

# Fondren Library Building Traffic

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# Overview

# Fondren Library: Changes in Traffic

- Possible Trend
  - Steadily increasing building traffic since renovation in 2015-16
- COVID-19 Disruption
  - Building closed due to March 13, 2020 through July 6, 2020
  - Jan-March visitor counts data lost due to staff turnover
  - Fall 2020: Reduced hours
  - Fall 2020: 50% decrease in available seating
  - Fall 2020: SMU Flex Red & Blue schedule meant only 50% of students on campus at a time.



# Questions of Interest

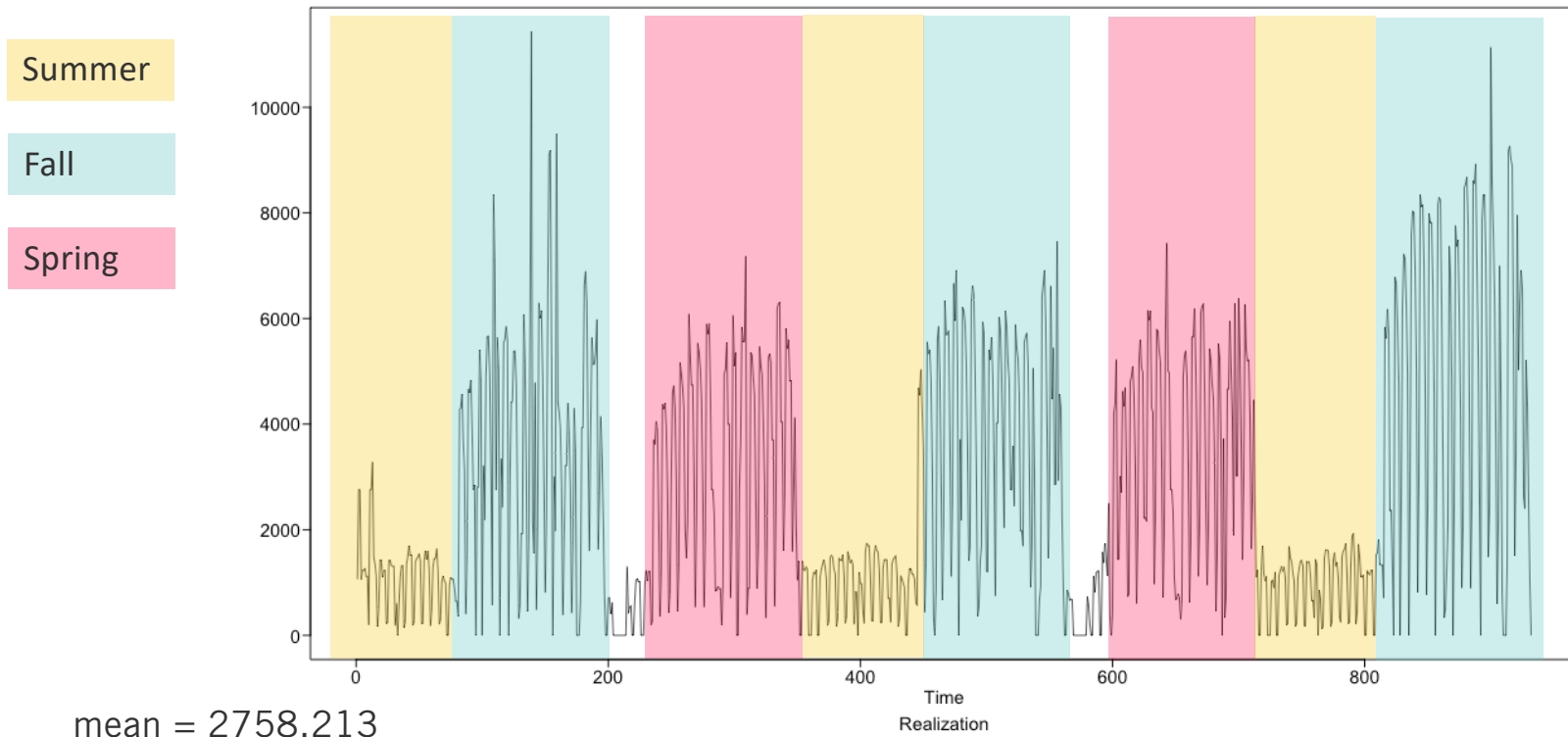
- Question 1: Did overall gate counts have an increasing trend prior to the pandemic?
- Question 2: How did COVID-19 closures impact gate counts?

