

## TRANSPORT FINDINGS

# Medium- and Long-Term Impacts of Transit on Congestion: Jakarta's Experience

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## Findings

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This study marks the first attempt to examine the medium- and long-term effects of the MRT Jakarta opening on congestion. By employing Differences-in-Differences (DiD) models at six months and one-year post-inauguration, this study reveals the dynamic of congestion relief impact. Specifically, six months after opening, no significant impact was observed during the morning peak hour; however, after a year, average delays in treated corridors decreased by nearly 40%. During the evening peak hour, the same treated corridors experienced congestion reductions from 33.6% to 34.9%. In summary, this study provides novel insights into roadway performance dynamics, emphasizing the importance of continuous transit impact monitoring.

## 1. Questions

One considerably obvious and common motivating factors of transit investment was to alleviate traffic congestion. Indeed, there is a growing literature aimed to assess the congestion relief impact of public transit, which, following Nguyen-Phuoc et al. (2020), could be categorized into: 1) studies that exploit shocks associated with an abrupt absence of public transit, most commonly due to strikes (Adler and van Ommeren 2016; Anderson 2014; Beaudoin, Farzin, and Lin Lawell 2015; van Exel and Rietveld 2001), and 2) research that assess the before-after transit opening (Bhattacharjee and Goetz 2012; Ewing et al. 2014; Giuliano, Chakrabarti, and Rhoads 2016; Tao, Cao, and Wu 2021; Widita et al. 2023). Some of these studies have taken advantage of the spatially embedded big data (e.g., Adler and van Ommeren 2016; Anderson 2014; Giuliano, Chakrabarti, and Rhoads 2016; Widita et al. 2023), paving ways to empirically assess transit's congestion relief impact at a granular, corridor level.

The congestion relief objective was also the factor behind the development of the 16-kilometer MRT (Mass Rapid Transit) Jakarta (Phase 1) (MRT Jakarta 2019), Indonesia's first subway, which was inaugurated on March 24, 2019. This study thus attempts to answer the following interrelated questions: Did the opening of the MRT Jakarta exert a congestion relief impact? And if so, did the impact hold over time? A recent study has shown that roadway performance improved within a short-term perspective (Widita et al. 2023); yet, it remains unclear whether the impact had persisted.

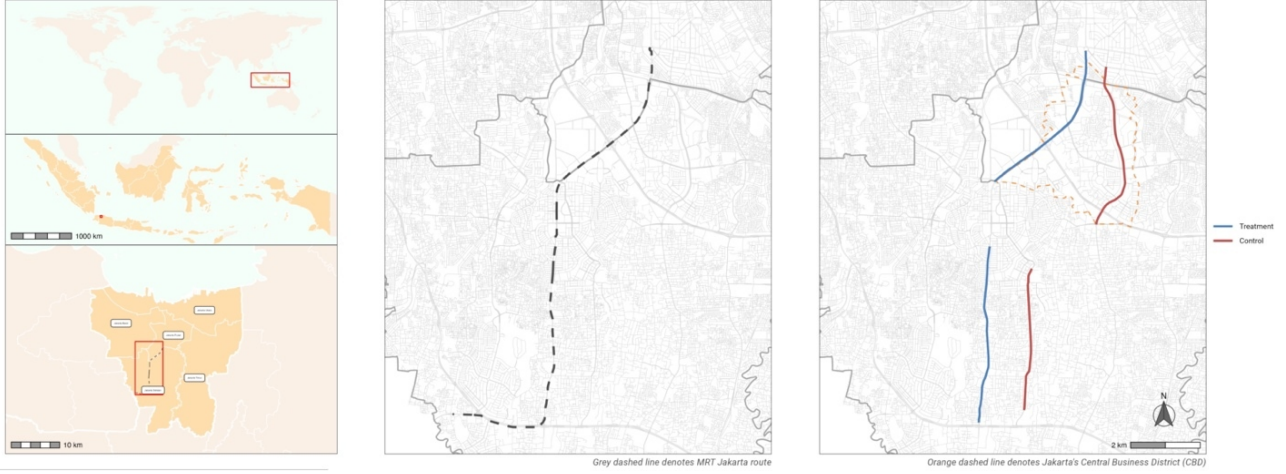


Figure 1. Study contexts showing MRT Jakarta route and treated and control corridors.

