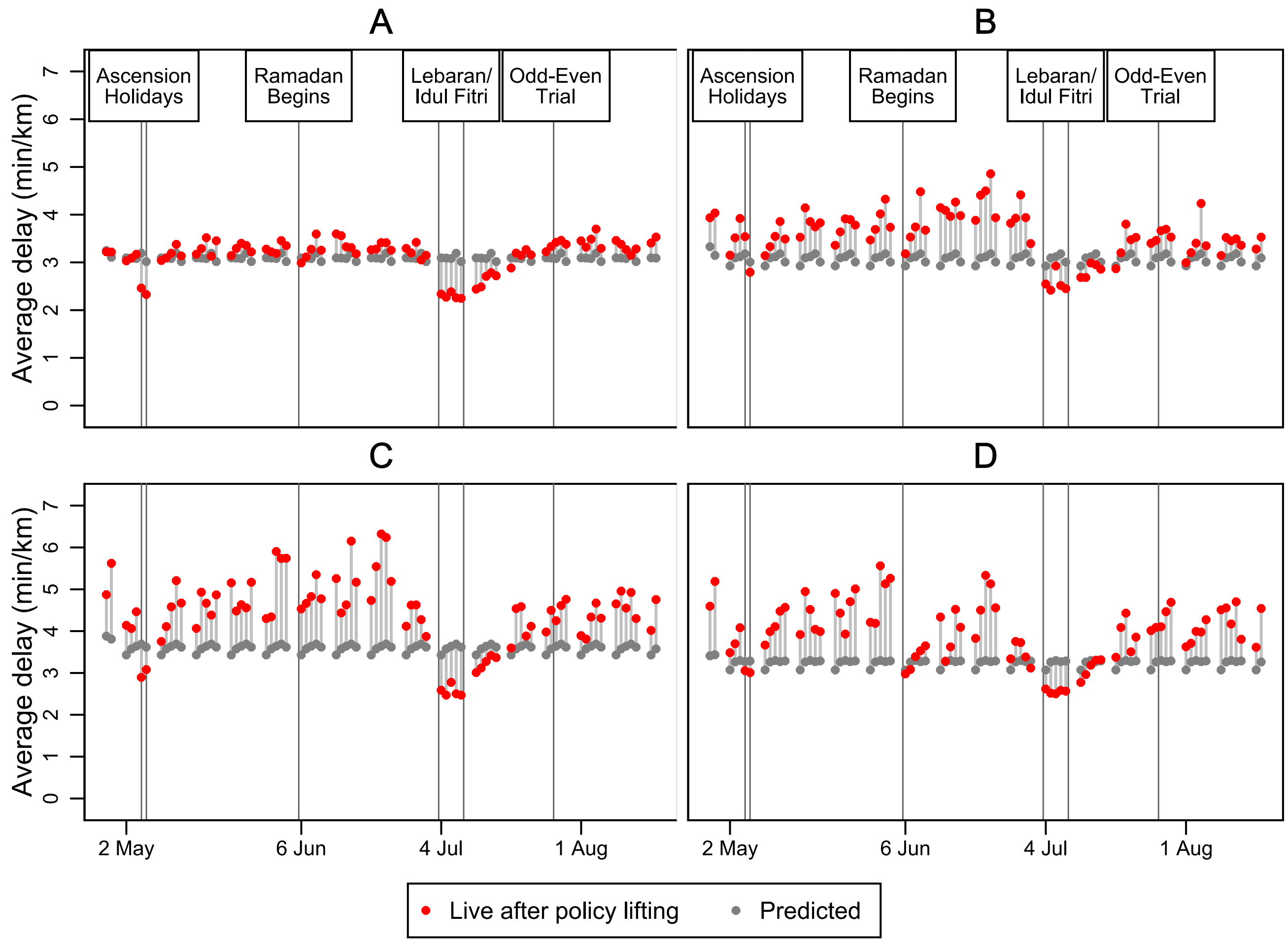

Figure S5.

Impact of three-in-one policy lifting over time on unrestricted roads. (A) Morning peak (7-10am), (B) Mid-day off-peak (10am-4:30pm), (C) Evening peak (4:30-7pm), (D) Hour after evening peak (7-8pm). Roads and dates in the sample are as in Figure 3 (B). Red points represent the average delay calculated using "live" data on unrestricted roads on a given date in the time interval for that panel. Gray points represent the same calculated using "predicted" data for the corresponding day of the week.