# About the Data

# Original Fondren Gate Count Dataset

- Date Range: June 1, 2017 – December 20, 2019
- Total Observations: 933
- Original Variables
  - Date
  - Number of Visitors

# Original Dataset Realization

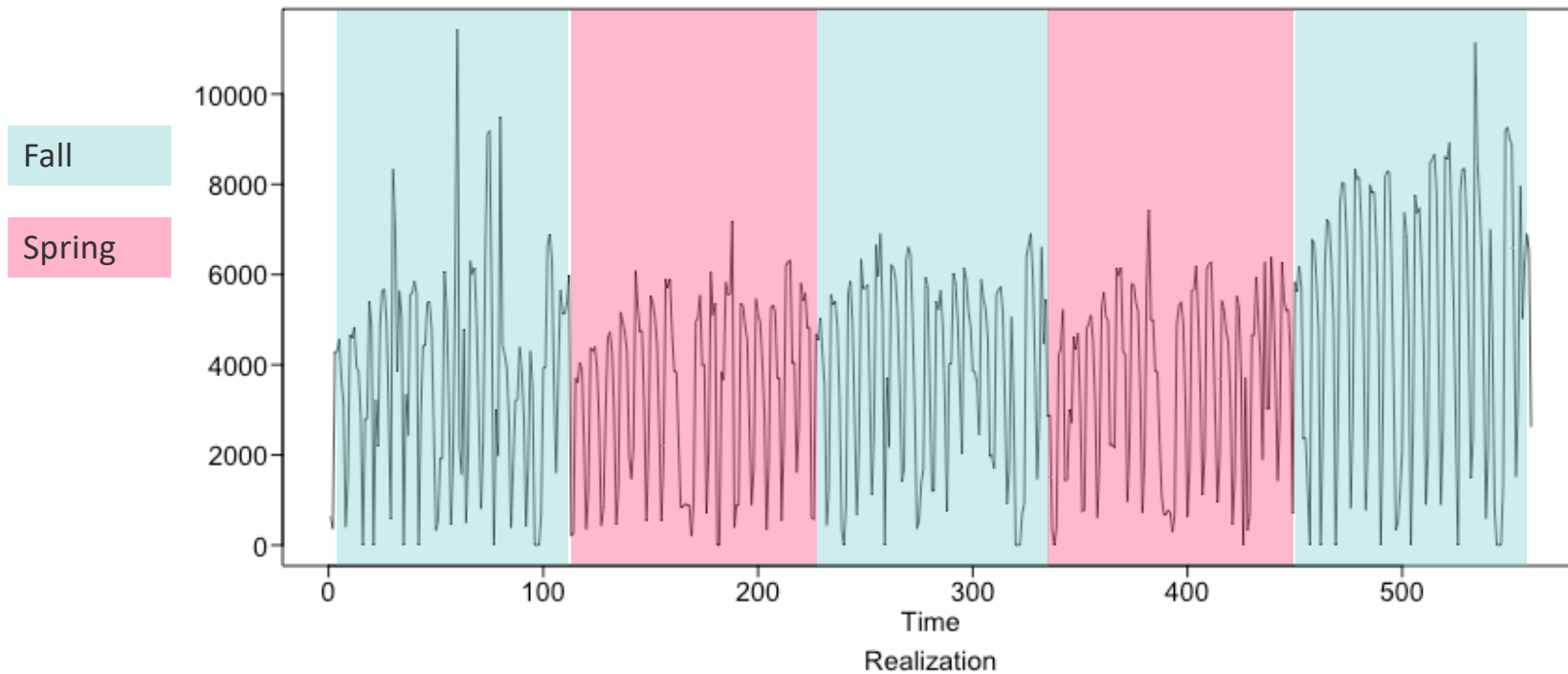


# Revised Fondren Gate Count Dataset

- Date Range: June 1, 2017 – December 20, 2019
- Limited to fall & spring semesters only
- Total Days: 560
- Variables Available
  - Date
  - Number of Visitors
  - Week Number of Semester
  - Day of the Week