Insets (left images): Geographic location of Indonesia in the world (upper); Jakarta within Indonesia (middle); MRT Jakarta route (grey dashed line) within the Jakarta province (lower).

## 2. Methods

We adopt a DiD approach to answer the aforesaid questions, which centers around the following equation:

$$Y_{it} = \beta_0 + \beta_1 Treat_i + \beta_2 Period_t + \beta_3 (Treat_i \times Period_t) + \beta_4 Controls + \epsilon_{it}$$

where  $Y_{it}$  represents average delay, computed as minutes required to cover one kilometer of distance (min/km);  $Treat_i$  refers to whether the corridor is treated ( $Treat_i = 1$ ) or serves as a control ( $Treat_i = 0$ );  $Period_t$  designates the period as either before ( $Period_t = 0$ ) or after MRT inauguration ( $Period_t = 1$ );  $Controls$  is a vector encompassing variables that include a categorical indicating place category (downtown or peripheral corridors), as well as weekdays and average precipitation derived from “openmeteo” package in R (Pisel 2023; Posit team 2023; R Core Team 2013), both serve as controls for seasonal variations; and  $\epsilon_{it}$  denotes the error term.

Concerning treatment status, we assign corridors (i.e., Jalan Sudirman and Jalan Panglima Polim) that host the MRT Jakarta system as the treatment group and selecting adjacent, similar corridors based on road characteristics, land use, and transit services that run parallel to the treated group as the control group (i.e., Jalan Rasuna Said and Jalan Pangeran Antasari) (Figure 1). Additionally, as a context, Jalan Sudirman and Jalan Rasuna Said are situated in the downtown area, while both Jalan Panglima Polim and Jalan Pangeran Antasari are in relatively peripheral areas.

Based on these treated and control group assignments, we used the “gmapdistance” R package (Azuerio and Zarruk 2022) to query travel time data from the Google Maps Travel Time API by deploying virtual sensors to retrieve corridor level roadway performance on weekdays. The queries

Table 1. Mean differences in average delay (min/km) between treated and control corridors.

|                         | Morning Peak Hour |       |            | Evening Peak Hour |       |            |
|-------------------------|-------------------|-------|------------|-------------------|-------|------------|
|                         | Before            | After | Difference | Before            | After | Difference |
| <b>Six months after</b> |                   |       |            |                   |       |            |
| Treated                 | 2.03              | 1.54  | -0.49**    | 1.62              | 1.19  | -0.43***   |
| Control                 | 1.78              | 1.47  | -0.31      | 1.20              | 1.33  | 0.13       |
| <b>One year after</b>   |                   |       |            |                   |       |            |
| Treated                 | 2.03              | 1.89  | -0.14      | 1.62              | 1.30  | -0.32**    |
| Control                 | 1.78              | 2.35  | 0.57**     | 1.20              | 1.43  | 0.23*      |

\*p < .1; \*\*p < .05; \*\*\*p < .01

were conducted prior to the MRT inauguration, six months after, and one year after, covering the periods between February 26, 2019 and March 22, 2019; September 25, 2019 and October 31, 2019; and February 11, 2020 and March 12, 2020, respectively. Data collection concluded on March 12, 2020, due to the global pandemic.

### 3. Findings

We elaborate on our findings through descriptive analyses followed by regression results. [Table 1](#) reveals an overall pattern indicating that the average delay decreased along the treated corridors but increased on the control corridors, except for the morning peak hour six months after the MRT inauguration. The t-test results ([Table 1](#)) also show that the reduction in average delay along the treated corridors was statistically significant, except for the morning peak hour one year after the MRT opening. Building on the descriptive assessment, [Figure 2](#) captures the descriptive counterfactual analyses, showing the likely impact if the MRT had not been implemented and the treated corridors had instead followed the trajectory of the control counterparts.

During the morning peak hour, the regression results suggest that there was no discernible reduction in congestion six months after the MRT inauguration ([Table 2, Model 1](#)). It is only in the model for the one-year period after the opening ([Table 2, Model 2](#)) that there is an approximately 40% reduction in the average delay of the treated corridors compared to the control corridors, all else equal. Similar estimates are evident for the evening peak hour results. As indicated in [Table 2](#), both during the six months and one year after the MRT inauguration, treated corridors experienced a reduction in congestion by 33.6% and 34.9%, respectively. These results align with the estimated 40% increase in congestion associated with Los Angeles' subway strike (Anderson 2014) and corroborate previous Jakarta-based studies (Widita, Widyastuti, and Ikaputra 2021; Widita et al. 2023).