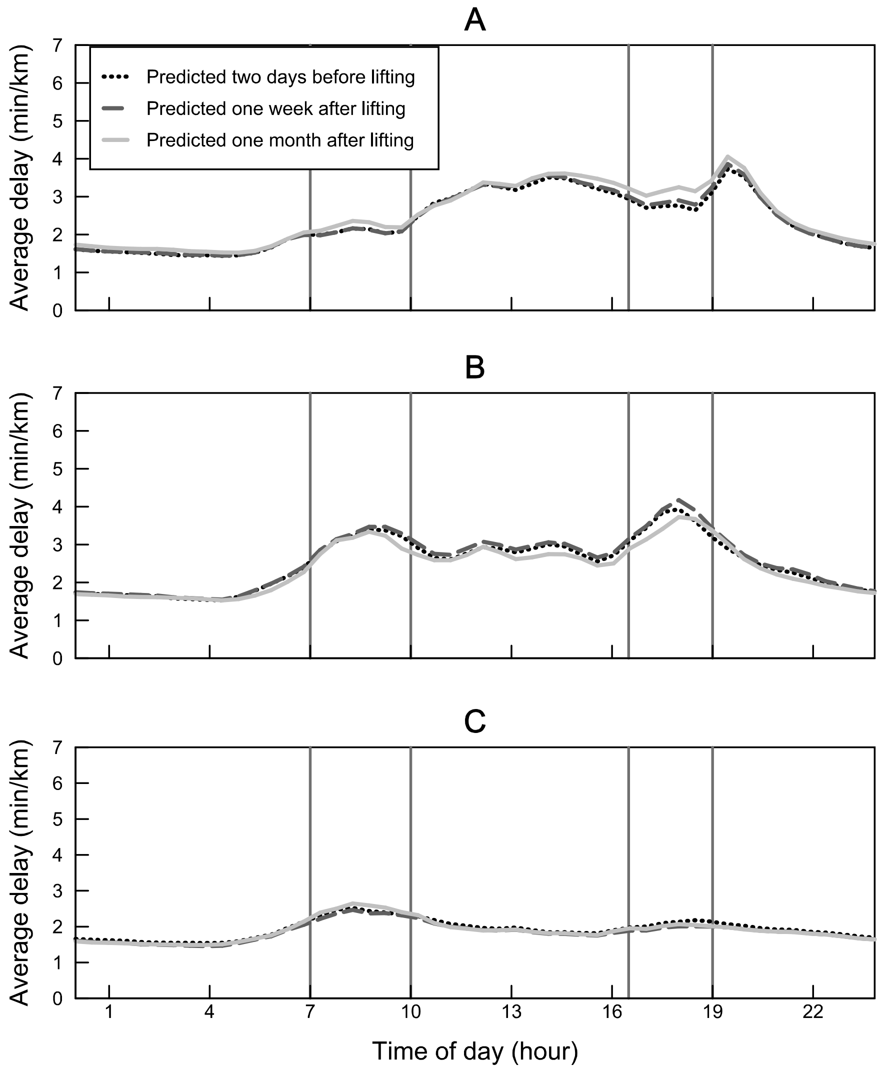

Figure S6.

Stability of "predicted" Google Maps data. (A) Former three-in-one restricted road (Jalan Sudirman) (B) unrestricted alternate road (Jalan Rasuna Said), unrestricted alternate road (Jalan Tentara Pelajar). This figure shows predicted data collected at three points in time. The first set of queries was made on April 3 (departure date Wednesday, April 20). The second set of queries was made on April 11 (departure date April 20). The third set of queries was made on May 2 (departure date Wednesday, May 18).

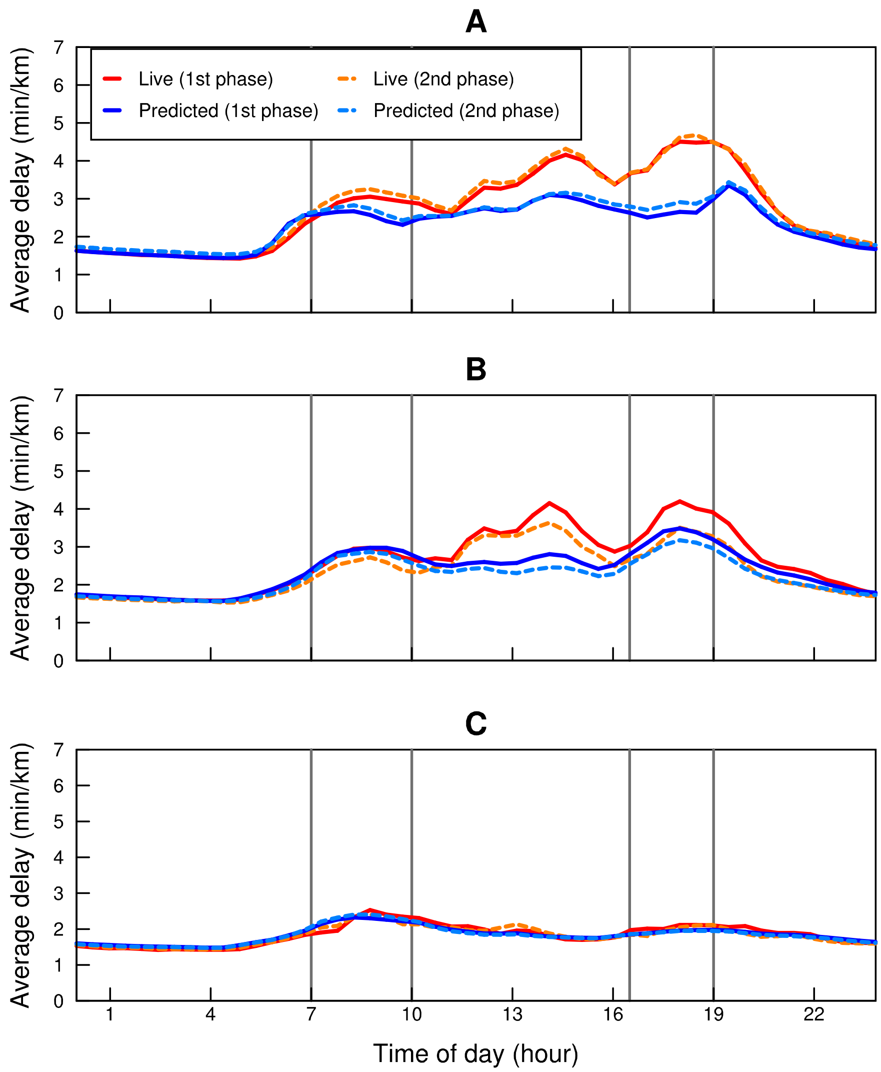

Figure S7.

Comparison of overlapping data from first and second phase data collection. (A) Former three-in-one restricted road (Jalan Sudirman) (B) unrestricted alternate road (Jalan Rasuna Said), unrestricted alternate road (Jalan Tentara Pelajar). Live data are from weekdays April 28 through May 6, the overlap period for the first and second phases of data collection.

