Fondren Library Building Traffic

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April 11, 2021

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

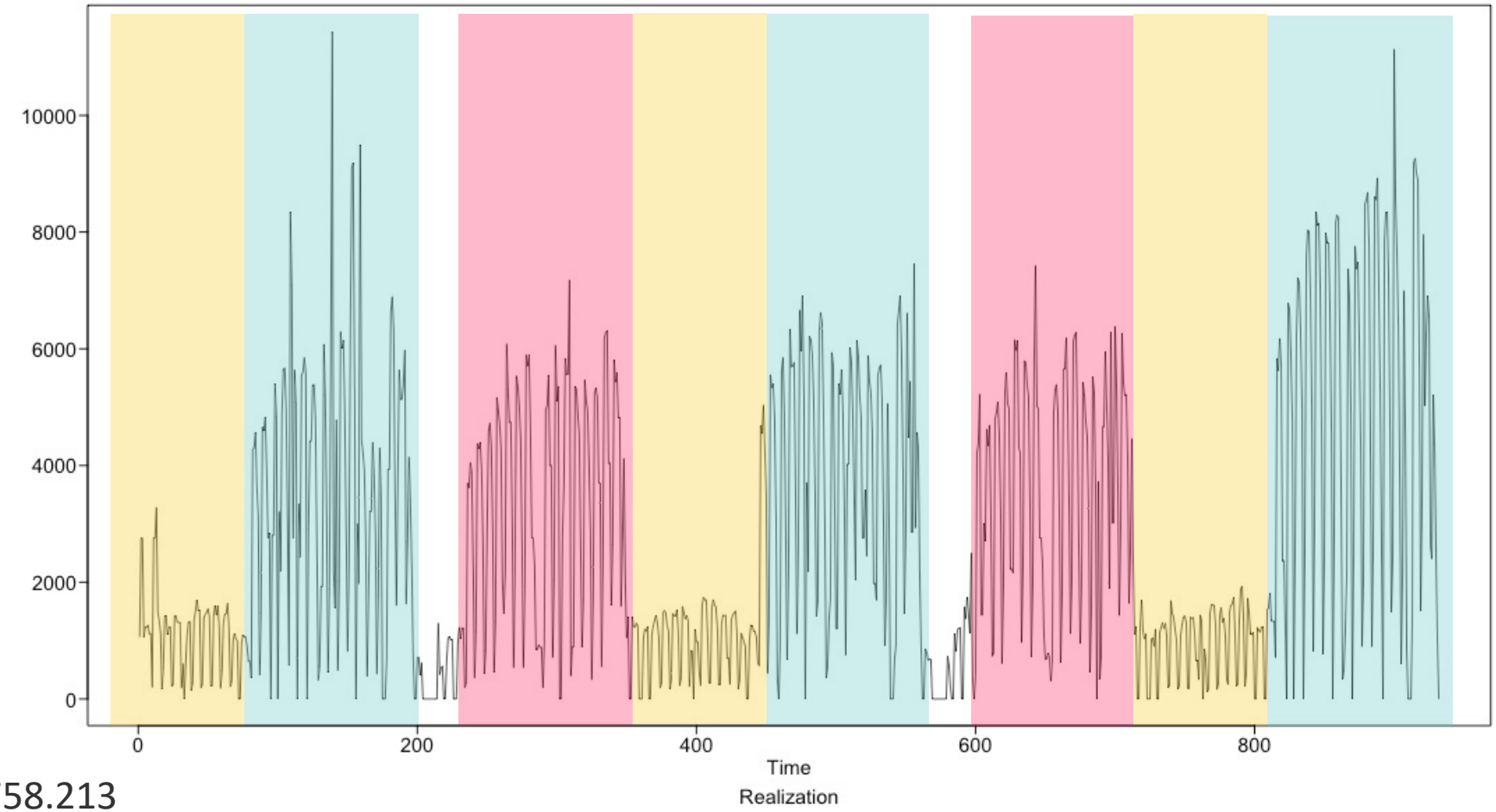
- Date Range: June 1, 2017 – December 20, 2019
- Total Observations: 933
- Original Variables
  - Date
  - Number of Visitors

