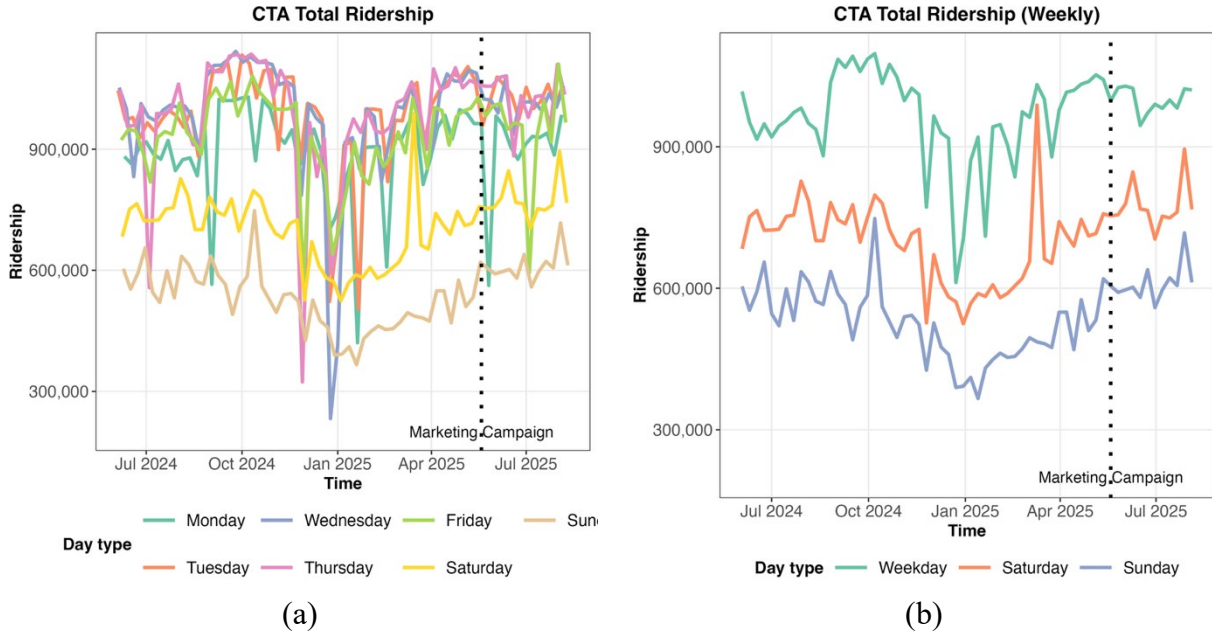


# National Transit Adaptation Strategy Phase III

## Internal Analysis of Marketing Campaign

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### 1 Chicago Transit Authority (CTA)



**Figure 1. CTA total ridership: (a) Daily ridership by day of week, (b) Weekly average ridership of weekday, Saturday, and Sunday (holidays removed)**

**Table 1. CTA ARIMA model results**

	<b>Weekday</b>		<b>Saturday</b>				<b>Sunday</b>			
	Pre-intervention model (3, 0, 5)		Pre-intervention model (5, 1, 3)		Full model (5, 0, 4)		Pre-intervention model (5, 1, 3)		Full model (5, 0, 5)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
ar1	1.12	0.26***	-0.15	0.20	0.68	0.16***	-1.53	0.20***	1.11	0.21***
ar2	0.52	0.49	0.28	0.20	0.24	0.19	-1.83	0.23***	-1.49	0.23***
ar3	-0.70	0.25**	-0.51	0.15**	0.60	0.10***	-1.58	0.28***	1.18	0.27***
ar4	-	-	-0.28	0.17	-0.94	0.13***	-0.98	0.21***	-0.65	0.18***
ar5	-	-	-0.32	0.16*	0.20	0.15	-0.55	0.12***	0.61	0.13***
ma1	-0.82	0.28**	-0.55	0.20*	-0.49	0.14***	1.08	0.22***	-0.84	0.24***
ma2	-0.89	0.43*	-0.48	0.24	-0.34	0.18	1.27	0.37**	1.84	0.17***
ma3	0.68	0.25*	0.97	0.22***	-0.49	0.15**	0.70	0.32*	-1.14	0.39**
ma4	0.47	0.16**	-	-	1.00	0.13***	-	-	1.18	0.16***
ma5	-0.43	0.14**	-	-	-	-	-	-	-0.45	0.22*
intercept	961104.10	8137.60***	-	-	686649.60	23686.20***	-	-	546992.20	34528.84***
Intervention indicator	-	-	-	-	117053.00	40296.50**	-	-	53321.35	35116.47
MAPE <sup>1</sup>	5.47%		5.66%		5.18%		7.49%		6.32%	
N	50		49		62		49		62	
Ljung-Box statistics on residuals (p-value)	3.93 (0.269)		2.48 (0.479)		2.17 (0.539)		5.60 (0.133)		7.19 (0.066)	
KPSS Unit Root Test <sup>2</sup>										
d=0	0.17		0.39		0.29		0.63		0.34	
d=1	0.12		0.09		0.06		0.20		0.14	
d=2	0.13		0.12		0.14		0.19		0.26	