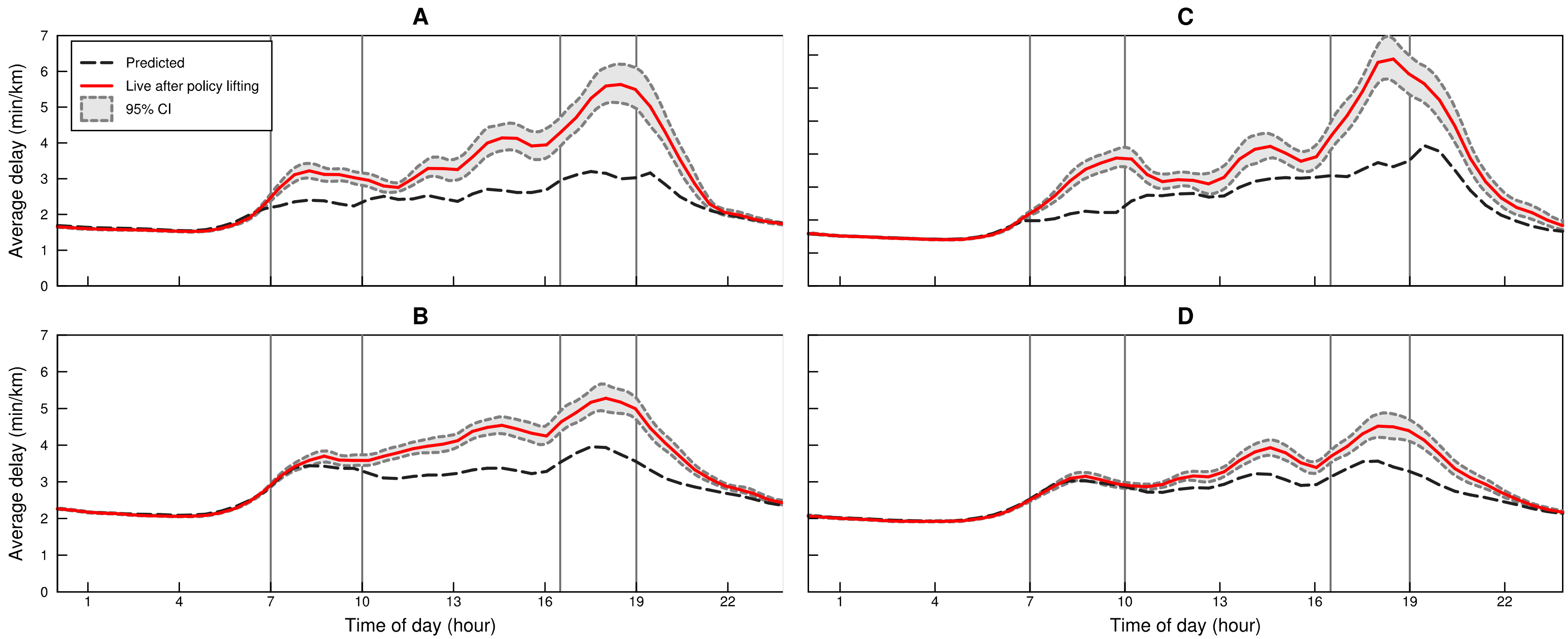

Figure S8.

Impact of three-in-one policy lifting by road direction. (A) and (C) Both former three-in-one restricted roads (Jalan Sudirman and Jalan Gatot Subroto), (B) and (D) 8 unrestricted alternate roads (identified by Jakarta Department of Transportation). Panels (A) and (B) include only northbound road segments, panels (D) and (E) include only southbound road segments. Replicates Figure 3 restricting to northbound or southbound road segments.

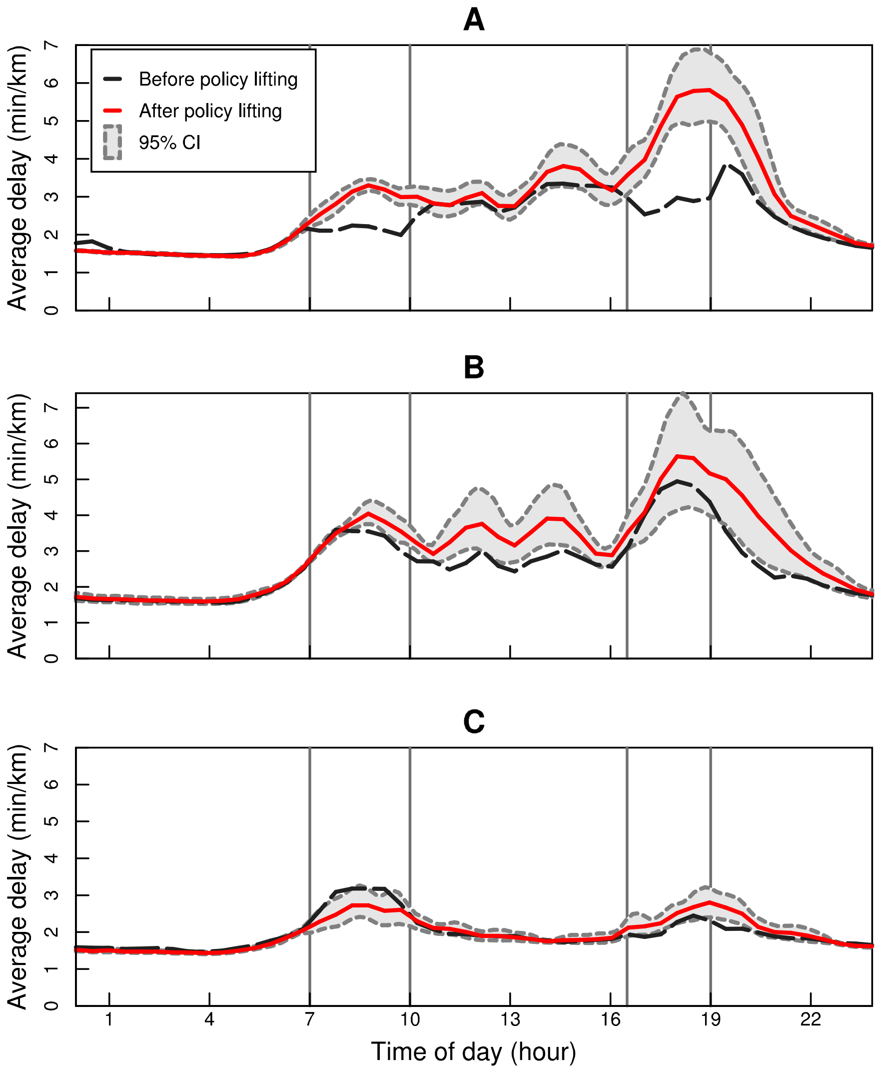

Figure S9.

Impact of three-in-one policy lifting on Mondays, Thursday evening and Fridays only. (A) Former three-in-one restricted road (Jalan Sudirman), (B) unrestricted alternate road (Jalan Rasuna Said), and (C) unrestricted alternate road (Jalan Tentara Pelajar). Replicates figure 2 restricting the date sample to Monday, Thursday evening and Fridays between March 31 and May 2.