We conducted a battery of robustness tests to evaluate these results. Firstly, we utilized an alternative outcome, namely average speed (km/h), and observed that the congestion relief impact remained consistently significant (see [Supp.](#)

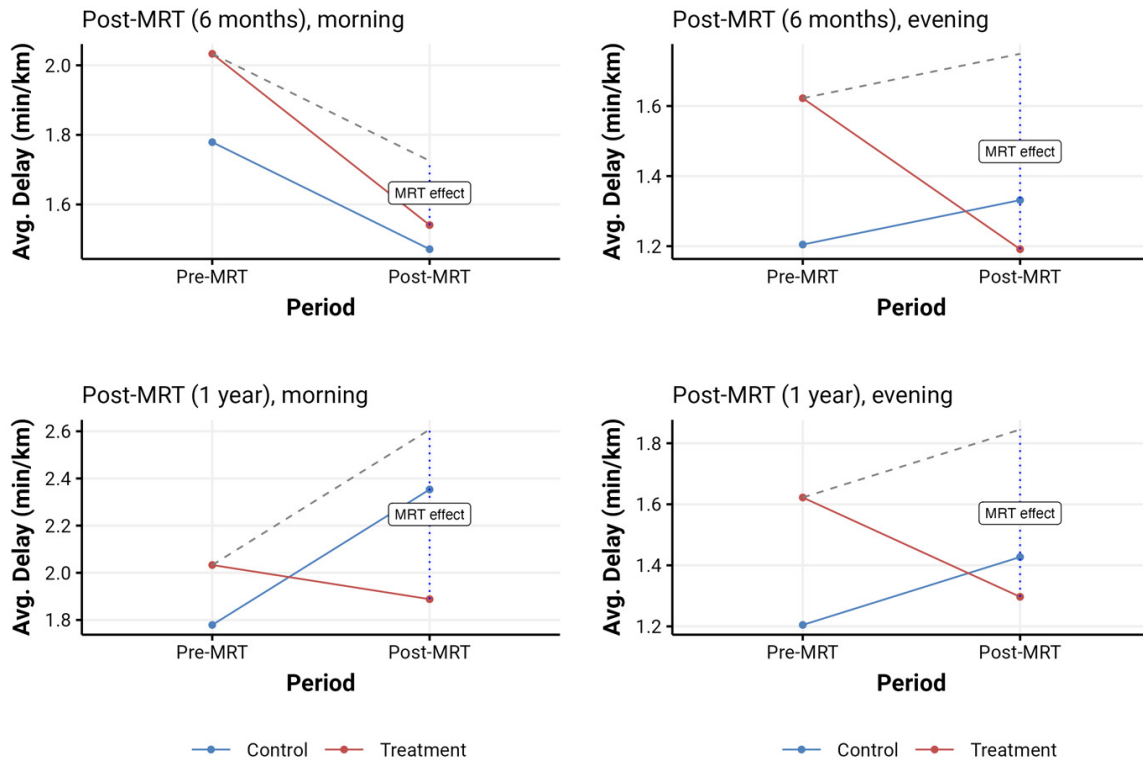


Figure 2. Changes in average delay between treated and control corridors before and after the MRT Jakarta opening.

Dashed lines denote counterfactual scenario for the treated corridors if the MRT had not been implemented.

Table 2. Difference-in-differences regression results.

|                | Dep. Variable: Average Delay (min/km) (log-transformed) |                       |                         |                       |
|----------------|---------------------------------------------------------|-----------------------|-------------------------|-----------------------|
|                | Morning Peak Hour                                       |                       | Evening Peak Hour       |                       |
|                | Six months after<br>(1)                                 | One year after<br>(2) | Six months after<br>(3) | One year after<br>(4) |
| MRT opening    | -0.17<br>(0.15)                                         | -0.39***<br>(0.13)    | -0.41***<br>(0.11)      | -0.43***<br>(0.11)    |
| N              | 144                                                     | 152                   | 144                     | 152                   |
| R-squared      | 0.18                                                    | 0.29                  | 0.23                    | 0.26                  |
| Adj. R-squared | 0.13                                                    | 0.24                  | 0.17                    | 0.21                  |

\*p < .1; \*\*p < .05; \*\*\*p < .01. Standard errors in parentheses. Controls are excluded for brevity.