Notes:

\*\*\* Coefficient is statistically significant at the 0.001 level.

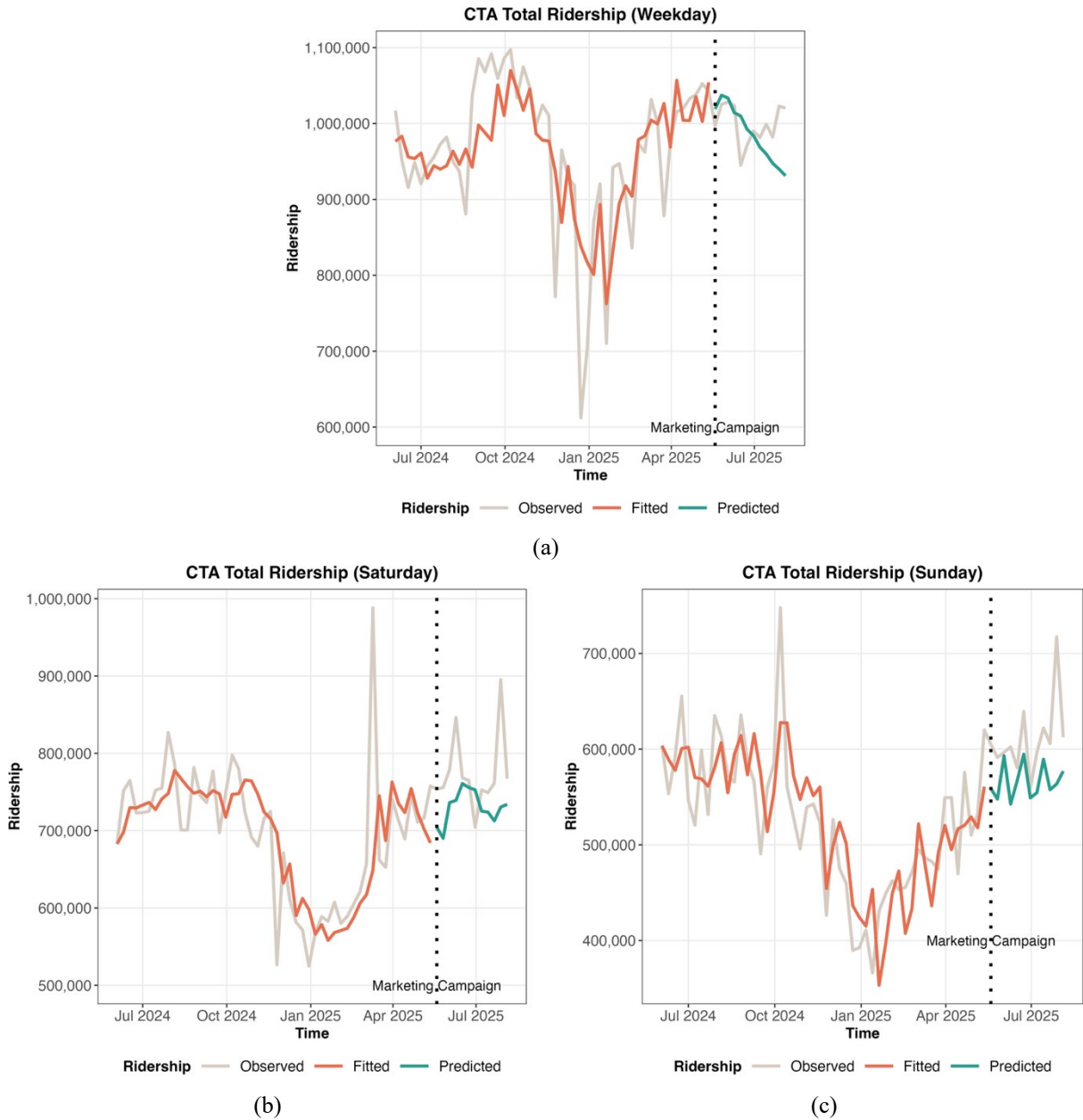
\*\* Coefficient is statistically significant at the 0.01 level.