Original Dataset Realization

Summer

Fall

Spring

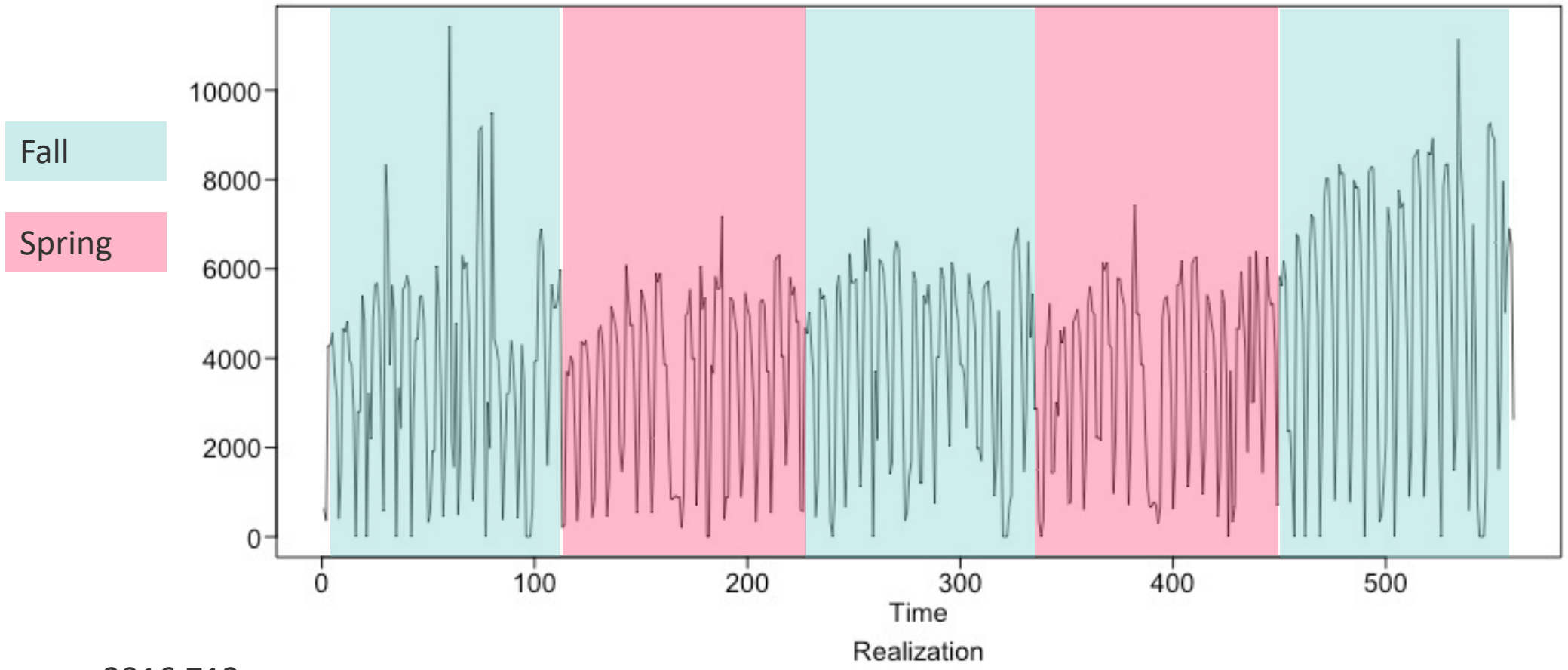


mean = 2758.213

Revised Fondren Gate Count Dataset

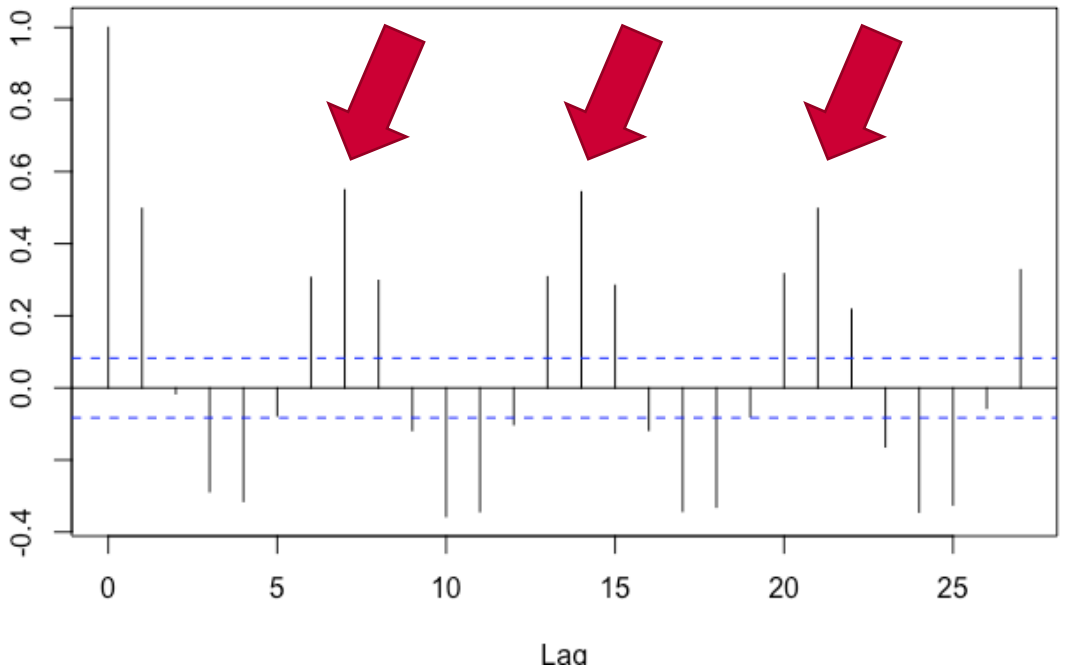
- Date Range: June 1, 2017 – December 20, 2019
- Limited to fall & spring semesters only
- Total Days: 560
- Variables Available
  - Date
  - Number of Visitors
  - Week Number of Semester
  - Day of the Week