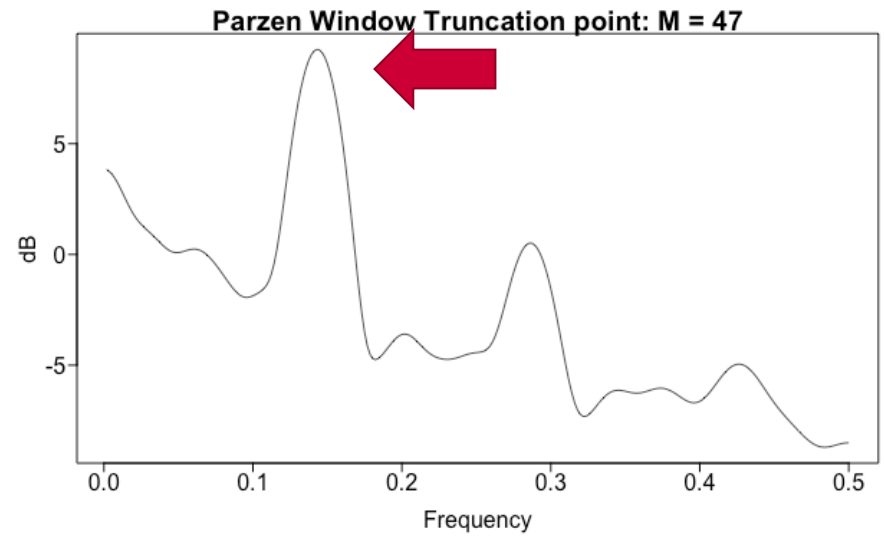
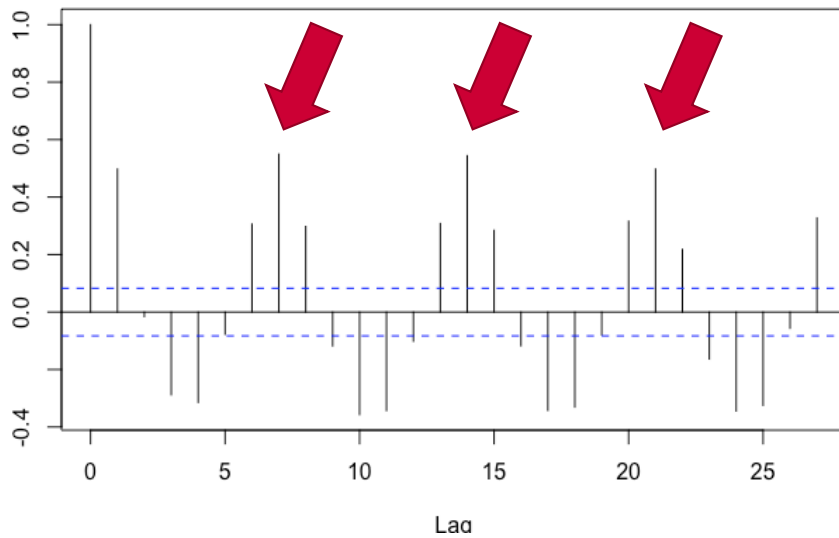


# Revised Dataset Realization



mean = 3916.712

# ACF and Spectral Density



# Addressing Seasonality

Overfitting the model to identify seasonal patterns

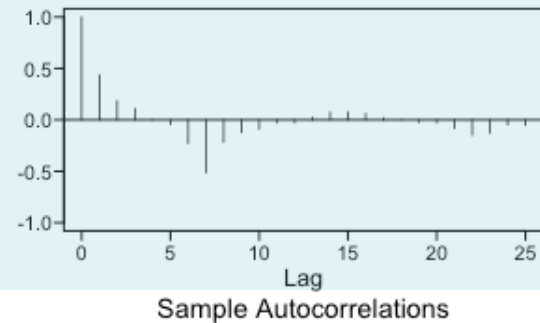
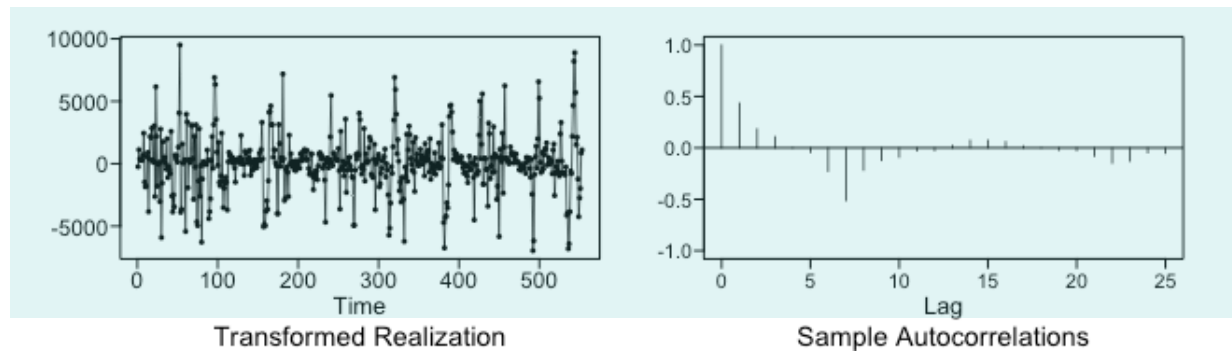
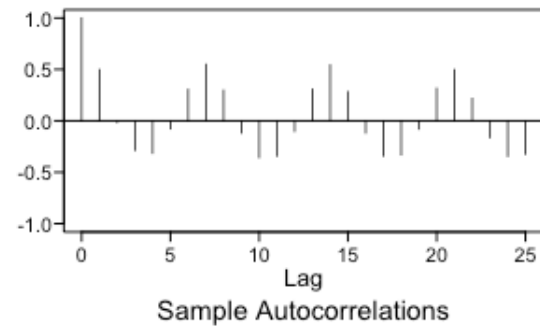
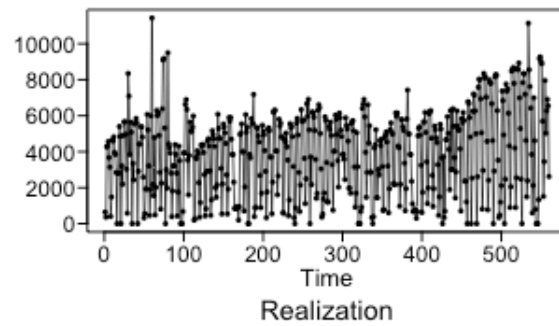
## Gate Count Data