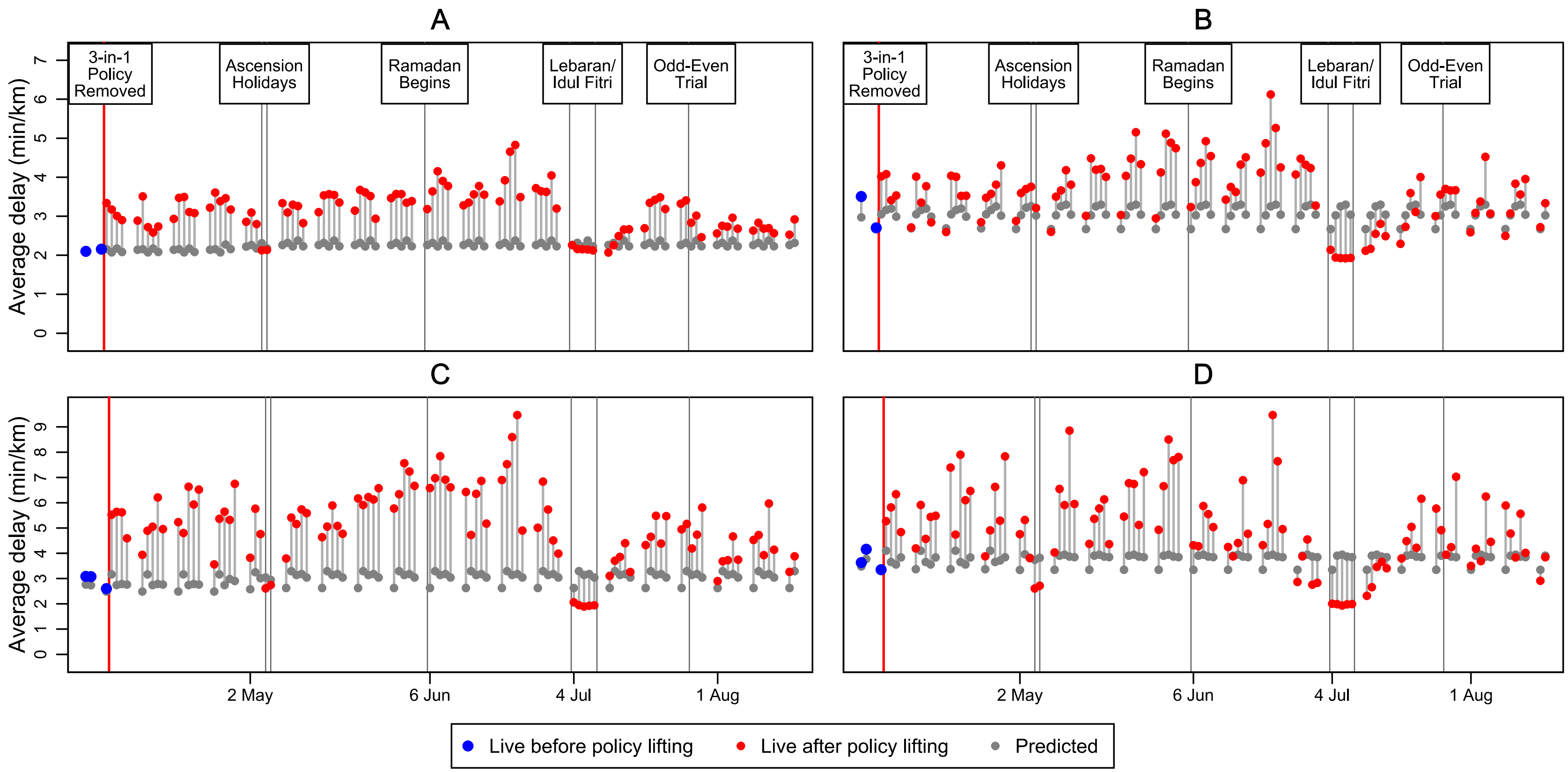

Figure S10.

Impact of three-in-one policy lifting over time on a formerly restricted road (Jalan Sudirman). (A) Morning peak (7-10am), (B) Mid-day off-peak (10am-4:30pm), (C) Evening peak (4:30-7pm), (D) Hour after evening peak (7-8pm). Roads and dates in the sample are as in Figure 2 (A). Blue points represent average delay calculated using "live" data on Jalan Sudirman on a given date before the policy lifting in the time interval for that panel. Red points represent the same object for dates after the lifting. Gray points represent the same calculated using "predicted" data for that day of the week.