\* Coefficient is statistically significant at the 0.05 level.

· Coefficient is statistically significant at the 0.1 level.

<sup>1</sup> Mean absolute percentage error:  $\frac{1}{N} \sum_{i=1}^N \frac{|Observed\ ridership_i - predicted\ ridership_i|}{Observed\ ridership_i}$ . MAPE is commonly used as a forecast error measure. We did not use information criteria such as AIC since they are not comparable across different orders of differencing.

<sup>2</sup> KPSS significance level (critical values): 0.05 (0.463); 0.025 (0.574); 0.001 (0.739)



**Figure 2. CTA observed and predicted ridership** Note: Since the time series data is aggregated on a weekly basis, there will be a one-week gap between the end of the fitted line and the start of the predicted line on the time axis.

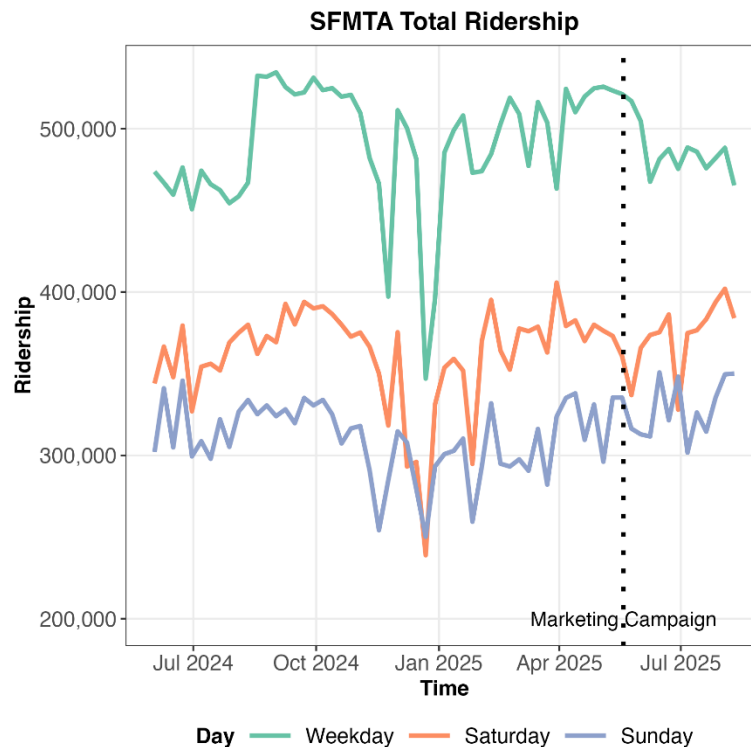
#### Summary:

- Weekday pre-intervention model: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was not significantly higher than predicted ridership ( $t = 0.98$ ,  $p = 0.174$ ). Therefore, we did not proceed with the full model.
- Saturday models: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was significantly higher than predicted ridership ( $t = 2.90$ ,  $p = 0.007$ ). We proceed with the full model including an intervention

dummy variable to represent the effect of the Marketing Campaign. Consistent with the paired t-test results, the intervention indicator has positive and significant coefficient. On average, the Marketing Campaign increases Saturday ridership by 117053 passengers per day.

