

Health Information Management and Analytics

Vanderbilt University Medical Center: Elective Surgery Schedule

Group 3

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CASE Info

Goal: Building the elective surgery schedule from a few weeks before the day of surgery to predict the final number of surgeries performed.

Total Number of OR units at Vanderbilt: 55

Elective Surgeries: 94% Week Day Cases

- Scheduled Several Weeks in advance to right up to the day of surgery

Add-on Surgeries: 6%

- Urgent or emergency cases are accommodated within 15 hours before the start of the day of surgery.

The mean of actual surgeries = 116 with a standard deviation = 18. Swings of 30 or more are common between weekdays.

Issues

- No one studied till now what is the potential cause for the variability. It is assumed that emergency cases are a major cause.
- The total number of surgeries performed are not finalized until 5 PM the day before.

Nurse Scheduling

**Pathology, Radiology, PACU
Scheduling**

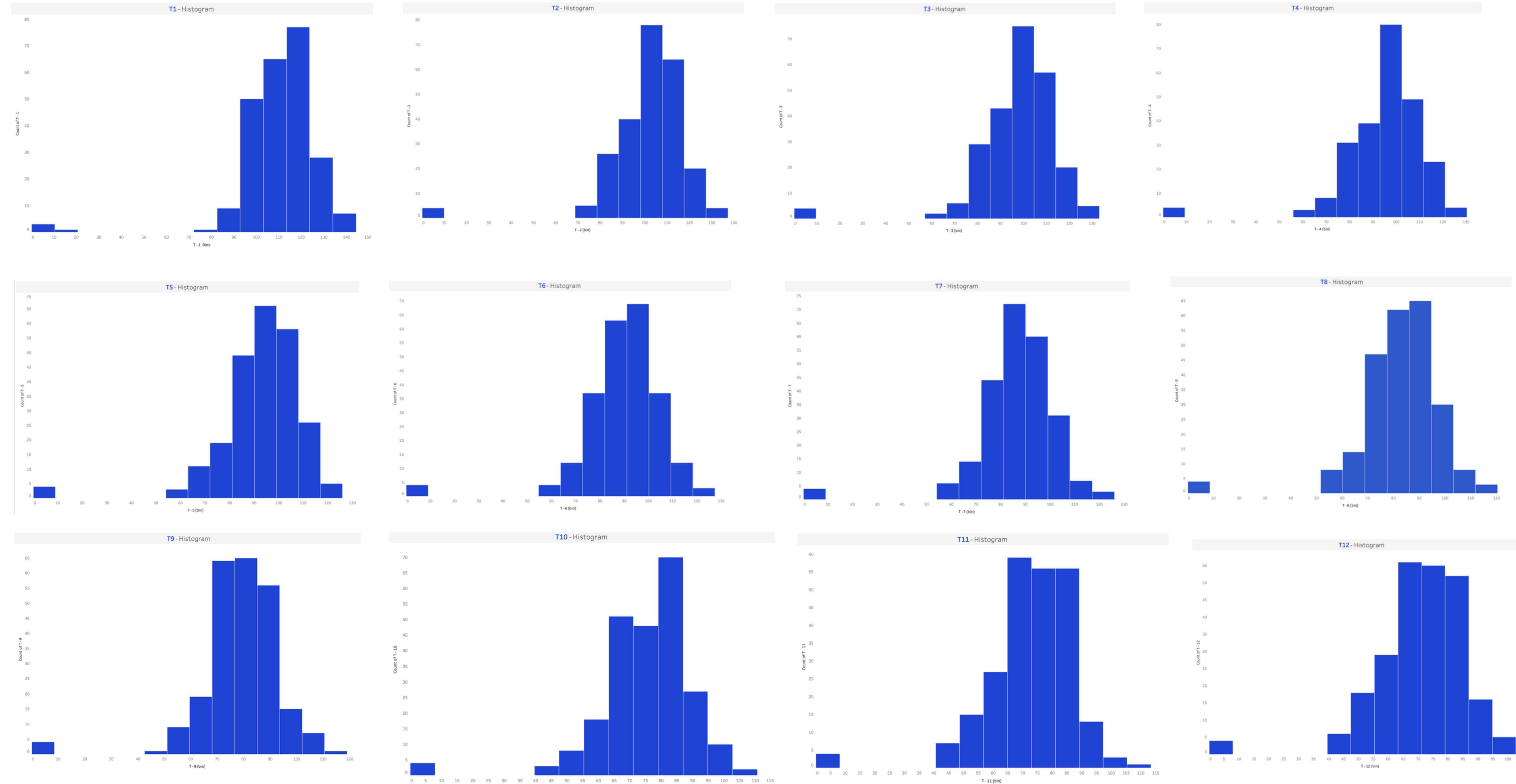
**Anesthesia Department
Scheduling**

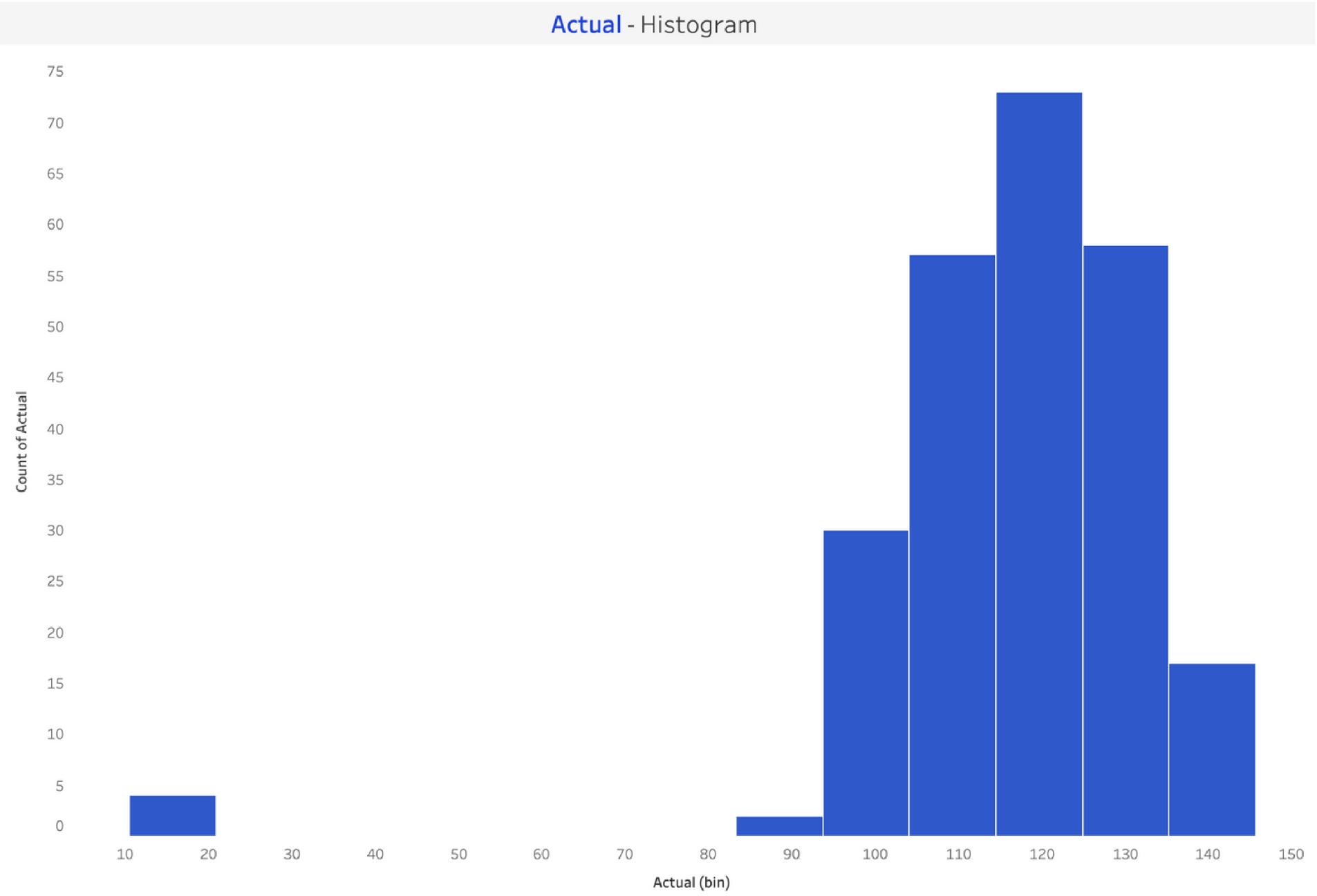
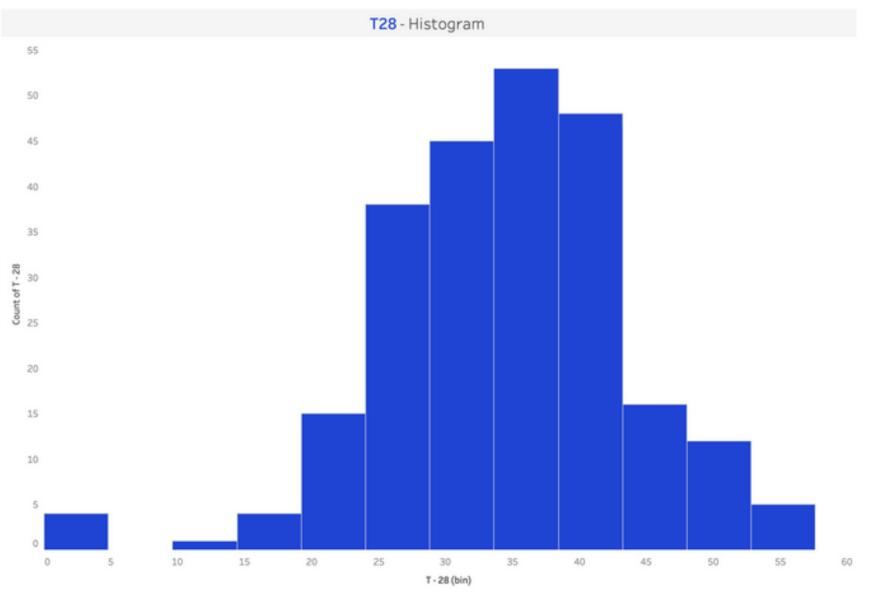
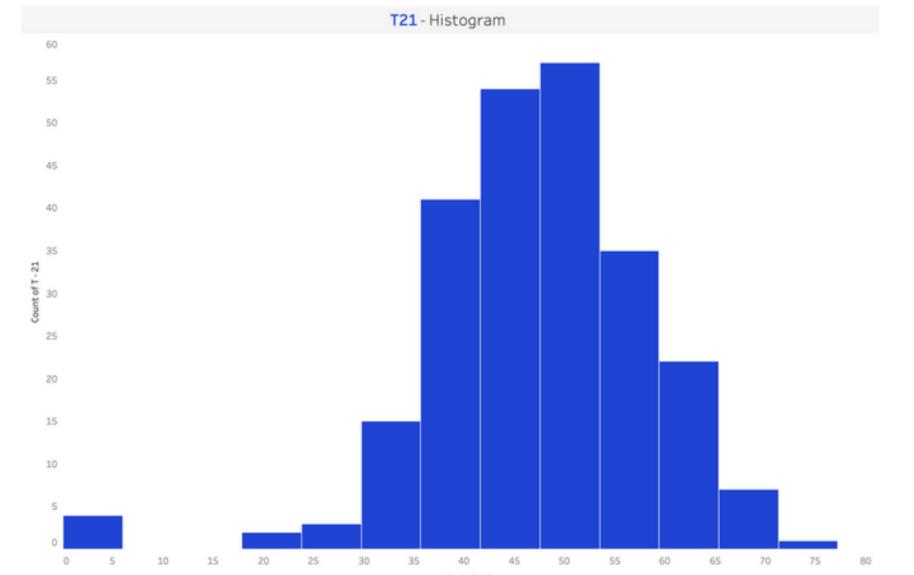
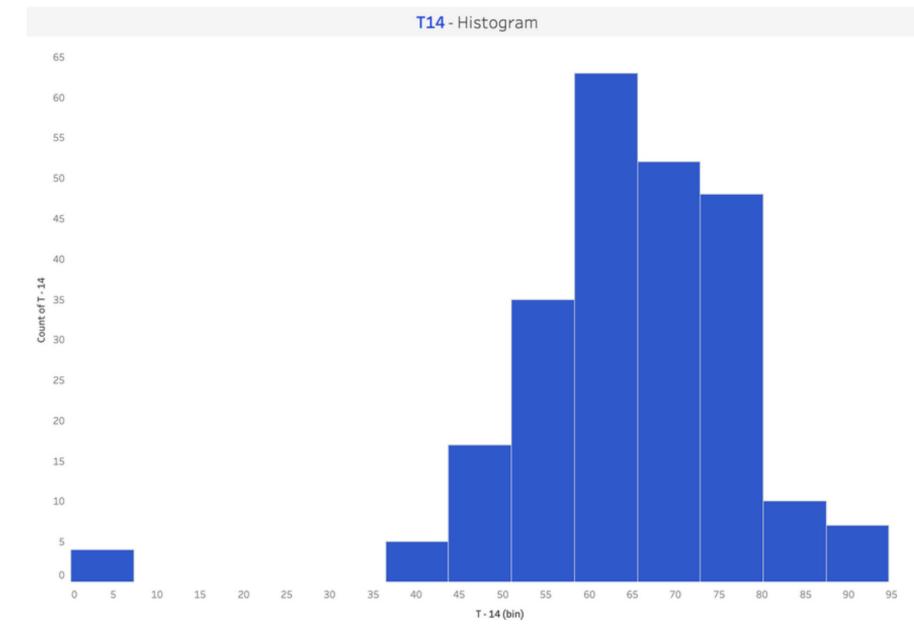
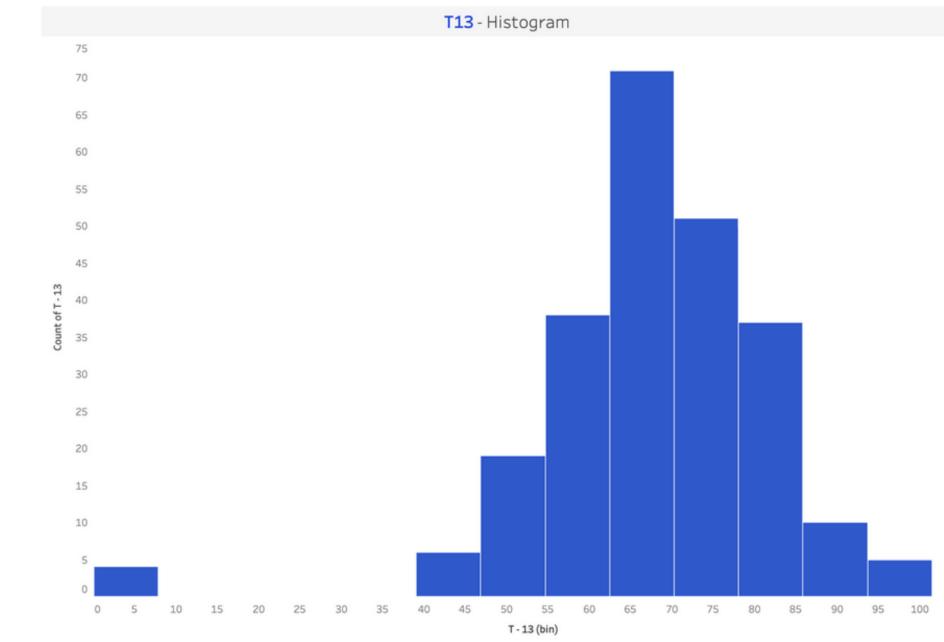
Sterile Equipment