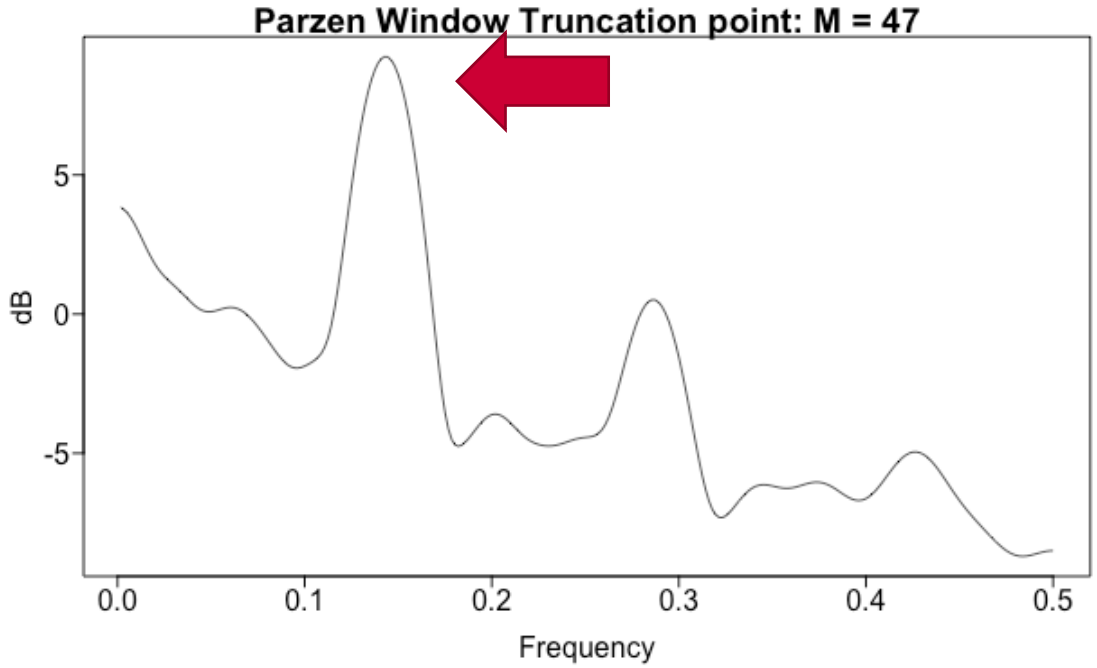
Revised Dataset Realization



mean = 3916.712

ACF and Spectral Density





Addressing Seasonality

Overfitting the model to identify seasonal patterns

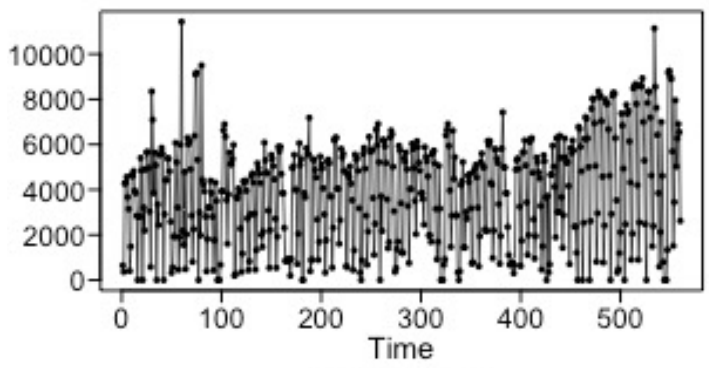
Gate Count Data

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

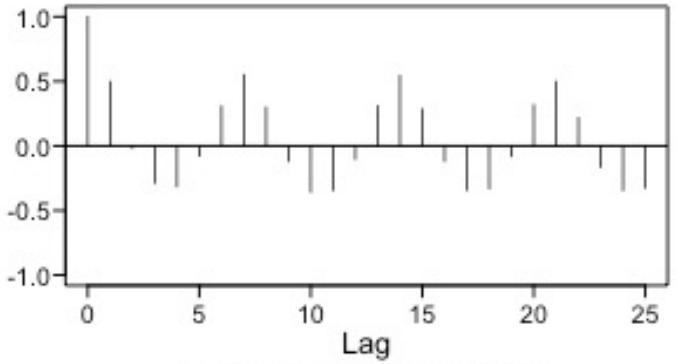
s=7 Factor Table

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