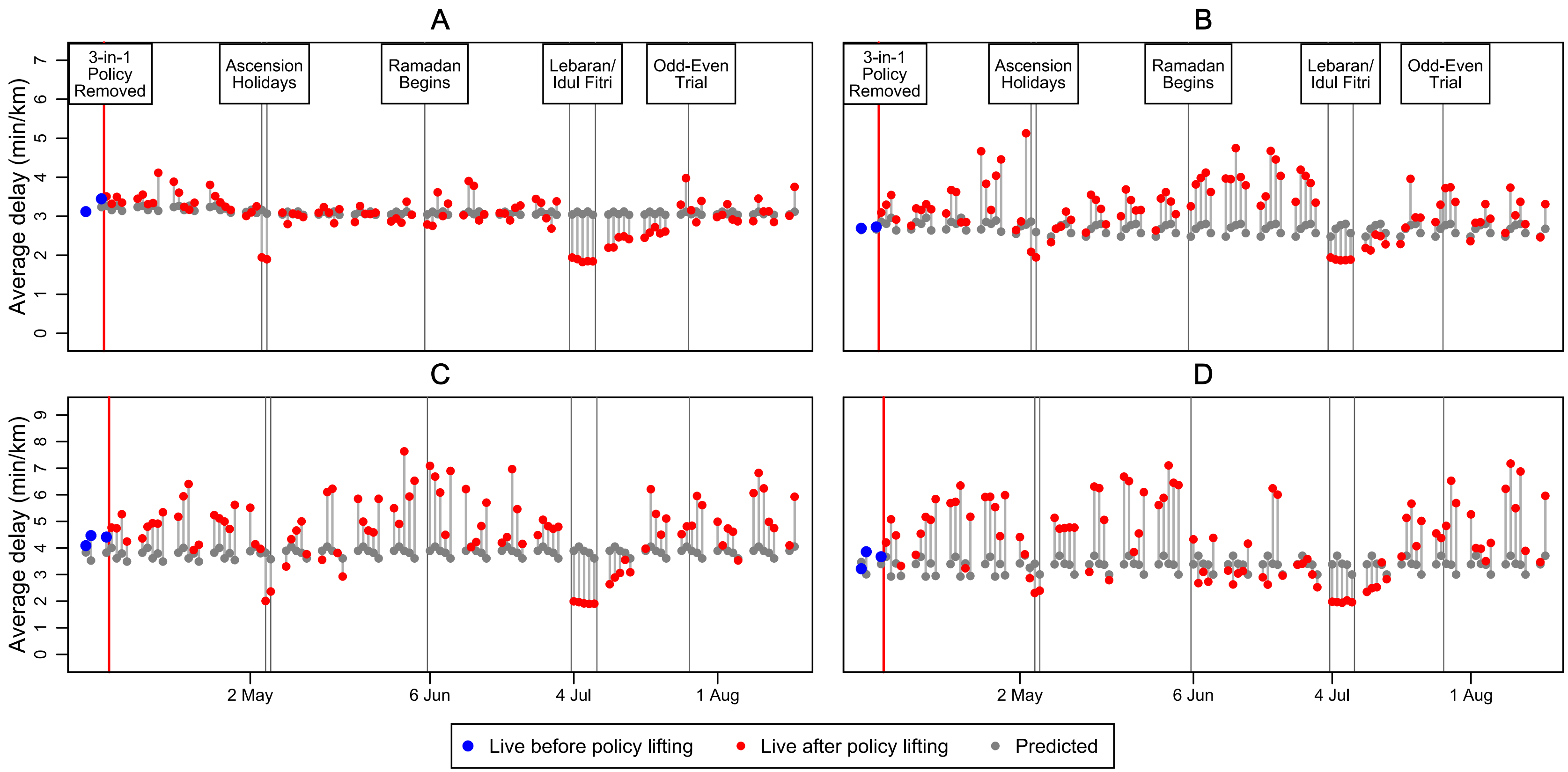

Figure S11.

Impact of three-in-one policy lifting over time on an unrestricted road (Jalan Rasuna Said). (A) Morning peak (7-10am), (B) Mid-day off-peak (10am-4:30pm), (C) Evening peak (4:30-7pm), (D) Hour after evening peak (7-8pm). Roads and dates in the sample are as in Figure 2 (B). Blue points represent average delay calculated using "live" data on Jalan Rasuna Said on a given date before the policy lifting in the time interval for that panel. Red points represent the same object for dates after the lifting. Gray points represent the same calculated using "predicted" data for that day of the week.

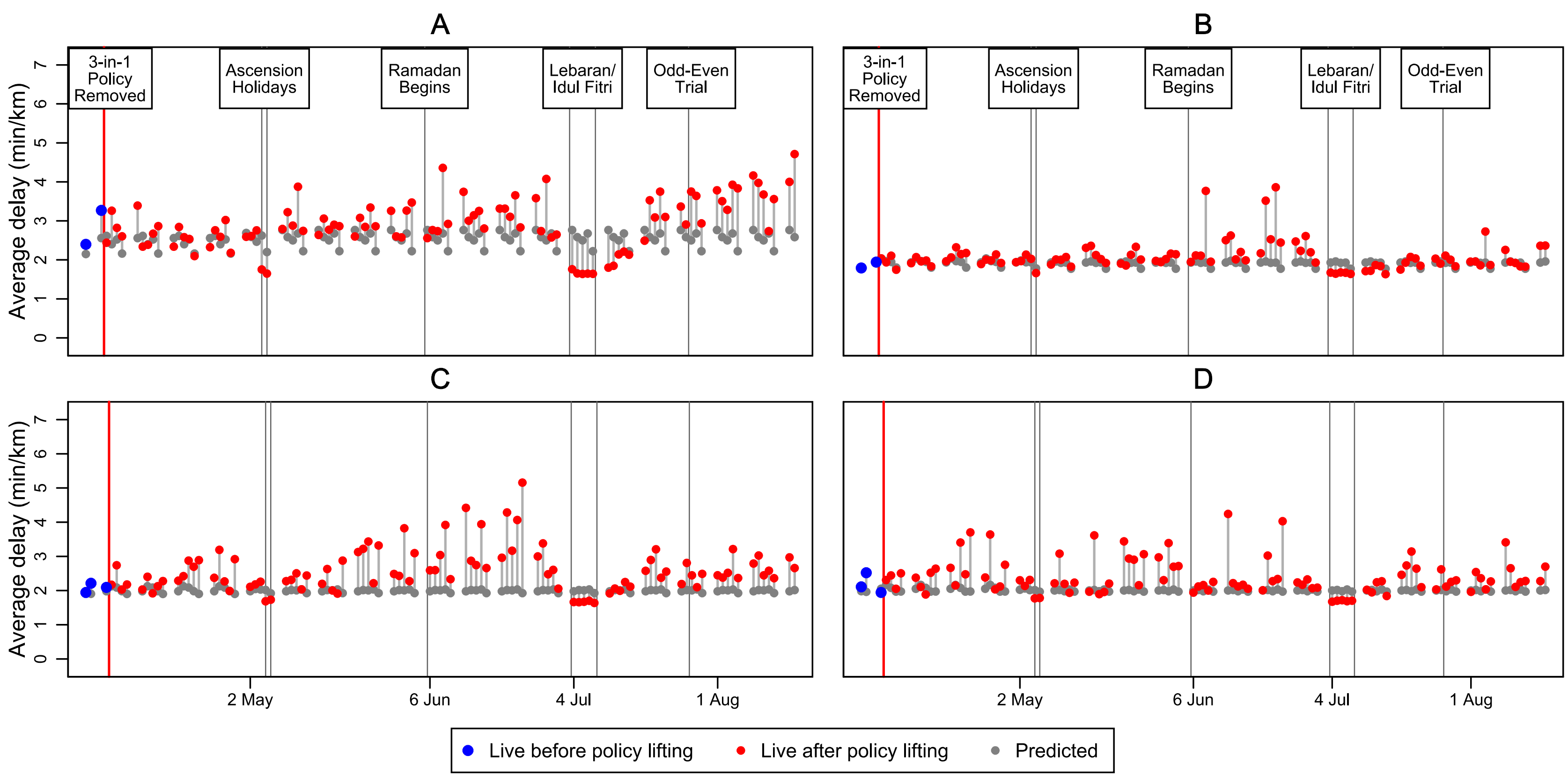

Figure S12.