Exploratory Data Analysis

```
▶ df.info()  
→ <class 'pandas.core.frame.DataFrame'>  
DatetimeIndex: 241 entries, 2011-10-10 to 2012-09-14  
Data columns (total 22 columns):  
 #   Column      Non-Null Count Dtype   
 ---   
 0   DOW         241 non-null    object  
 1   T - 28      241 non-null    int64  
 2   T - 21      241 non-null    int64  
 3   T - 14      241 non-null    int64  
 4   T - 13      241 non-null    int64  
 5   T - 12      241 non-null    int64  
 6   T - 11      241 non-null    int64  
 7   T - 10      241 non-null    int64  
 8   T - 9       241 non-null    int64  
 9   T - 8       241 non-null    int64  
 10  T - 7       241 non-null    int64  
 11  T - 6       241 non-null    int64  
 12  T - 5       241 non-null    int64  
 13  T - 4       241 non-null    int64  
 14  T - 3       241 non-null    int64  
 15  T - 2       241 non-null    int64  
 16  T - 1       241 non-null    int64  
 17  Actual      241 non-null    int64
```

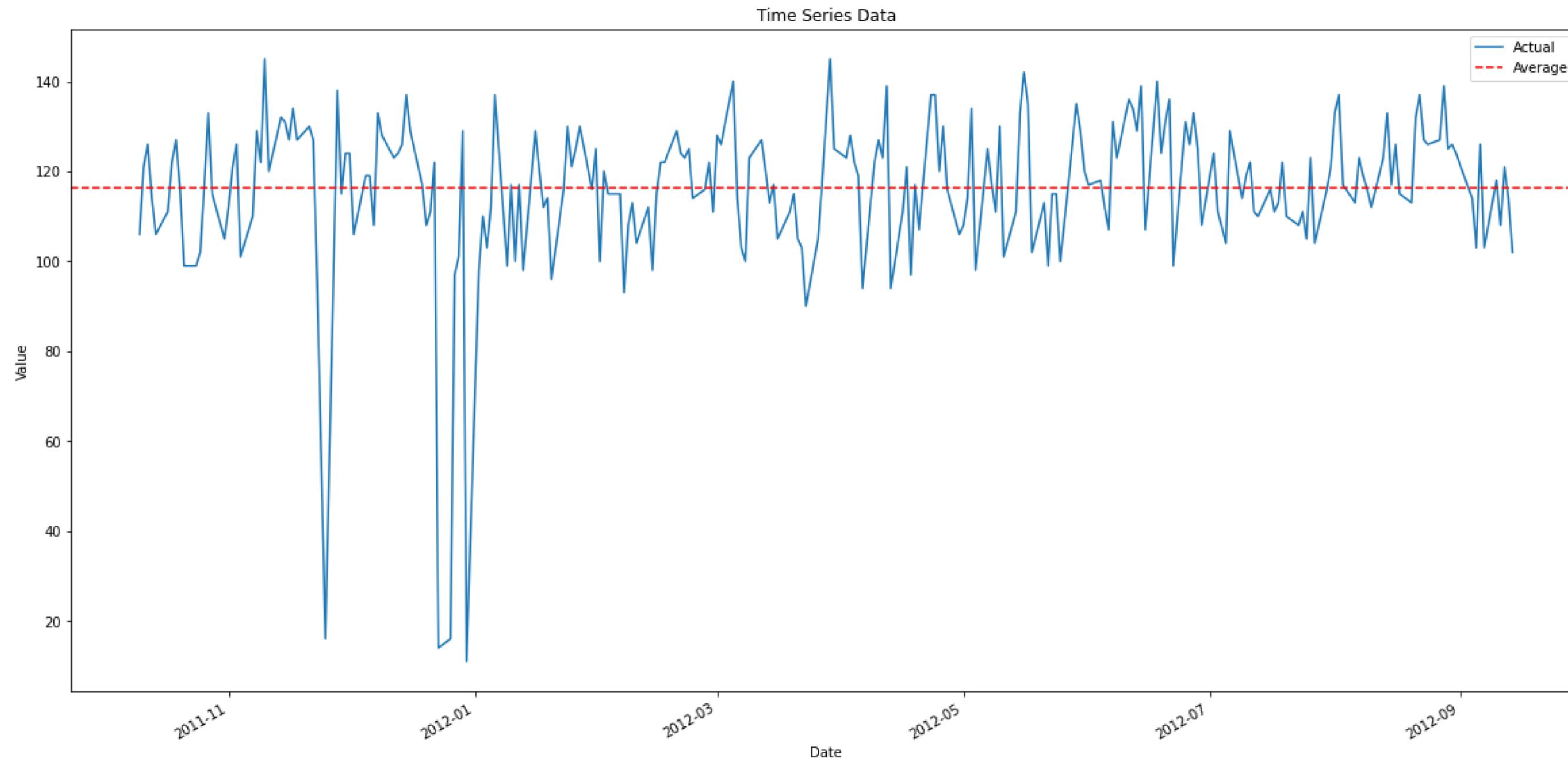
- Data: 48 Weeks surgery scheduled Data.
- No of Surgeries scheduled for a particular day is available from 28, 21, 14, 13, 12, 11....1 days prior.