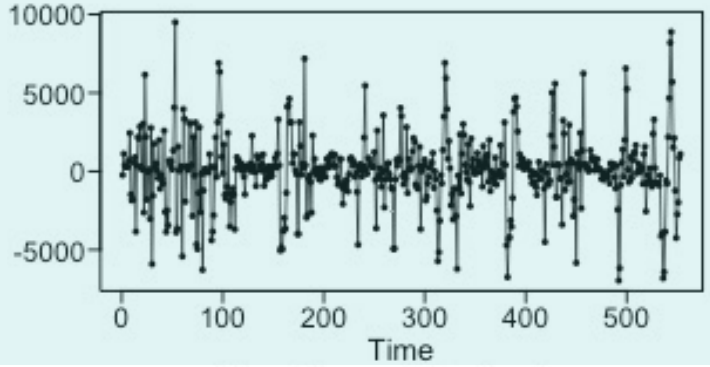
Transformation – Removing the *s=7*



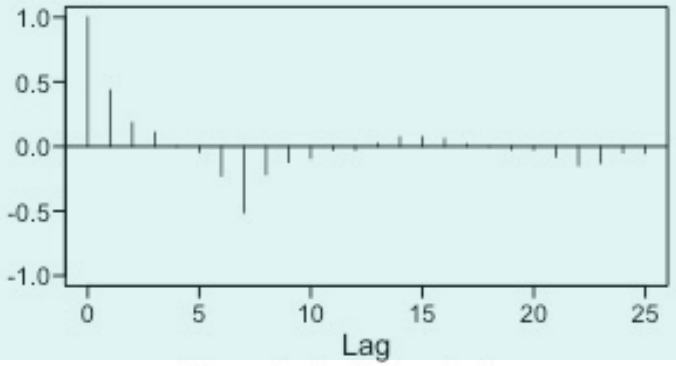
Realization



Sample Autocorrelations



Transformed Realization

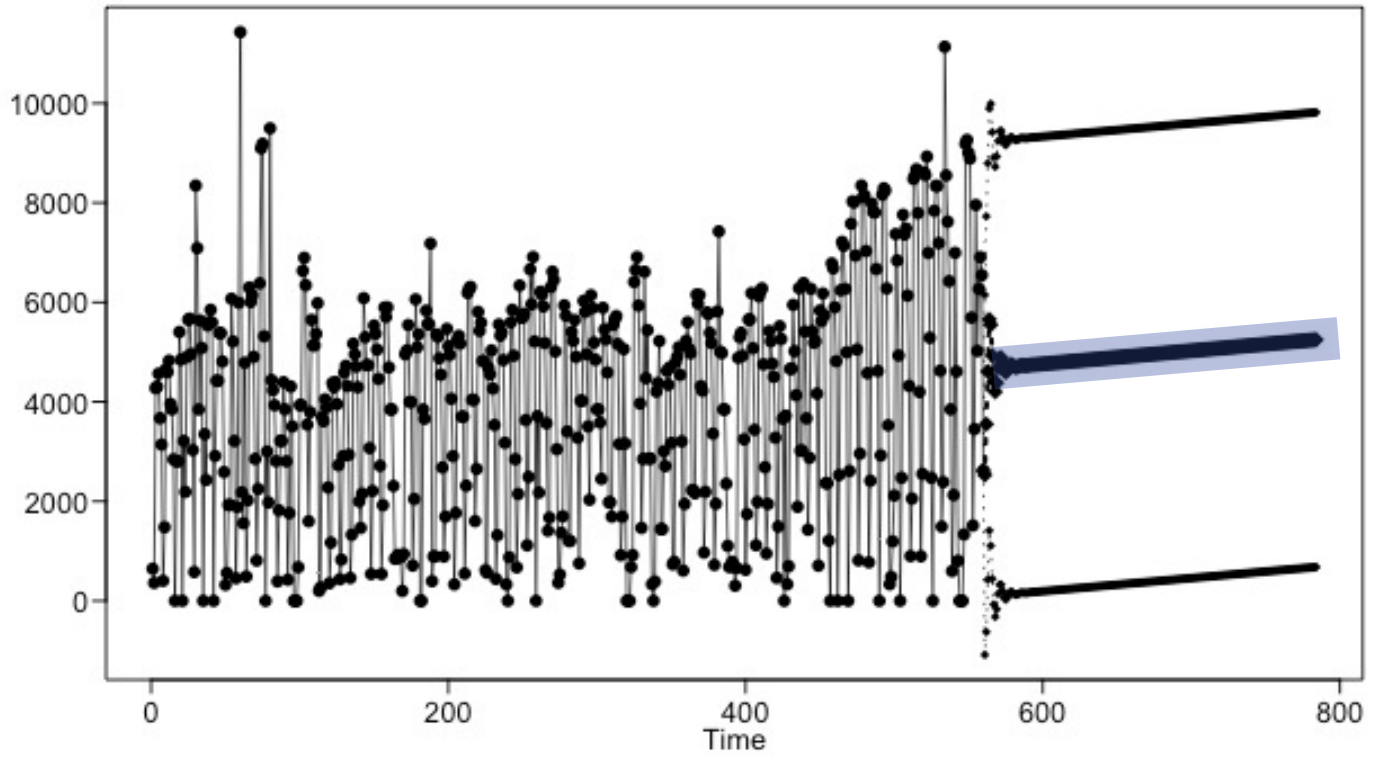


Sample Autocorrelations

Univariate Models

Signal Plus Noise Model

visitors = 3174 + 2.6455(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-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