Factor	Roots	Abs Recip	System Freq
$1-1.2264B+0.9700B^2$	$0.6321+-0.7945i$	0.9849	0.1430
$1+0.4271B+0.9053B^2$	$-0.2359+-1.0242i$	0.9515	0.2860
$1-0.9159B$	1.0919	0.9159	0.0000
$1+1.6321B+0.8148B^2$	$-1.0016+-0.4735i$	0.9027	0.4297
$1+1.1610B+0.7923B^2$	$-0.7326+-0.8517i$	0.8901	0.3631
$1-0.3551B+0.7902B^2$	$0.2247+-1.1023i$	0.8889	0.2180
$1-1.6230B+0.7885B^2$	$1.0292+-0.4572i$	0.8880	0.0665
$1+0.8450B$	-1.1834	0.8450	0.5000
$1-0.4238B$	2.3598	0.4238	0.0000

## s=7 Factor Table

Factor	Roots	Abs Recip	System Freq
$1-1.0000B$	1.0000	1.0000	0.0000
$1+0.4450B+1.0000B^2$	$-0.2225+-0.9749i$	1.0000	0.2857
$1-1.2470B+1.0000B^2$	$0.6235+-0.7818i$	1.0000	0.1429
$1+1.8019B+1.0000B^2$	$-0.9010+-0.4339i$	1.0000	0.4286

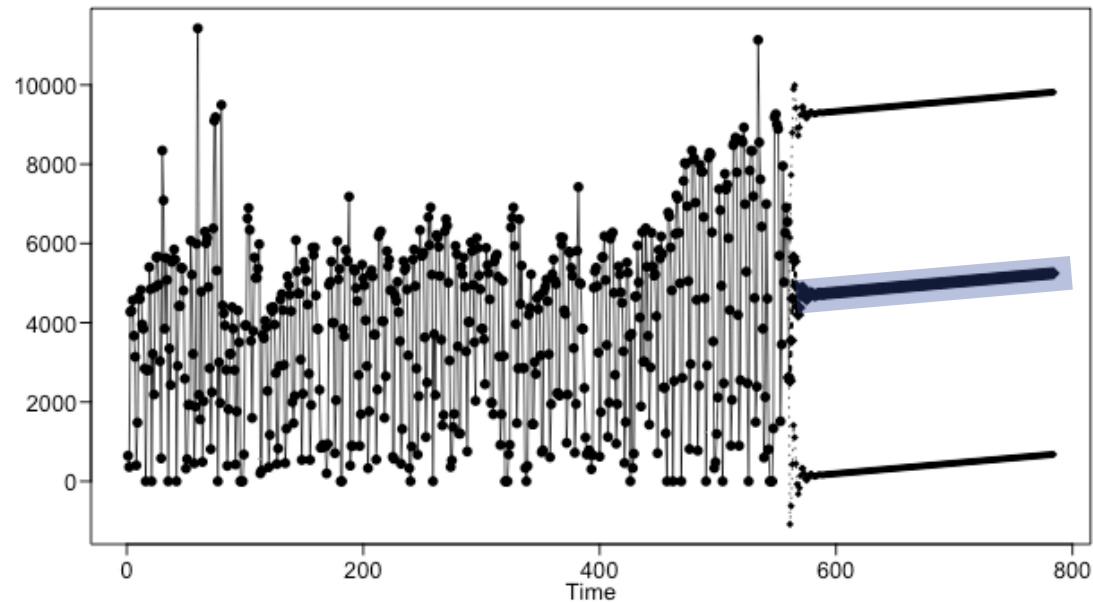
# Transformation – Removing the $s=7$



# Univariate Models

# Signal Plus Noise Model

$$\text{visitors} = 3174 + 2.6455(\text{days})$$



**Slope: 2.645543**

*Question #1: Visual evidence to suggest that the number of visitors to Fondren Library is increasing over time.*

