



ABSTRACT

This paper examines impacts of the COVID-19 pandemic upon bus ridership through autoregression and multi-linear regression models. Measuring the impacts of the pandemic upon the bus transportation system is important because public transportation authorities can use this modeling approach to recognize how COVID-19 affects system ridership. The models developed use 2019 and 2020 ridership data from three high frequency routes run by the Capital Metro Transportation Authority in Austin, TX. Each route's autoregression model revealed that daily ridership can be explained by lagging the 2019 to 2020 ridership data by 5, 7, 12, and 14 days ($R^2 = \sim 75\%$). These lags capture major trend changes, such as when the first case of COVID-19 appeared in Travis County. The weekday and weekend multi-linear regression models used 2020 COVID-19 daily confirmed case and fatality data as the independent variables. The weekday models show a significant decrease in bus ridership from the increase in COVID-19 cases and fatalities during the business week. On Saturdays, ridership is not significantly related to the COVID-19 variables. However, the Sunday models show a significant relationship between increasing fatalities and decreasing daily ridership. One conclusion is that trips happening on Saturday are more essential and are not as significantly affected by the spread of the virus in comparison to trips happening during the weekdays and Sundays.

METHODOLOGY

- Data**
- Ridership Data**
 - Daily ridership from Cap Metro high frequency bus routes (Routes: 7, 325, and 300)
 - January 1st, 2019, to December 31st, 2020,
 - COVID-19 Case and Fatality Data**
 - COVID-19 case, and fatality data (Texas Department of State Health Services)
 - January 1st, 2020, to December 31st, 2020.
 - Both confirmed cases and fatality cases = total daily count for Travis County, Texas.