Impact of three-in-one policy lifting over time on an unrestricted road (Jalan Tentara Pelajar). (A) Morning peak (7-10am), (B) Mid-day off-peak (10am-4:30pm), (C) Evening peak (4:30-7pm), (D) Hour after evening peak (7-8pm). Roads and dates in the sample are as in Figure 2 (C). Blue points represent average delay calculated using "live" data on Jalan Tentara Pelajar on a given date before the policy lifting in the time interval for that panel. Red points represent the same object for dates after the lifting. Gray points represent the same calculated using "predicted" data for that day of the week.

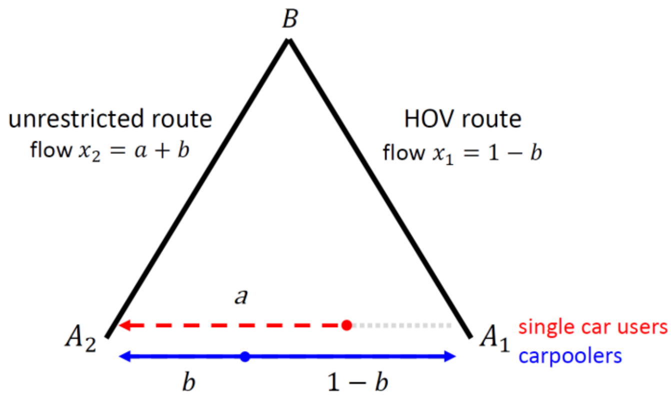

Figure S13.

Illustration of a model that predicts more cars on the road after the policy lifting. Two types of commuters (carpoolers in blue and single car users in red) live along the A_1A_2 line and commute from home to point B via either A_1 or A_2, or decide to not commute at all.

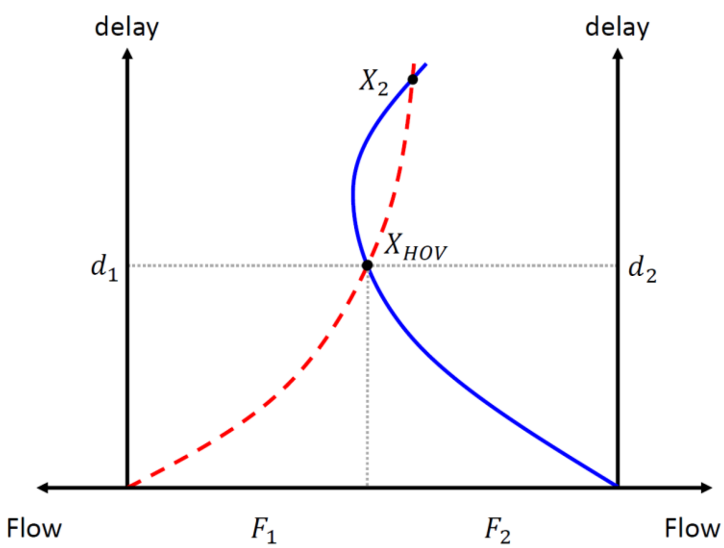

Figure S14.

Illustration of a model with hypercongestion. The delay-flow diagrams for two roads are shown reflected such that the total flow on the X axis between the two roads sums up to a constant.

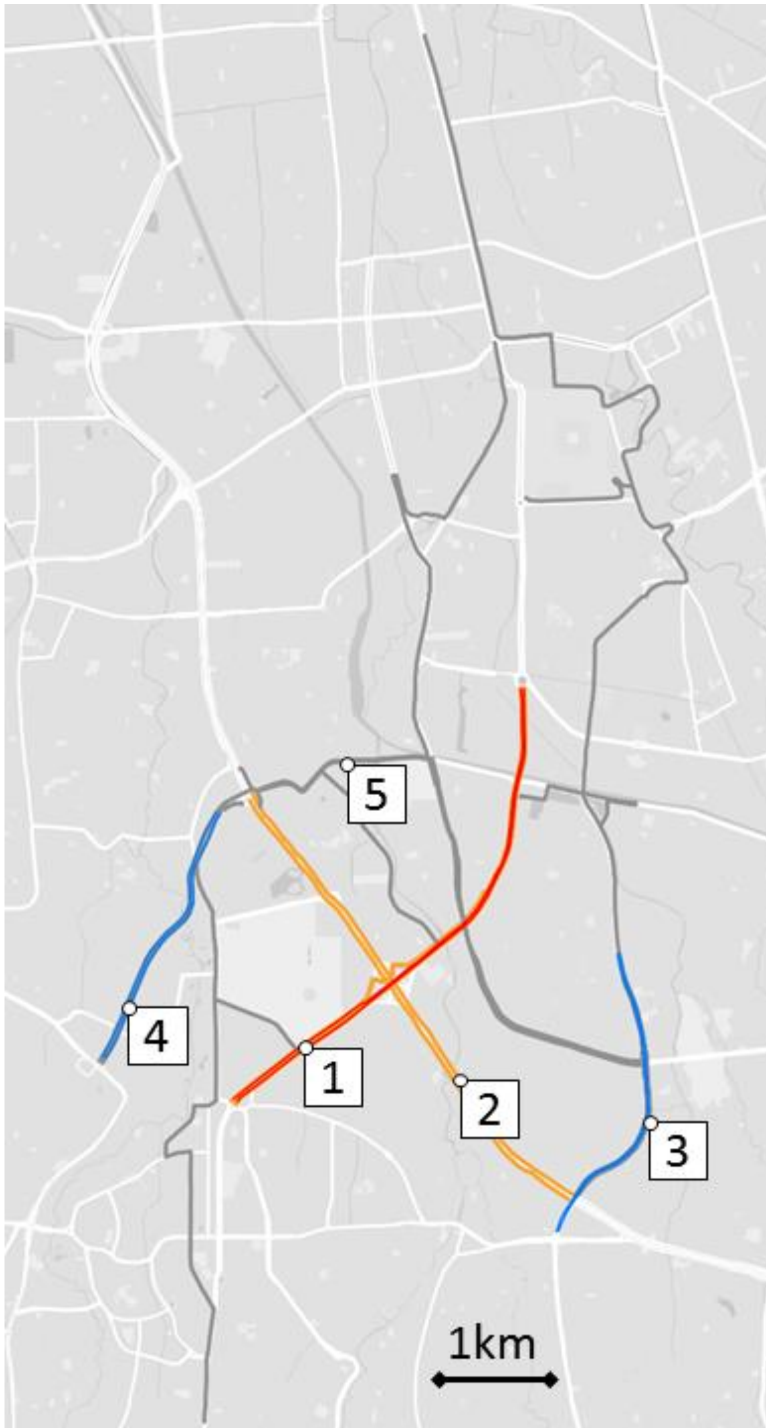

Figure S15

Routes included in the analysis (higher resolution). (1) Former three-in-one road (Jalan Sudirman, red and orange), (2) Former three-in-one road (Jalan Gatot Subroto, orange), (3) Unrestricted alternate road (Jalan Rasuna Said, blue), (4) Unrestricted alternate road (Jalan Tentara Pelajar, blue), (5) 8 unrestricted alternate routes from the Jakarta Department of Transport (gray). Routes from the first phase of data collection are drawn with thin lines: 1 (red), 3 (blue), and 4 (blue). Map data ©2017 Google