- Sunday models: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was significantly higher than predicted ridership ( $t = 4.00$ ,  $p = 0.001$ ). We proceed with the full model including an intervention dummy variable to represent the effect of the Marketing Campaign. Although the coefficient of the intervention indicator is positive, it is not significant.
- Interpretation: Marketing Campaign in Chicago did not significantly increase weekday transit ridership for the three months after the campaign started, but positively influence Saturday and Sunday ridership. The Marketing Campaign may first influence the non-work travel on weekends and may take longer time or more efforts (e.g., more frequent service, improve safety) to alter commuters.

## 2 San Francisco Municipal Transportation Authority (SFMTA)



**Figure 3. SFMTA Weekly Ridership**

**Table 2. SFMTA ARIMA model results**

	Weekday		Saturday				Sunday			
	Pre-intervention model (3, 0, 5)		Pre-intervention model (4, 0, 4)		Full model (5, 0, 3)		Pre-intervention model (5, 1, 3)		Full model (5, 0, 5)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
ar1	1.03	0.09***	0.98	0.14***	-0.54	0.17**	0.82	0.18***	-1.61	0.12***
ar2	-0.76	0.10***	0.29	0.22	-0.10	0.30	-0.12	0.12	-1.88	0.21***
ar3	-	-	0.21	0.20	-0.37	0.15*	-0.39	0.09***	-1.43	0.26***
ar4	-	-	-0.58	0.13***	0.42	0.17*	0.91	0.13***	-0.96	0.21***
ar5	-	-	-	-	0.37	0.12**	-0.63	0.17***	-0.50	0.12***
ma1	-1.50	0.09***	-0.81	0.13***	0.96	0.15***	-0.68	0.17***	0.04	0.10
ma2	1.00	0.11***	-0.37	0.09***	0.72	0.36	0.26	0.22	0.01	0.11
ma3	-	-	-0.81	0.14***	0.76	0.30*	0.25	0.16	-0.97	0.11***
ma4	-	-	1.00	0.14***	-	-	-0.75	0.18***	-	-
ma5	-	-	-	-	-	-	0.92	0.24***	-	-
intercept	-	-	358790.10	808.81***	363149.40	8420.23***	311118.70	5666.14***	-	-
Intervention indicator	-	-	-	-	6591.03	15448.51	-	-	-4684.53	15035.36
MAPE <sup>1</sup>	4.08%		4.26%		4.88%		4.56%		4.40%	
N	50		51		63		51		61	
Ljung-Box statistics on residuals (p-value)	3.26 (0.775)		4.59 (0.204)		5.55 (0.136)		4.72 (0.194)		3.42 (0.332)	
KPSS Unit Root Test <sup>2</sup>										
d=0	0.18		0.13		0.18		0.28		0.31	
d=1	0.06		0.07		0.05		0.09		0.08	
d=2	0.06		0.07		0.07		0.16		0.16	

Notes:

\*\*\* Coefficient is statistically significant at the 0.001 level.