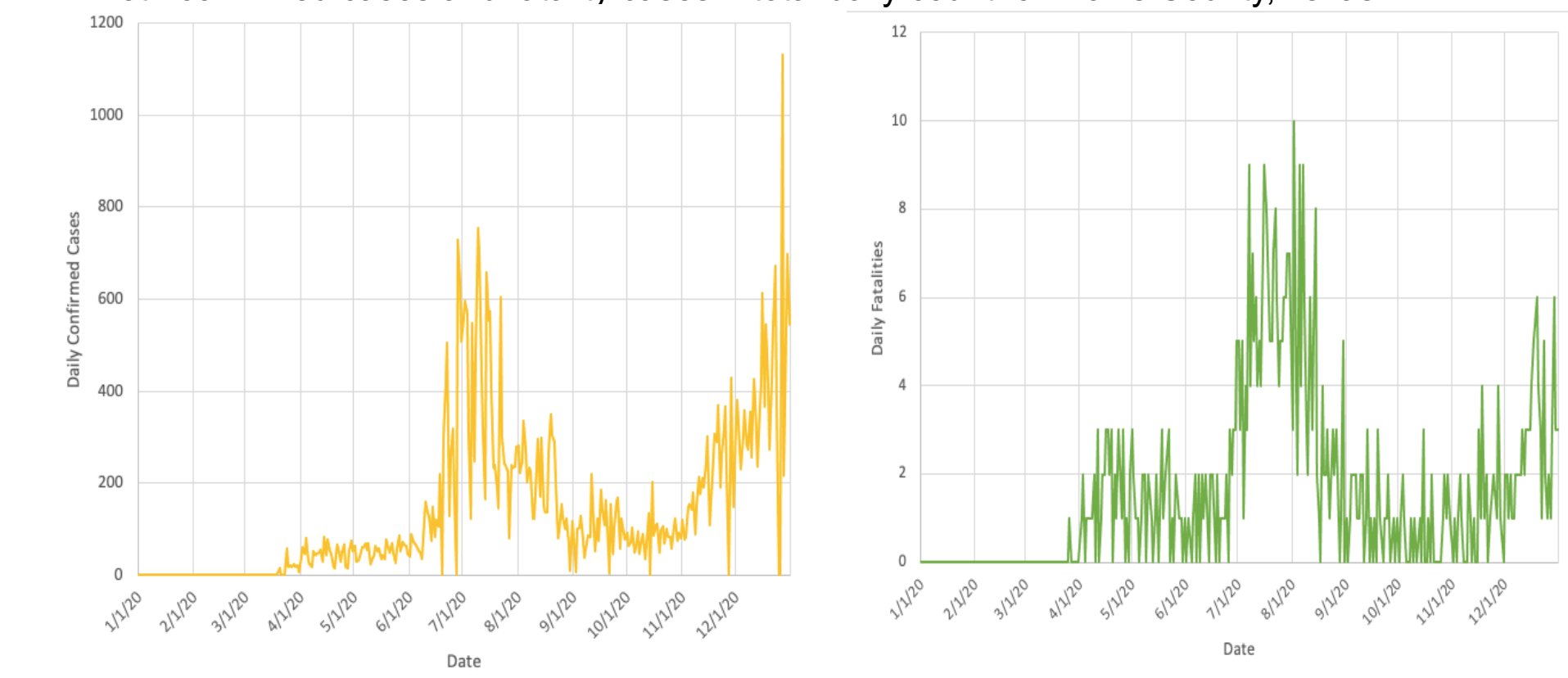


Figure 1. Daily Confirmed COVID-19 Cases and Fatalities in Travis County

Models

- Autoregression (AR)**
 - Helps predict future datapoints from past datapoints.
 - Predicted Variable:** Daily Ridership
 - Explanatory Variables:** 5-day lag, 7-day lag, 12-day lag, 14-day lag
- Multi-Linear**
 - Linear regression model with two or more explanatory variables
 - Predicted Variable:** Daily Ridership
 - Explanatory Variables:** Daily COVID-19 Cases and Fatalities

RESEARCH QUESTION

How has the pandemic affected public transportation and how does one capture and measure these effects?