ARMA(5,2) values

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

$theta
[1] 0.06113105 0.88951583
```

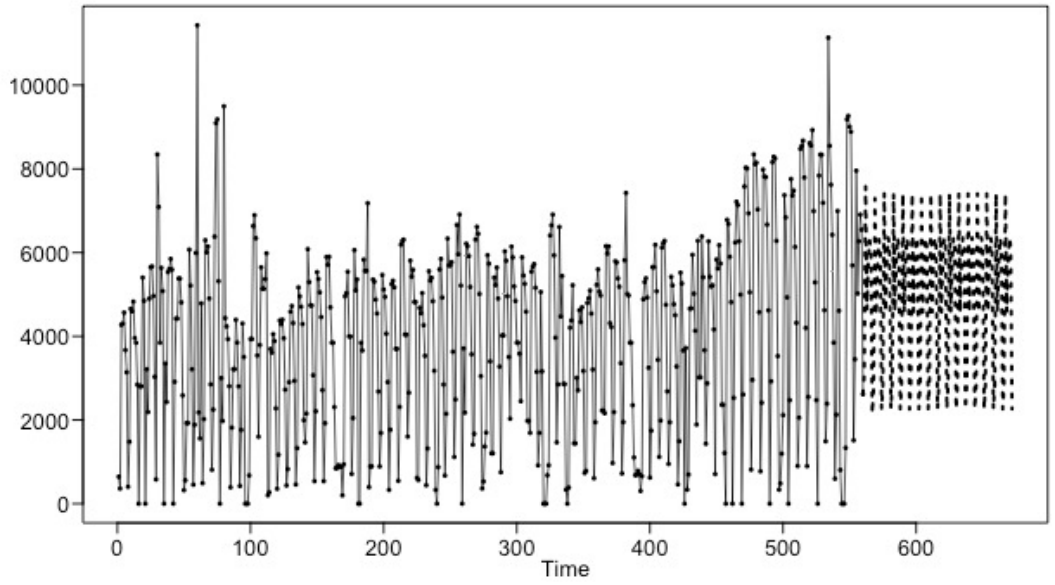
Candidate Model

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

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

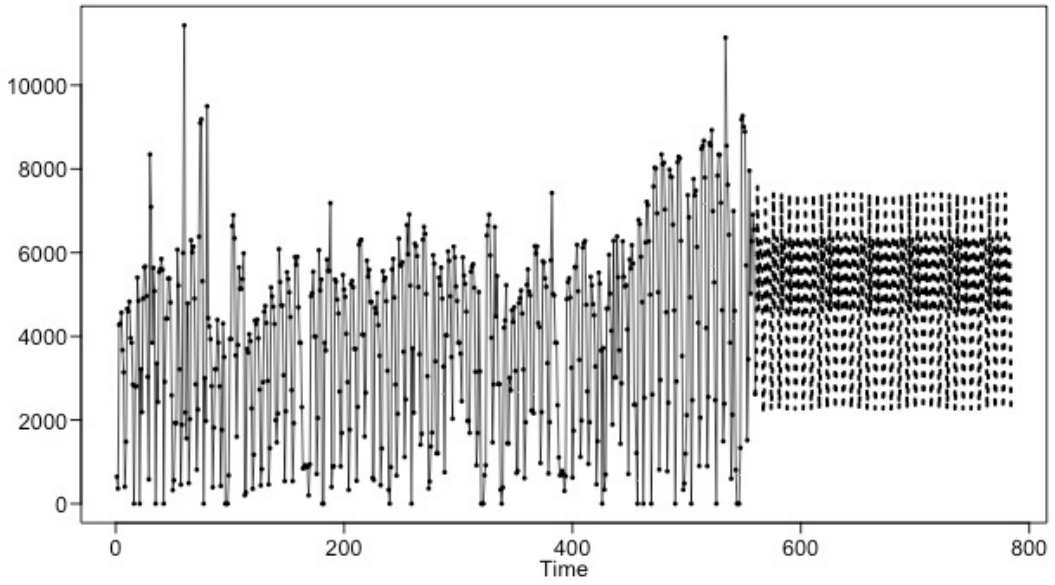
Univariate Model: ARIMA(5,0,2), s=7

Predictions for Spring 2020