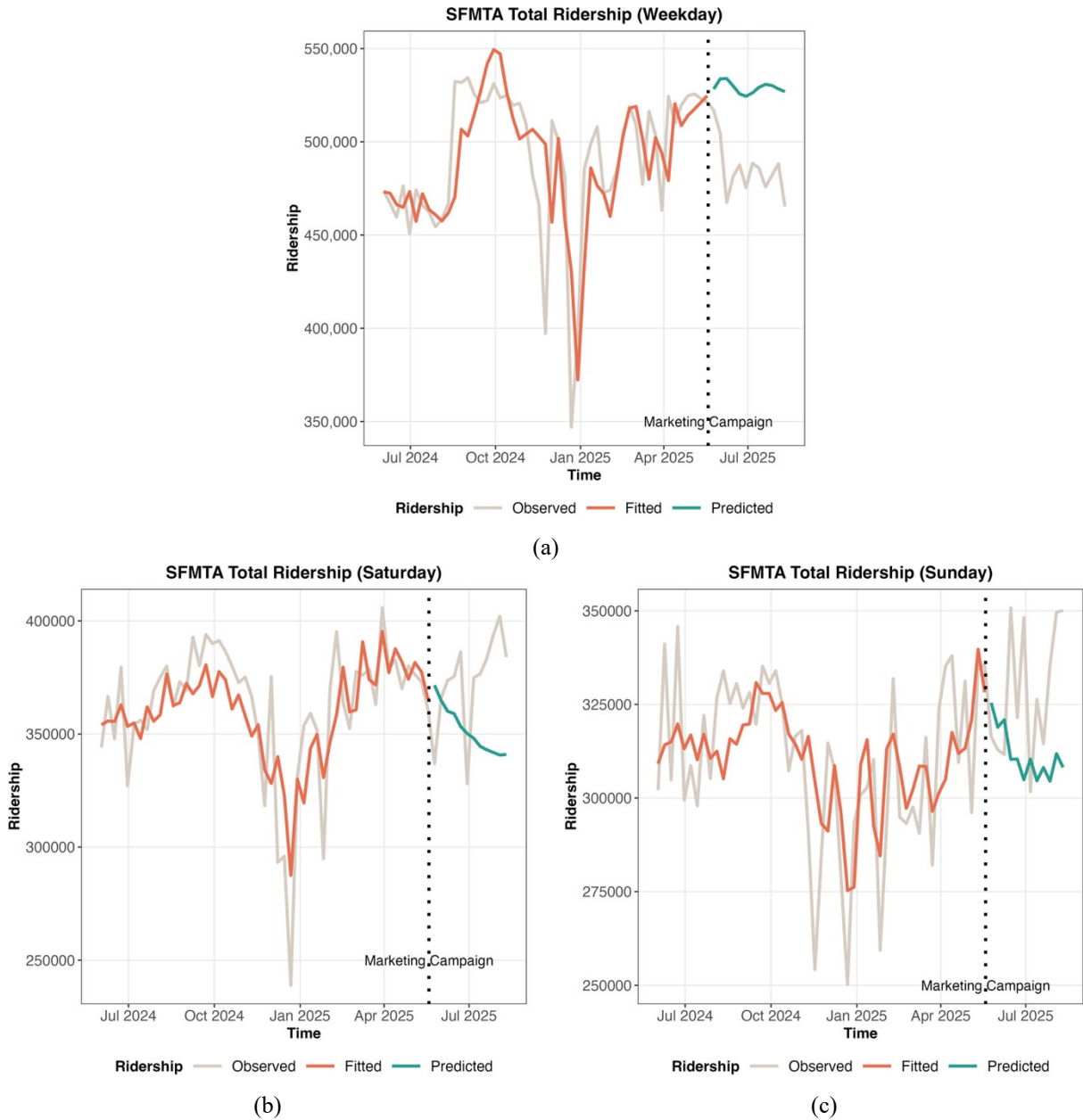
\*\* Coefficient is statistically significant at the 0.01 level.

\* Coefficient is statistically significant at the 0.05 level.

· Coefficient is statistically significant at the 0.1 level.

<sup>1</sup> Mean absolute percentage error:  $\frac{1}{N} \sum_{i=1}^N \frac{|Observed\ ridership_i - predicted\ ridership_i|}{Observed\ ridership_i}$ . MAPE is commonly used as a forecast error measure. We did not use information criteria such as AIC since they are not comparable across different orders of differencing.

<sup>2</sup> KPSS significance level (critical values): 0.05 (0.463); 0.025 (0.574); 0.001 (0.739)