# Cochrane-Orcutt Procedure

```
> cfit = cochrane.orcutt(fit)
> summary(cfit)
Call:
lm(formula = x ~ t, data = df)

            Estimate Std. Error t value Pr(>|t|)
(Intercept) 3216.7646   335.9848   9.574 < 2e-16 ***
t            2.5151     1.0343    2.432 0.01534 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2044.96 on 557 degrees of freedom
Multiple R-squared:  0.0105 , Adjusted R-squared:  0.0087
F-statistic: 5.9 on 1 and 557 DF, p-value: < 1.534e-02

Durbin-Watson statistic
(original):  1.03431 , p-value: 7.465e-31
(transformed): 1.64541 , p-value: 1.108e-05
```

- Conclusion: Reject the null hypothesis. There is evidence to suggest that the slope does not equal 0 ( $p\text{-value} < .015$ ,  $\alpha = .05$ )
- Therefore, reasonably confident there is a deterministic, positive trend with slope around 2.5151.

# Building the ARIMA(p,d,q) Model: *Identifying Parameters & Coefficients*

AIC	Five Smallest Values of			aic
	p	q	aic	
18	5	2	15.12607	
15	4	2	15.16240	
12	3	2	15.17845	
4	1	0	15.22296	
5	1	1	15.22652	

BIC	Five Smallest Values of			bic
	p	q	bic	
18	5	2	15.18850	
15	4	2	15.21702	
12	3	2	15.22527	
4	1	0	15.23857	
5	1	1	15.24993	

```

> Xs.arma
$phi
[1] 0.41069522 0.78321460 -0.27787570 0.01083583 -0.18535146

$theta
[1] 0.06113105 0.88951583
  
```

ARMA(5,2)  
values

## Candidate Model

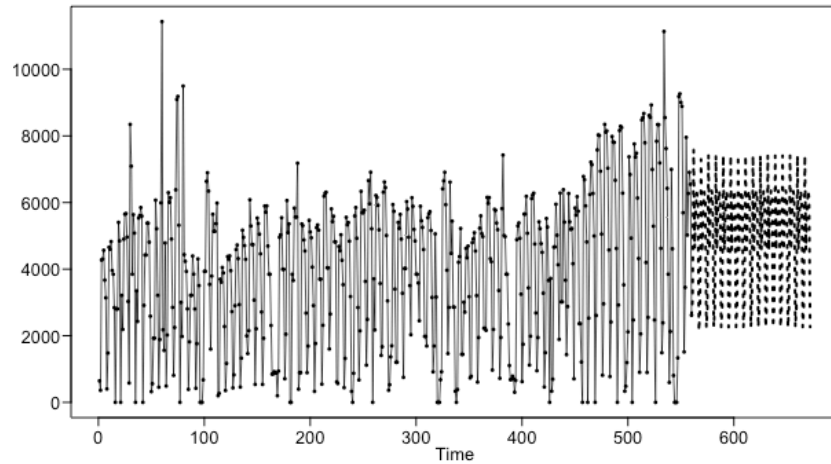
**ARIMA(5,0,2), s=7**

$$(1-B^7)(1-.410B-.783B^2 + .277B^3-.010B^4+.185B^5)(X_t - 3916.712) = (1-.061B-.889B^2)a_t$$