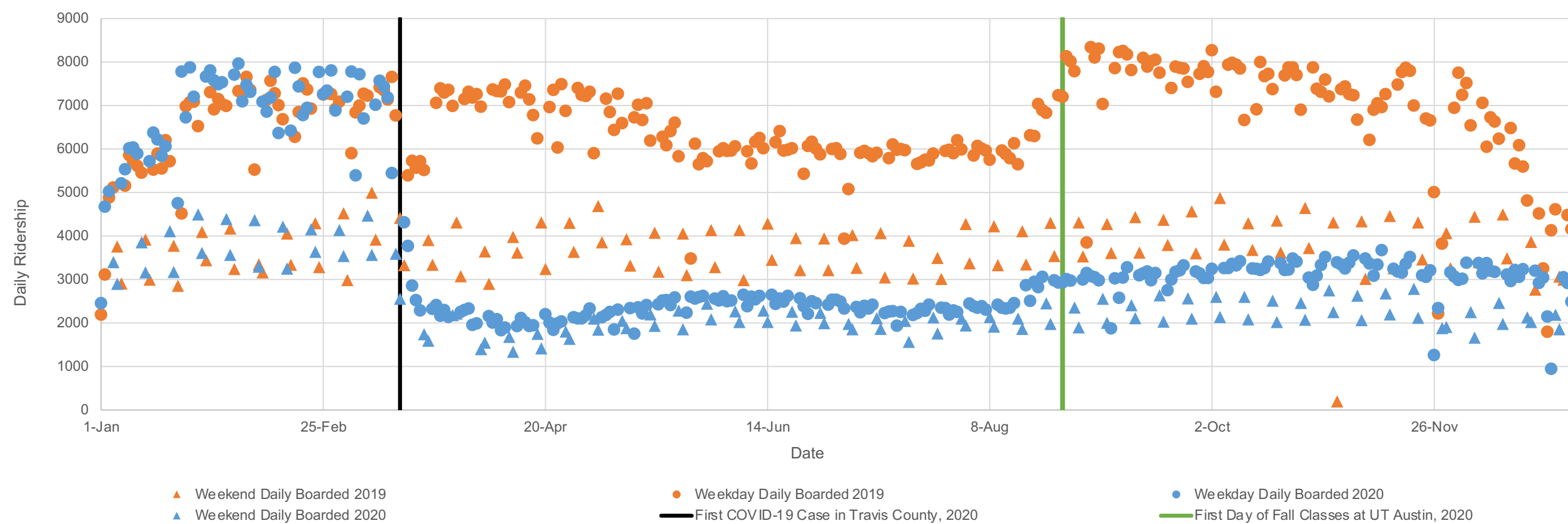


Figure 2. Route 7 Daily Boarded Passengers for 2019 and 2020

RESULTS

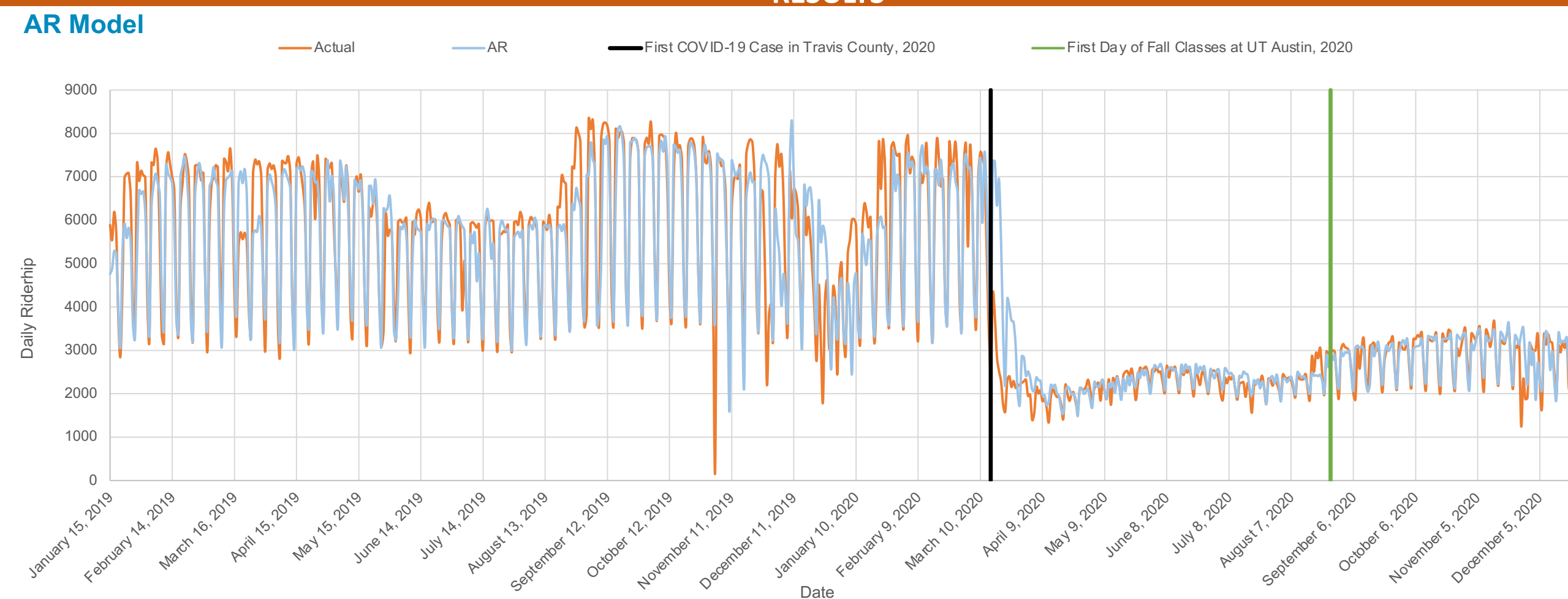


Figure 3. Autoregression Model for Route 7

Route 7					
Adjusted R ²	0.864				
Standard Error	765.847				
Observations	717.00				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>P-value</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	158.701	76.974	0.040	7.577	309.824
LAG 5	0.226	0.038	<0.000	0.150	0.301
LAG 7	0.619	0.038	<0.000	0.544	0.693
LAG 12	-0.200	0.039	<0.000	-0.276	-0.125
LAG 14	0.315	0.038	<0.000	0.240	0.389

Multi-Linear Model Weekday

Route 7					
Adjusted R ²	0.197				
Standard Error	1586.421				
Observations	262.000				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>P-value</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	4222.795	132.768	<0.000	3961.353	4484.237
Cumulative Confirmed COVID-19	-2.350	0.692	0.001	-3.712	-0.988
Cumulative COVID-19 Fatalities	-261.402	60.506	<0.000	-380.548	-142.257

Saturday

Route 7					
Adjusted R ²	0.196				
Standard Error	744.950				
Observations	52.000				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>P-value</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	3023.080	145.653	<0.000	2730.378	3315.781
Cumulative Confirmed COVID-19	-1.760	0.962	0.073	-3.692	0.173
Cumulative COVID-19 Fatalities	-97.323	56.250	0.090	-210.361	15.716

Sunday

Route 7					
Adjusted R ²	0.247				
Standard Error	535.434				
Observations	52.000				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>P-value</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	2514.506	103.230	<0.000	2307.056	2721.955
Cumulative Confirmed COVID-19	-0.668	0.387	0.091	-1.446	0.110
Cumulative COVID-19 Fatalities	-130.042	36.816	0.001	-204.025	-56.058

CONCLUSION

AR time lags captured major trend changes

Multi-Linear Models confirmed that **increases** in COVID-19 cases and fatalities cause a **decrease** in daily ridership

- Weekday:** increases in COVID-19 cases and fatalities result in decrease in ridership
- Saturday:** have **no significant relationship** between the COVID-19 variables and ridership
- Sunday:** increases in COVID-19 fatalities result in decreases in ridership.
- Maybe Saturday trips are more essential than Sunday trips?

Fatalities have a **greater impact** on ridership than confirmed cases

TxDOT APPLICATION

- These models can aid TxDOT in reallocating and **distributing funding** toward transit authorities.
- Accurate estimate of ridership during a pandemic, TxDOT can figure out which transit routes are the **most essential**.
- Essential routes provide trips that are considered essential to survival (i.e., grocery store or the doctor's office)
- Can be applied to metropolitan as well as rural authority networks.

DIRECTIONS FOR FUTURE WORK

- Add the daily number of people getting vaccinated for COVID-19 into the AR and multi-linear models