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Average Delay (min/km)				Total Distance (km)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.	
Panel A: three-in-one Road							
Sudirman	1.92	2.14	2.98	2.84	3.59	1.87	9.65
Panel B. Alternate Road							
Rasuna Said	2.19	3.34	2.71	4.35	3.61	1.89	5.72
Panel C. Alternate Road							
Tentara Pelajar	1.92	2.98	1.89	2.09	2.13	1.68	4.95

Table S1.

Summary Statistics Before Policy Lifting. Columns 1-6 provide average traffic delay computed using "live" data before the lifting of the three-in-one policy. Column 7 reports the total distance of northbound and southbound segments. The sample covers Thursday March 31, Friday April 1 and Monday April 4.

	(1)	(2)	(3)	(4)	(5)	(6)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.
Panel A. Delay on three-in-one Road (Jalan Sudirman)						
Policy Lifting	-0.00	0.98***	0.55**	2.48***	1.98***	0.05
	(0.05)	(0.07)	(0.23)	(0.30)	(0.34)	(0.08)
Northbound	0.24***	0.12	-0.98***	-1.48***	-2.01***	-0.08
	(0.01)	(0.12)	(0.16)	(0.26)	(0.36)	(0.05)
Observations	264	792	1,720	670	270	2,656
Control mean	1.92	2.14	2.98	2.84	3.59	1.87
Panel B. Delay on Alternate Road (Jalan Rasuna Said)						
Policy Lifting	0.03	0.13	0.71***	0.60***	1.32***	0.16*
	(0.03)	(0.09)	(0.12)	(0.20)	(0.37)	(0.09)
Northbound	-0.08***	-0.14	-0.80***	-4.24***	-4.03***	-0.77***
	(0.02)	(0.09)	(0.17)	(0.21)	(0.33)	(0.07)
Observations	264	792	1,720	670	270	2,656
Control mean	2.19	3.34	2.71	4.35	3.61	1.89
Panel C. Delay on Alternate Road (Jalan Tentara Pelajar)						
Policy Lifting	-0.00	-0.35	0.12	0.30***	0.38**	-0.04
	(0.03)	(0.37)	(0.07)	(0.11)	(0.19)	(0.03)
Northbound	0.21***	0.31*	-0.04	-0.14	-0.52***	-0.04*
	(0.05)	(0.16)	(0.05)	(0.12)	(0.17)	(0.02)
Observations	264	792	1,720	670	270	2,656
Control mean	1.92	2.98	1.89	2.09	2.13	1.68

Table S2.

Impact of three-in-one policy lifting on restricted and unrestricted roads. This table extends Table 1 to include a second unrestricted road (Jalan Tentara Pelajar) in Panel (C). See Table 1 notes for more details.

	(1)	(2)	(3)	(4)	(5)	(6)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.
Panel A. Delay on three-in-one Road (Jalan Sudirman)						
Policy Lifting	-0.00	0.98***	0.55*	2.48***	1.98***	0.05
	(0.03)	(0.07)	(0.28)	(0.24)	(0.31)	(0.11)
Observations	132	396	860	335	135	1,328
Control mean	1.92	2.14	2.98	2.84	3.59	1.87
Panel B. Delay on Alternate Road (Jalan Rasuna Said)						
Policy Lifting	0.03	0.13	0.71***	0.60***	1.32***	0.16**
	(0.03)	(0.12)	(0.12)	(0.15)	(0.24)	(0.06)
Observations	132	396	860	335	135	1,328
Control mean	2.19	3.34	2.72	4.36	3.61	1.89
Panel C. Delay on Alternate Road (Jalan Tentara Pelajar)						
Policy Lifting	-0.00	-0.35	0.12**	0.30***	0.38**	-0.04
	(0.03)	(0.29)	(0.06)	(0.09)	(0.18)	(0.02)
Observations	132	396	860	335	135	1,328
Control mean	1.93	2.98	1.89	2.09	2.13	1.68

Table S3.

Impact of three-in-one policy lifting averaging across road direction. This table replicates Table 1 averaging delay over both road directions (northbound and southbound). It also includes a second unrestricted road (Jalan Tentara Pelajar) in Panel (C). See Table 1 notes for more details.

	(1)	(2)	(3)	(4)	(5)	(6)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.
Panel A. Delay on three-in-one Road (Jalan Sudirman)						
Policy Lifting	0.00	0.99***	0.51***	2.53***	1.91***	0.13***
	(0.01)	(0.07)	(0.09)	(0.22)	(0.27)	(0.04)
Northbound	0.24***	0.12	-0.97***	-1.38***	-1.98***	-0.09*
	(0.01)	(0.10)	(0.15)	(0.22)	(0.30)	(0.05)
Observations	306	918	1,992	762	306	3,052
Control mean	1.92	2.13	3.02	2.79	3.66	1.78
Panel B. Delay on Alternate Road (Jalan Rasuna Said)						
Policy Lifting	-0.01	0.25***	0.64***	1.21***	1.66***	0.18**
	(0.01)	(0.05)	(0.11)	(0.29)	(0.40)	(0.07)
Northbound	-0.07***	-0.17**	-0.77***	-3.93***	-3.72***	-0.73***
	(0.02)	(0.08)	(0.15)	(0.21)	(0.30)	(0.05)
Observations	306	918	1,992	762	306	3,052
Control mean	2.23	3.21	2.78	3.74	3.27	1.87
Panel C. Delay on Alternate Road (Jalan Tentara Pelajar)						
Policy Lifting	-0.03	0.18*	0.07	0.37***	0.46***	-0.02
	(0.03)	(0.09)	(0.04)	(0.07)	(0.11)	(0.02)
Northbound	0.23***	0.20	-0.04	-0.16	-0.51***	-0.03
	(0.04)	(0.14)	(0.04)	(0.11)	(0.15)	(0.02)
Observations	306	918	1,992	762	306	3,052
Control mean	1.95	2.45	1.94	2.02	2.05	1.67

Table S4.