ASE = 5,143,247

Predictions for Spring & Fall 2020



ASE = 6,257,223

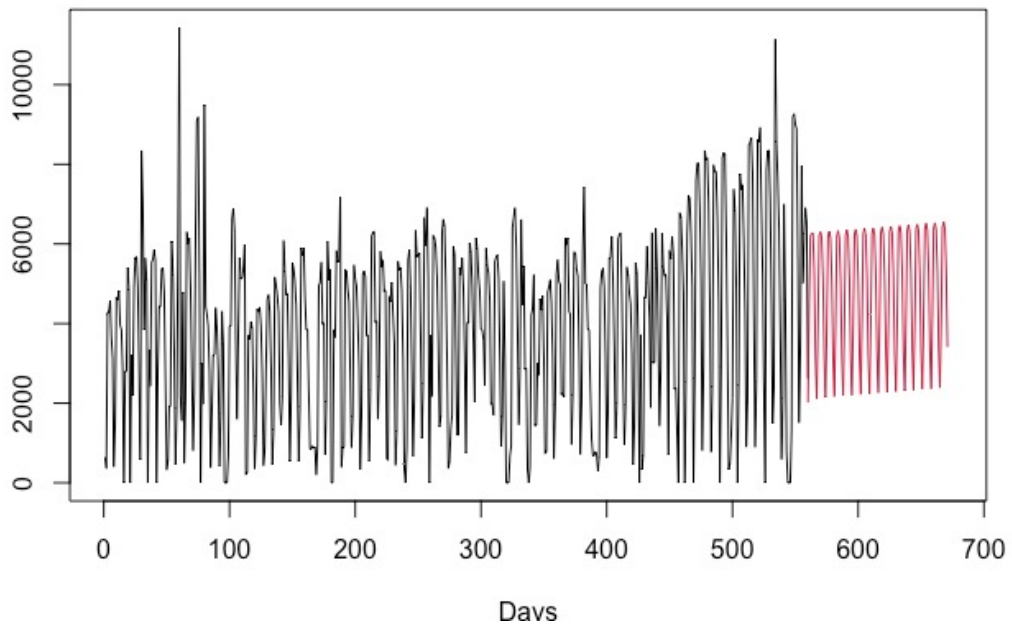
Multivariate Models

Vector Autoregressive Model

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

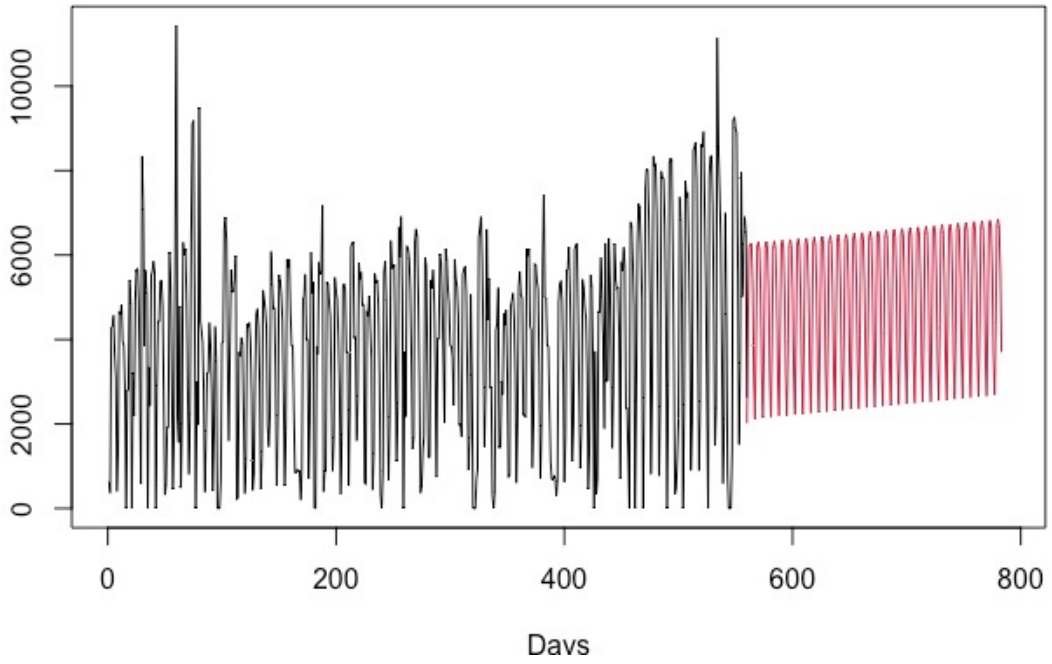
VAR(7) Model - Predictions

Predictions for Spring 2020



ASE = 5,504,134

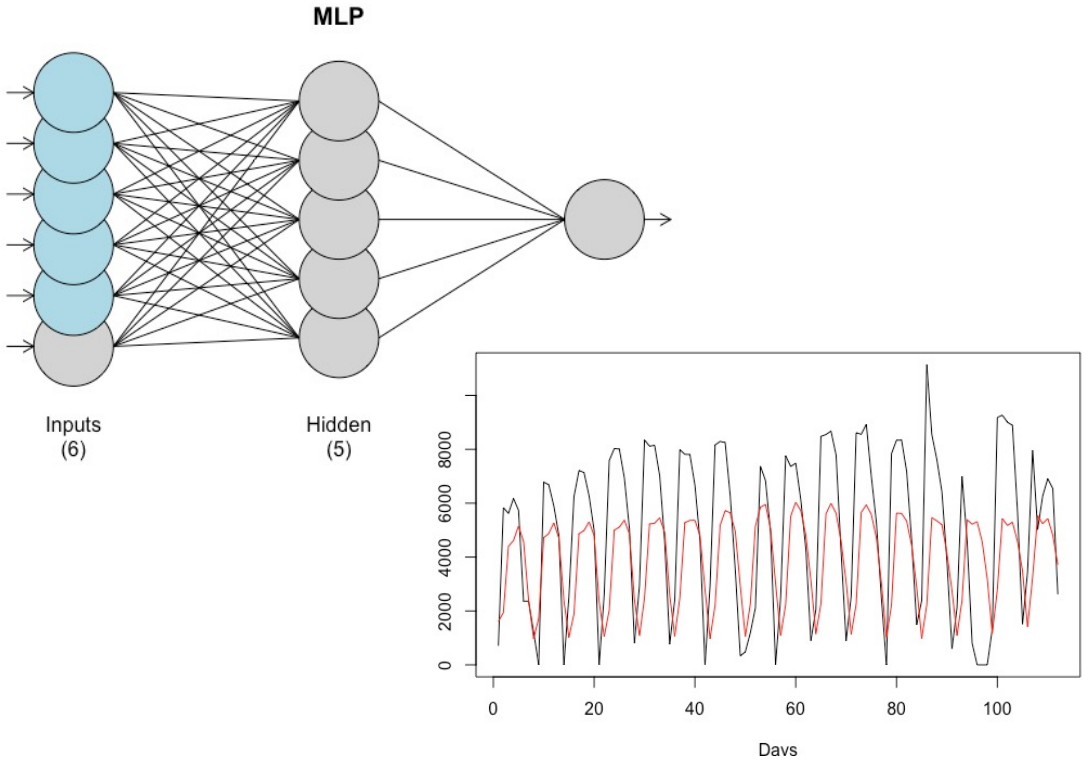