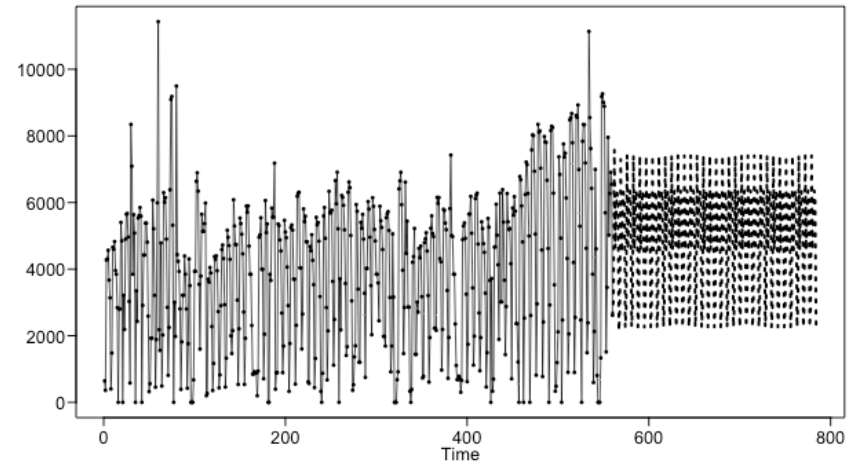
# Univariate Model: ARIMA(5,0,2), s=7

*Predictions for Spring 2020*



ASE = 5,143,247

*Predictions for Spring & Fall 2020*



ASE = 6,257,223

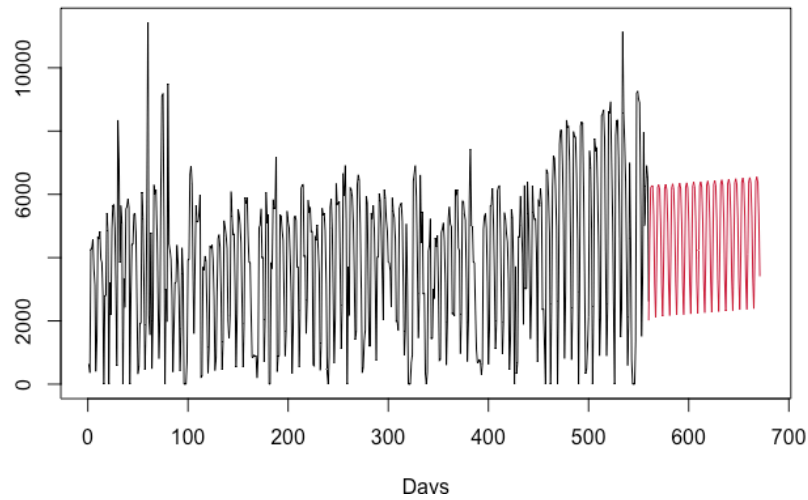
# Multivariate Models

# Vector Autoregressive Model

- Multiple regressors included:
  - lagged visitors
  - day of the week
- VARselect:  $p = 7$