**Figure 4. SFMTA observed and predicted ridership**

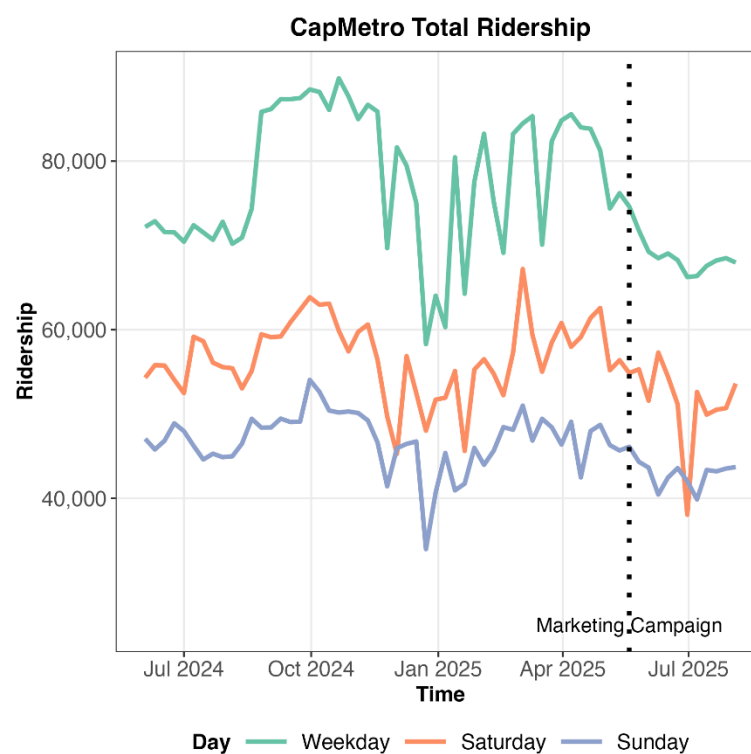
Summary:

- Weekday pre-intervention model: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was not significantly higher than predicted ridership ( $t = -10.40$ ,  $p = 1.00$ ). Therefore, we did not proceed with the full model.
- Saturday models: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was significantly higher than predicted ridership ( $t = 2.62$ ,  $p = 0.012$ ). We proceed with the full model including an intervention

dummy variable to represent the effect of the Marketing Campaign. Although the coefficient of the intervention indicator is positive, it is not significant.

- Sunday models: Paired t-tests comparing observed and predicted values after the intervention indicate that observed ridership was significantly higher than predicted ridership ( $t = 2.66$ ,  $p = 0.011$ ). We proceed with the full model including an intervention dummy variable to represent the effect of the Marketing Campaign. However, the coefficient is not significant.
- Interpretation: Similar to Chicago, the Marketing Campaign in San Francisco did not significantly increase weekday transit ridership during the first three months after its launch, but it does appear to have a positive impact on weekend ridership.

### 3 Capital Metropolitan Transportation Authority (CapMetro)



**Figure 5. CapMetro total ridership**

**Table 3. WMATA ARIMA model results**

	<b>Weekday</b>		<b>Saturday</b>		<b>Sunday</b>	
	Pre-intervention model (5, 1, 2)		Pre-intervention model (5, 1, 4)		Pre-intervention model (3, 0, 5)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
ar1	1.25	0.14***	-0.70	0.13***	-0.06	0.23
ar2	-0.19	0.21	-0.40	0.14**	-0.11	0.24
ar3	-0.15	0.21	0.08	0.16	0.53	0.16**
ar4	0.36	0.21	0.72	0.14***	-	-
ar5	-0.39	0.13**	0.47	0.13***	-	-
ma1	-2.00	0.24***	0.45	0.11***	0.45	0.26
ma2	1.00	0.24***	0.00	0.15	0.33	0.31
ma3	-	-	-0.45	0.12***	-0.22	0.21
ma4	-	-	-1.00	0.14***	0.35	0.14*
ma5	-	-	-	-	0.45	0.21*
Intercept					46907.67	1168.74***
MAPE	5.05%		3.47%		3.68%	
N	49		49		50	
Ljung-Box statistics on residuals (p-value)	6.08 (0.108)		6.20 (0.103)		3.21 (0.361)	
KPSS Unit Root Test <sup>1</sup>						
d=0	0.14		0.12		0.15	
d=1	0.09		0.08		0.06	
d=2	0.10		0.09		0.08	

Notes:

\*\*\* Coefficient is statistically significant at the 0.001 level.

\*\* Coefficient is statistically significant at the 0.01 level.