**Table 1**). Secondly, we implemented Oster's (2019) tests using the "robomit" R package (Schaub and Zurich 2021), which suggest that unobservable variables would need to exert a noticeably stronger influence than the observable indicators in the models. Thirdly, we disaggregated the data by place category, revealing that the congestion relief impact appears to be driven by improved road performance along peripheral corridors compared to downtown locations ([Supp. Table 2](#) and [Supp. Table 3](#)).

In conclusion, this study reveals the dynamics of congestion relief through an examination of both medium and long-term assessments, extending the short-term-focused study on the MRT Jakarta (Widita et al. 2023). Overall, it contributes to the literature on transit congestion relief while simultaneously extending the case to the Global South.

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## Supplementary Materials

Supp. Table 1. Difference-in-differences regression results using an alternative outcome (speed, km/h).

|                     | Dep. Variable: Average Speed (km/h) (log-transformed) |                       |                         |                       |
|---------------------|-------------------------------------------------------|-----------------------|-------------------------|-----------------------|
|                     | Morning Peak Hour                                     |                       | Evening Peak Hour       |                       |
|                     | Six months after<br>(1)                               | One year after<br>(2) | Six months after<br>(3) | One year after<br>(4) |
| MRT opening         | 0.11<br>(0.08)                                        | 0.23***<br>(0.08)     | 0.22***<br>(0.06)       | 0.22***<br>(0.06)     |
| N                   | 144                                                   | 152                   | 144                     | 152                   |
| R <sup>2</sup>      | 0.18                                                  | 0.26                  | 0.24                    | 0.24                  |
| Adj. R <sup>2</sup> | 0.13                                                  | 0.21                  | 0.19                    | 0.19                  |

\*p < .1; \*\*p < .05; \*\*\*p < .01. Standard errors in parentheses. Controls are excluded for brevity.

Supp. Table 2. Difference-in-differences regression results for downtown corridors, i.e., Jalan Sudirman (treatment) and Jalan H.R. Rasuna Said (control).

|                     | Dep. Variable: Average Delay (min/km) (log-transformed) |                       |                         |                       |
|---------------------|---------------------------------------------------------|-----------------------|-------------------------|-----------------------|
|                     | Morning Peak Hour                                       |                       | Evening Peak Hour       |                       |
|                     | Six months after<br>(1)                                 | One year after<br>(2) | Six months after<br>(3) | One year after<br>(4) |
| MRT opening         | -0.57<br>(0.41)                                         | -0.59**<br>(0.34)     | -0.54*<br>(0.30)        | -0.44<br>(0.34)       |
| N                   | 72                                                      | 76                    | 72                      | 76                    |
| R <sup>2</sup>      | 0.16                                                    | 0.21                  | 0.19                    | 0.17                  |
| Adj. R <sup>2</sup> | 0.06                                                    | 0.12                  | 0.09                    | 0.07                  |

\*p < .1; \*\*p < .05; \*\*\*p < .01. Standard errors in parentheses. Controls are excluded for brevity.

Supp. Table 3. Difference-in-differences regression results for peripheral corridors, i.e., Jalan Panglima Polim (treatment) and Jalan Pangeran Antasari (control).

|                     | Dep. Variable: Average Delay (min/km) (log-transformed) |                       |                         |                       |
|---------------------|---------------------------------------------------------|-----------------------|-------------------------|-----------------------|
|                     | Morning Peak Hour                                       |                       | Evening Peak Hour       |                       |
|                     | Six months after<br>(1)                                 | One year after<br>(2) | Six months after<br>(3) | One year after<br>(4) |
| MRT opening         | 0.20<br>(0.41)                                          | -0.85*<br>(0.42)      | -0.58***<br>(0.11)      | -0.65***<br>(0.10)    |
| N                   | 72                                                      | 76                    | 72                      | 76                    |
| R <sup>2</sup>      | 0.14                                                    | 0.27                  | 0.66                    | 0.68                  |
| Adj. R <sup>2</sup> | 0.03                                                    | 0.18                  | 0.61                    | 0.65                  |

\*p < .1; \*\*p < .05; \*\*\*p < .01. Standard errors in parentheses. Controls are excluded for brevity.