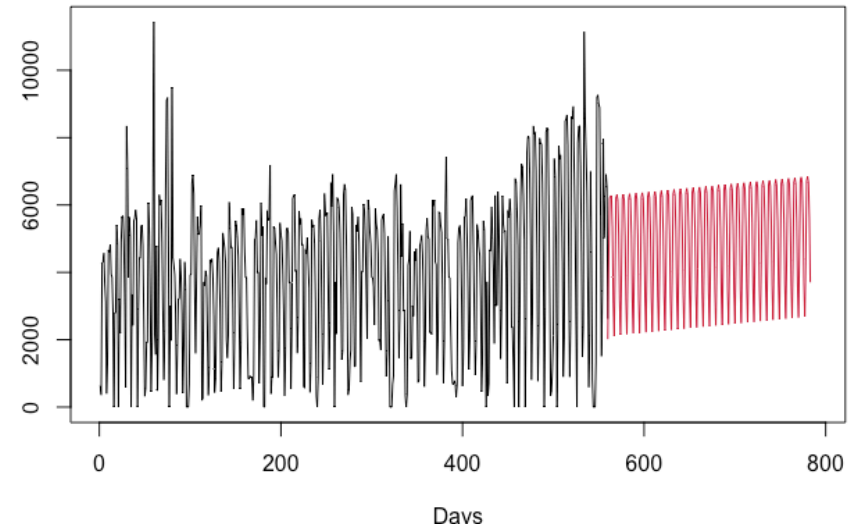
# VAR(7) Model - Predictions

*Predictions for Spring 2020*



ASE = 5,504,134

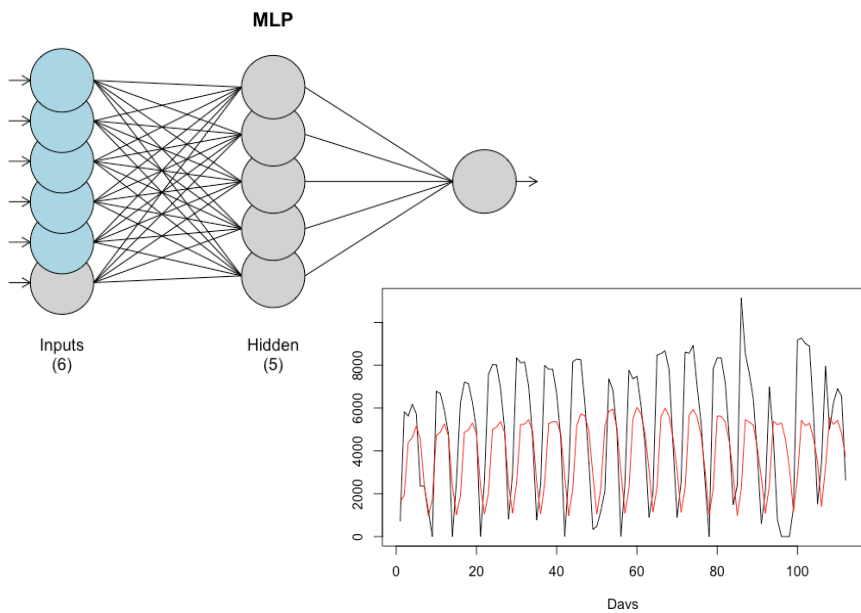
*Predictions for Spring & Fall 2020*



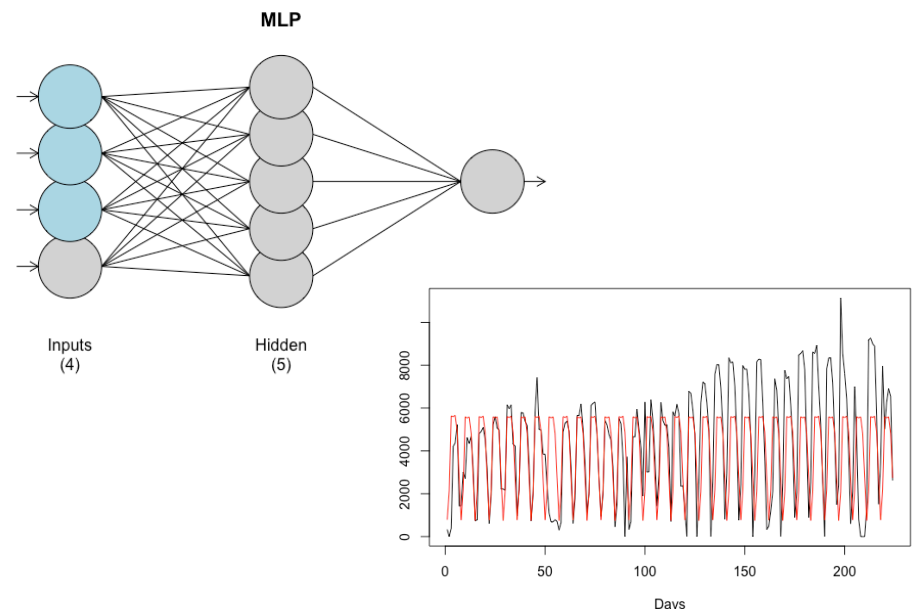
ASE = 4,547,001

# Neural Network Model

*Predictions for Spring 2020*

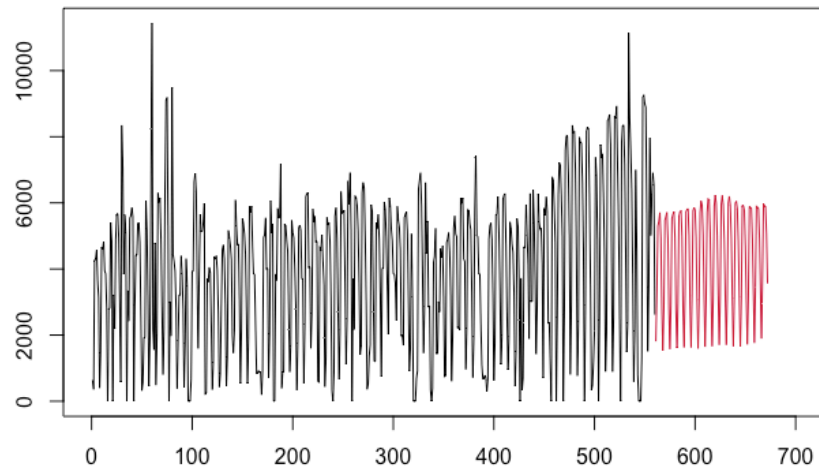


*Predictions for Spring & Fall 2020*



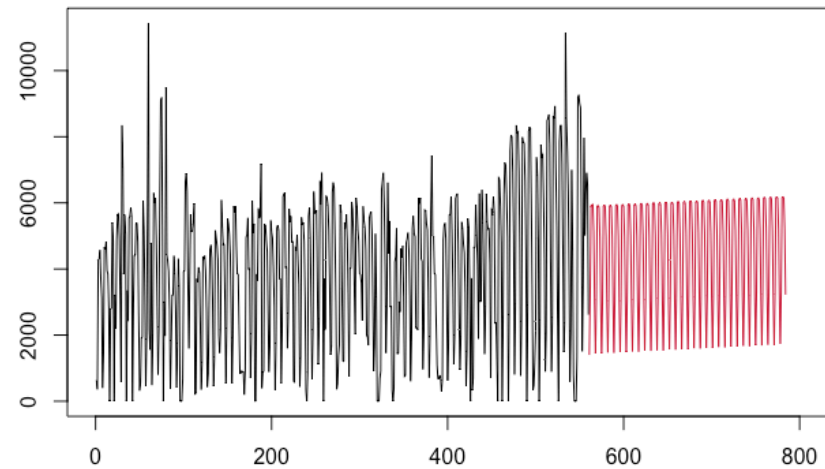
# Neural Network Model Predictions

*Predictions for Spring 2020*



Index  
ASE = 7,918,749

*Predictions for Spring & Fall 2020*



Index  
ASE = 5,141,396

# Ensemble Model

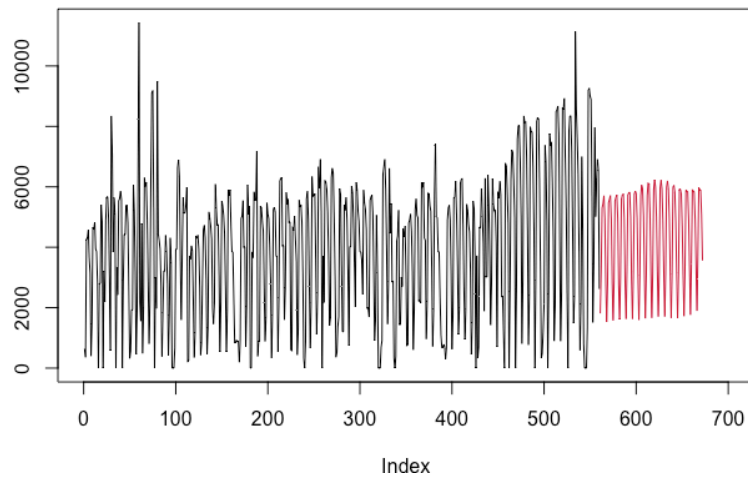
**MLP model**



**VAR(7)**

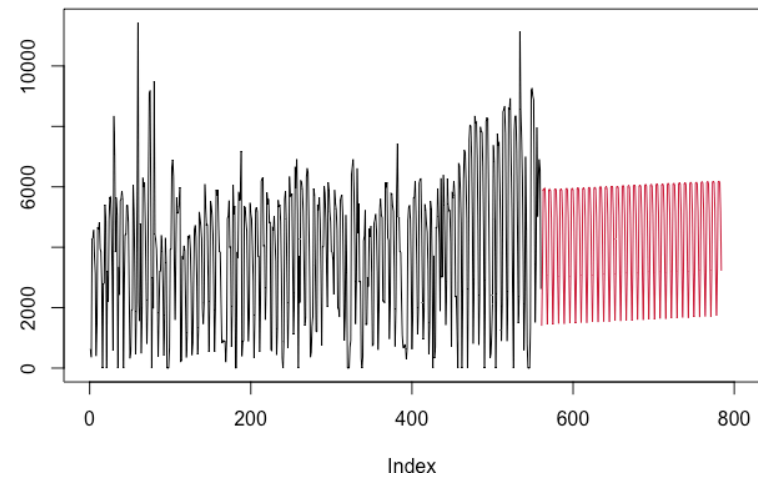
# Ensemble Model

*Predictions for Spring 2020*



ASE = 6,442,674


*Predictions for Spring & Fall 2020*



ASE = 4,487,149



# Model Comparison

Model	Spring 2020 ASE	Spring & Fall 2020 ASE
ARIMA(5,0,2), s=7	5,143,247	6,257,223
VAR(7)	5,504,134	4,547,001
MLP (visitors alone)	7,796,298	4,748,041
MLP	7,918,749	5,141,396
Ensemble	6,442,674	4,487,149 

## Question of Interest #2

*How did COVID-19 impact gate counts?*

Predicted Spring 2020: 487,626.9

Actual Spring 2020 Visitors: Unknown

Predicted Fall 2020 Visitors: 503,273.8

Actual Fall 2020 Visitors: 172,405

## Question of Interest #2

*How did COVID-19 impact gate counts?*

**65.7 %**

decrease in potential traffic due to  
COVID-19 fears and protocols

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