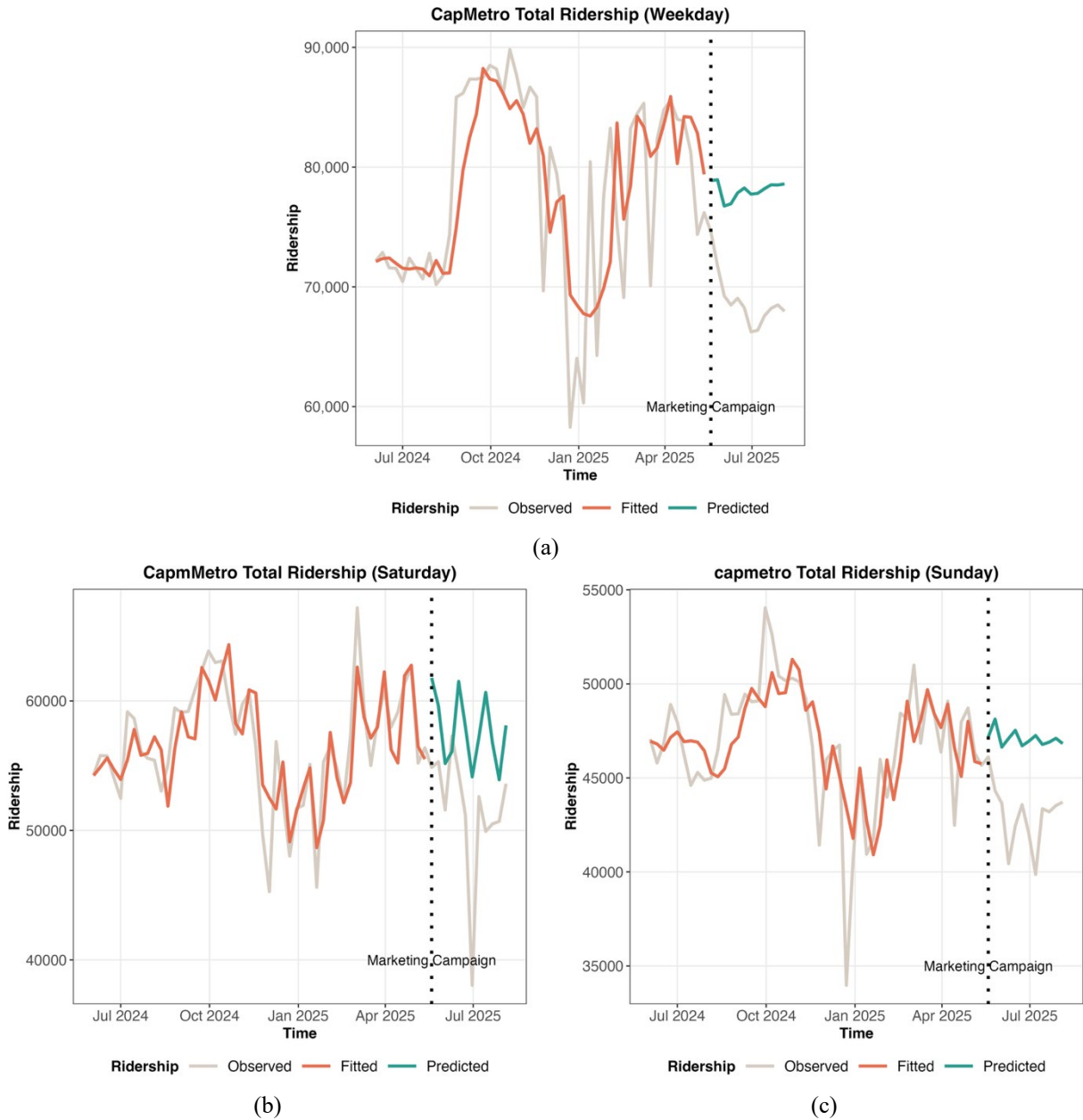
\* Coefficient is statistically significant at the 0.05 level.

· Coefficient is statistically significant at the 0.1 level.

<sup>1</sup> Mean absolute percentage error:  $\frac{1}{N} \sum_{i=1}^N \frac{|Observed\ ridership_i - predicted\ ridership_i|}{Observed\ ridership_i}$ . MAPE is commonly used as a forecast error measure. We did not use information criteria such as AIC since they are not comparable across different orders of differencing.

<sup>2</sup> KPSS significance level (critical values): 0.05 (0.463); 0.025 (0.574); 0.001 (0.739)





**Figure 6. CapMetro observed and predicted ridership**

Summary:

- All three pre-intervention models predict much higher ridership than the predicted ridership. Since CapMetro reduces their service during summer, the analysis is subject to compound effect of multiple treatments. The model cannot distinguish the two treatments.