Impact of three-in-one policy lifting using predicted data. This table replicates Table 1 using “predicted” data as a counterfactual, instead of “live” data from before the lifting. It also includes a second unrestricted road (Jalan Tentara Pelajar) in Panel (C). See Table 1 notes for more details. Predicted data for each day of the week (Monday-Friday) are included.

	(1)	(2)	(3)	(4)	(5)	(6)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.
Panel A. Delay on three-in-one Road (Jalan Sudirman)						
Policy Lifting	-0.01	0.84***	0.03	2.11***	1.87***	0.17*
	(0.04)	(0.07)	(0.09)	(0.36)	(0.39)	(0.09)
Northbound	0.22***	0.22**	-0.68***	-1.38***	-1.83***	-0.09
	(0.02)	(0.10)	(0.17)	(0.31)	(0.44)	(0.10)
Observations	108	324	704	402	162	1,294
Control mean	1.92	2.14	2.98	2.84	3.59	1.87
Panel B. Delay on Alternate Road (Jalan Rasuna Said)						
Policy Lifting	0.04	0.28**	0.67***	0.53***	1.23***	0.30**
	(0.03)	(0.10)	(0.22)	(0.18)	(0.38)	(0.13)
Northbound	-0.10***	-0.14	-0.52	-4.03***	-3.75***	-0.91***
	(0.02)	(0.17)	(0.34)	(0.24)	(0.43)	(0.12)
Observations	108	324	704	402	162	1,294
Control mean	2.19	3.34	2.71	4.35	3.61	1.89
Panel C. Delay on Alternate Road (Jalan Tentara Pelajar)						
Policy Lifting	-0.04	-0.36	0.04	0.22*	0.39**	0.00
	(0.02)	(0.35)	(0.07)	(0.12)	(0.18)	(0.04)
Northbound	0.19***	0.52	-0.05	-0.01	-0.60***	-0.07*
	(0.03)	(0.31)	(0.09)	(0.13)	(0.18)	(0.04)
Observations	108	324	704	402	162	1,294
Control mean	1.92	2.98	1.89	2.09	2.13	1.68

Table S5.

Impact of three-in-one policy lifting on Monday, Thursday evening and Friday only. This table replicates table 1 restricting the sample to days of the week and times for which we have pre- data. Specifically, the sample includes Monday, Friday, and Thursday after 4:30pm. See Table 1 notes for more details.

	(1)	(2)	(3)	(4)	(5)	(6)
Time interval	6 - 7 a.m.	7 - 10 a.m.	10 a.m. - 4:30 p.m.	4:30 - 7 p.m.	7 - 8 p.m.	8 p.m. - 6 a.m.
Panel A. Delay on three-in-one Road (Jalan Sudirman)						
Policy Lifting	0.01	1.28***	1.64***	3.38***	2.40***	0.14
	(0.08)	(0.39)	(0.46)	(0.60)	(0.44)	(0.12)
Northbound	0.20***	-0.20	-1.08***	-1.68***	-1.87***	-0.09
	(0.03)	(0.18)	(0.24)	(0.31)	(0.35)	(0.06)
Days Since Lifting	-0.00	-0.09	-0.24**	-0.20	-0.11	-0.03
	(0.01)	(0.08)	(0.09)	(0.12)	(0.11)	(0.03)
Observations	66	198	430	178	72	682
Control mean	1.92	2.14	2.98	2.84	3.59	1.87
Wildbootstrap p-value	0.85	0.01	0.02	0.00	0.01	0.46
Panel B. Delay on Alternate Road (Jalan Rasuna Said)						
Policy Lifting	-0.01	0.00	0.55***	0.49**	1.13*	0.16
	(0.05)	(0.14)	(0.17)	(0.18)	(0.56)	(0.14)
Northbound	-0.13***	-0.04	-0.66***	-3.76***	-3.13***	-0.60***
	(0.03)	(0.08)	(0.14)	(0.21)	(0.42)	(0.07)
Days Since Lifting	0.01	0.02	-0.01	-0.02	-0.11	-0.02
	(0.01)	(0.03)	(0.05)	(0.07)	(0.13)	(0.02)
Observations	66	198	430	178	72	682
Control mean	2.19	3.34	2.71	4.35	3.61	1.89
Wildbootstrap p-value	0.85	1.00	0.05	0.01	0.02	0.34

Table S6.

Impact of three-in-one policy lifting estimated using regression discontinuity. This table replicates table 1 using a regression discontinuity specification. The sample is restricted to all pre-policy lifting data and one week after the lifting. Due to the small number of clusters, p-values for the coefficient on policy lifting are calculated using the wild bootstrap cluster procedure (Cameron, Gelbach and Miller 2008).

Time interval	(1) 6 - 7 a.m.	(2) 7 - 10 a.m.	(3) 10 a.m. - 4:30 p.m.	(4) 4:30 - 7 p.m.	(5) 7 - 8 p.m.	(6) 8 p.m. - 6 a.m.
Panel C. Delay on Alternate Road (Jalan Tentara Pelajar)						
Policy Lifting	0.39	-0.59	0.15	0.29	0.37	0.05**
	(0.24)	(0.54)	(0.12)	(0.26)	(0.25)	(0.02)
Northbound	0.39***	0.81**	0.13	-0.06	-0.39**	0.03**
	(0.11)	(0.27)	(0.09)	(0.17)	(0.17)	(0.01)
Days Since Lifting	-0.08	0.11	-0.02	-0.02	-0.04	-0.02***
	(0.05)	(0.10)	(0.03)	(0.04)	(0.06)	(0.01)
Observations	66	198	430	178	72	682
Control mean	1.92	2.98	1.89	2.09	2.13	1.68
Wildbootstrap p-value	0.23	0.42	0.25	0.32	0.32	0.12

Table S6. (continued)

Impact of three-in-one policy lifting estimated using regression discontinuity. (continued)

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