Predictions for Spring & Fall 2020



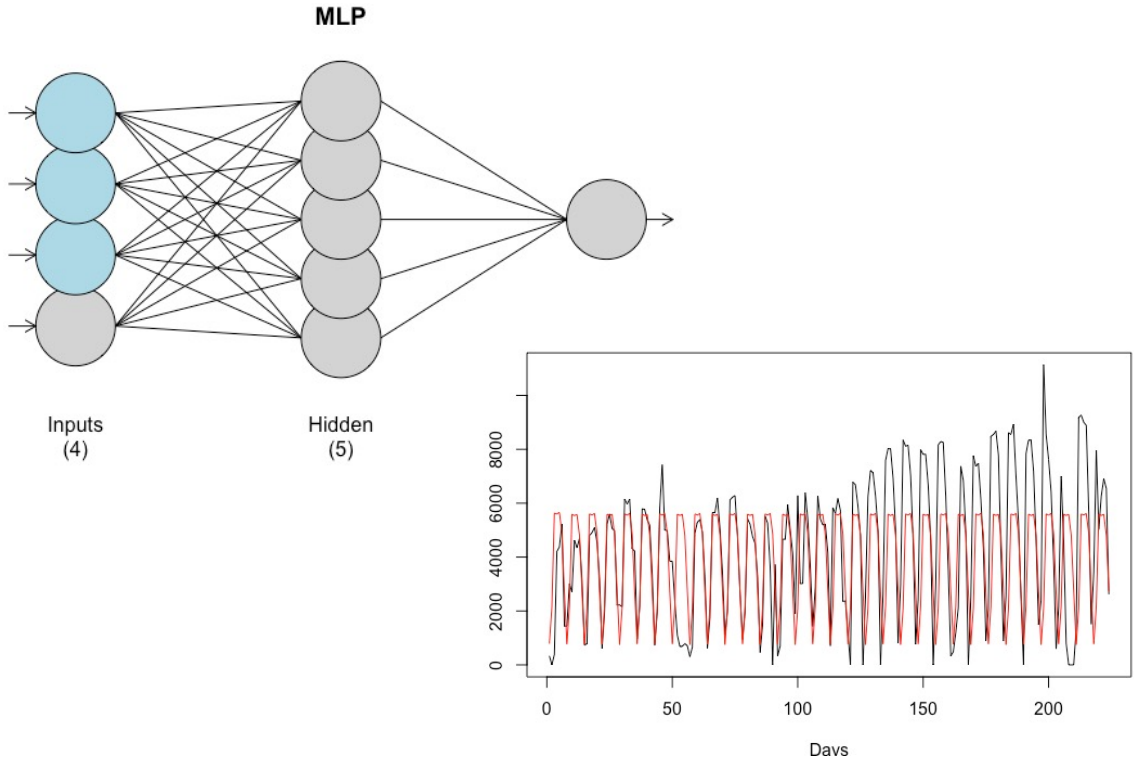
ASE = 4,547,001

Neural Network Model

Predictions for Spring 2020

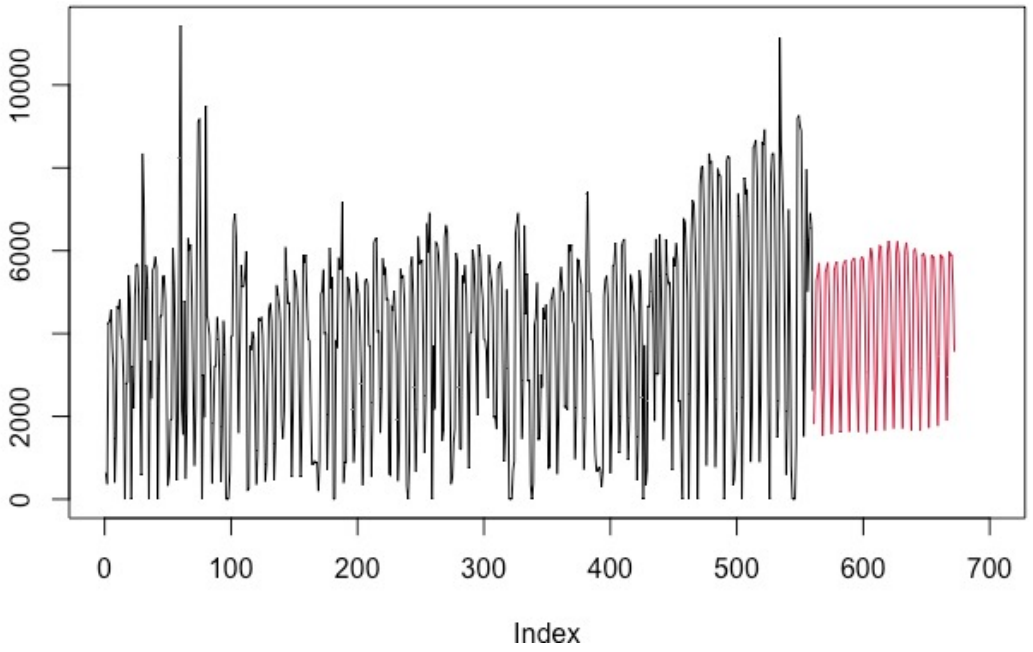


Predictions for Spring & Fall 2020



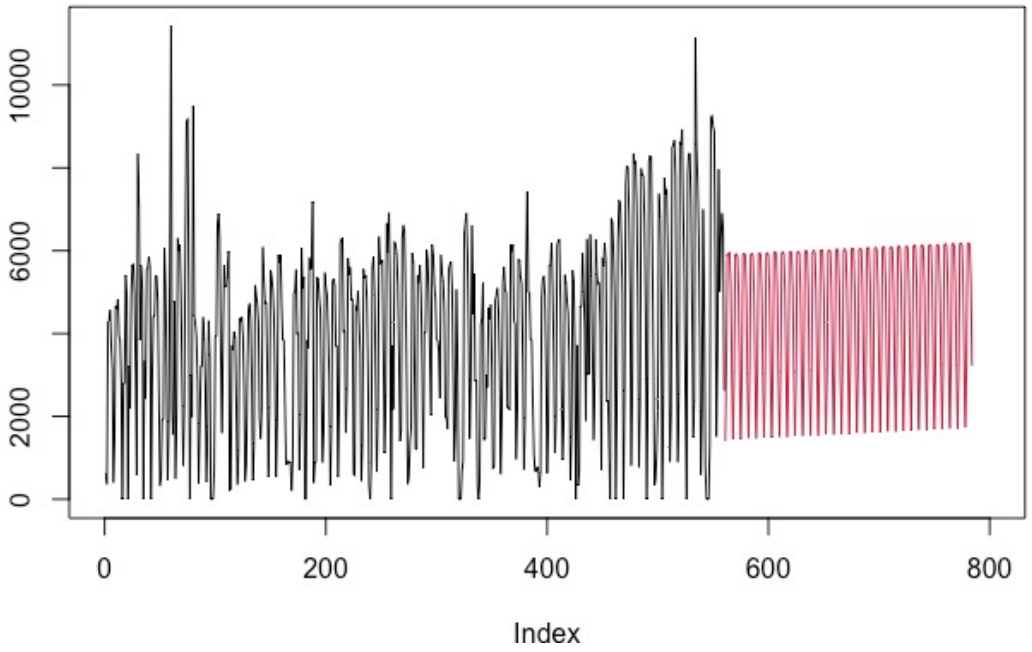
Neural Network Model Predictions

Predictions for Spring 2020



ASE = 7,918,749

Predictions for Spring & Fall 2020



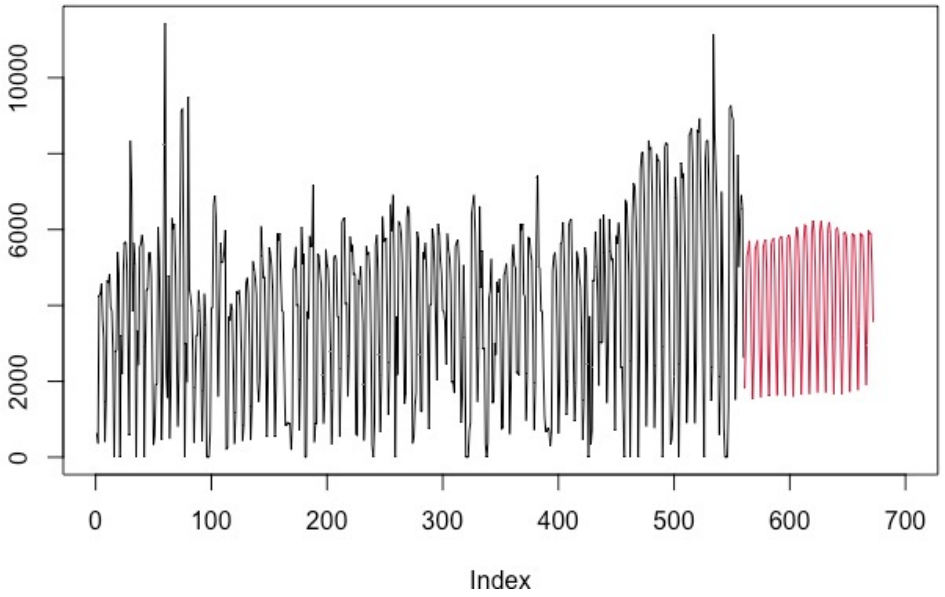
ASE = 5,141,396

Ensemble Model

MLP model + **VAR(7)**

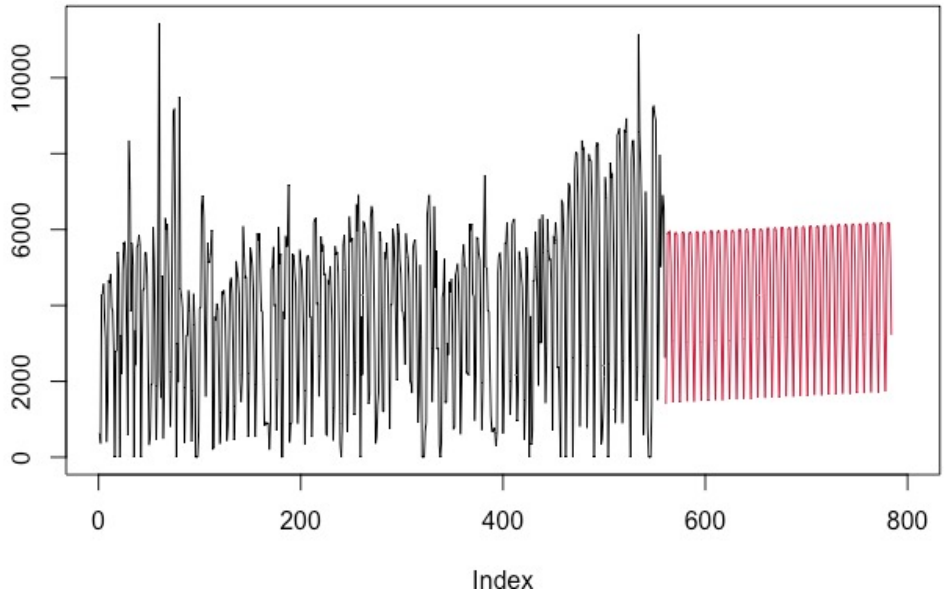
Ensemble Model

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

Fondren Library Building Traffic

Hollie Gardner, Director of Strategic Initiatives

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