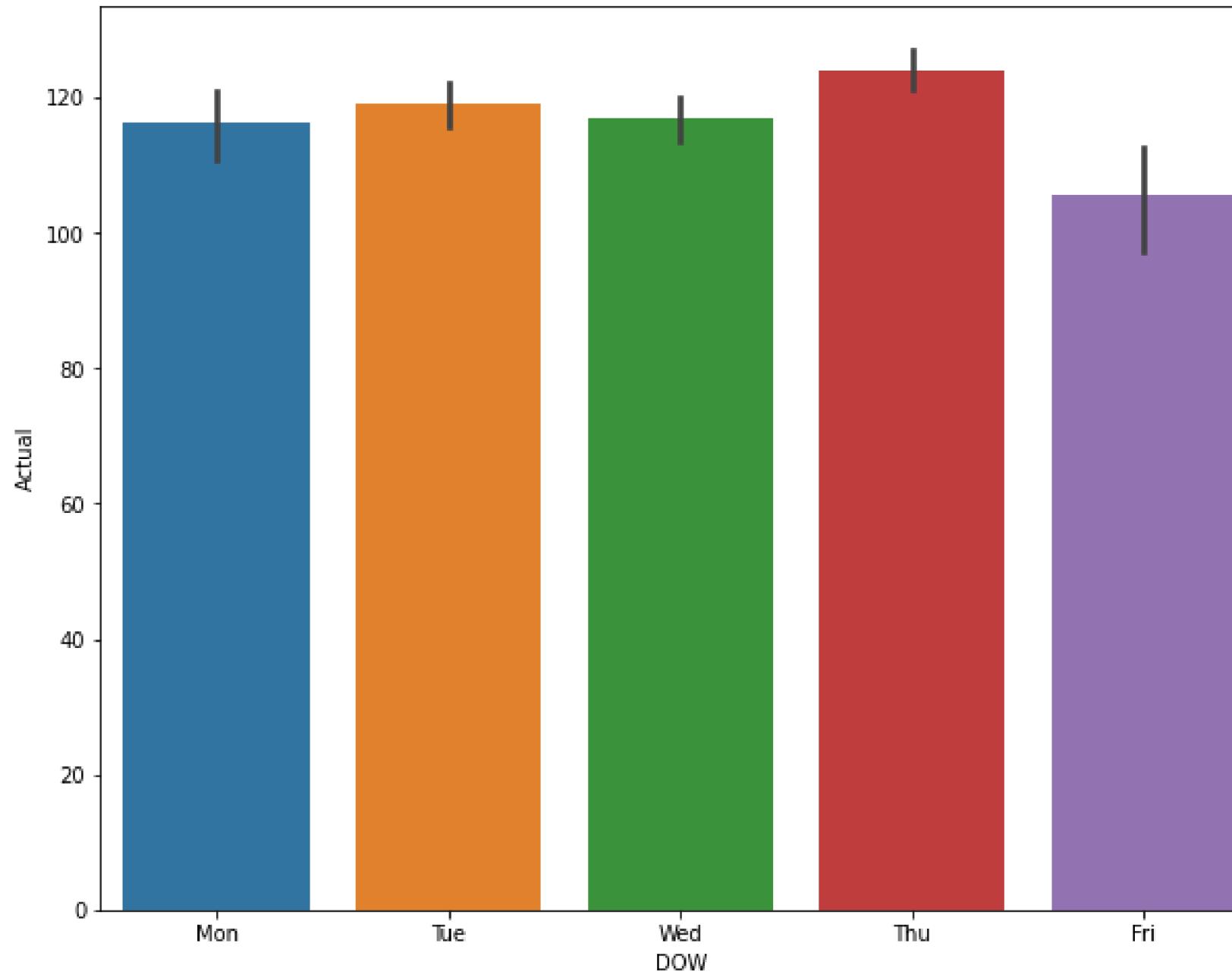
- All the variables are near normal.
- As this is time series data, all the variables are highly correlated.

Actual Surgeries with Date



- Outliers were holidays. There were no surgeries scheduled for those days.
- Removed them from the dataset.

Exploratory Data Analysis



Observation:
Friday and Thursday
are different compared to the rest of
the day of the week.

No of Actual Surgeries Mean with
respect to the day of the week.

Exploratory Data Analysis | ANOVA Test

Null Hypothesis: Day of the week doesn't effect the number of actual surgeries performed.

```
ANOVA F-statistic: 7.68914635390634, p-value: 7.799948393447803e-06
T-test between Mon and Tue: t-statistic: -0.28885837646632884, p-value: 0.7733326494244768, adjusted p-value: 7.733326494244768
T-test between Mon and Wed: t-statistic: 0.6082238933970111, p-value: 0.5445376627215985, adjusted p-value: 5.445376627215985
T-test between Mon and Thu: t-statistic: -2.567077873678444, p-value: 0.011869384827647015, adjusted p-value: 0.11869384827647016
T-test between Mon and Fri: t-statistic: 2.8692109040753717, p-value: 0.005127164288960083, adjusted p-value: 0.05127164288960083
T-test between Tue and Wed: t-statistic: 0.9089109390837744, p-value: 0.3656972438648315, adjusted p-value: 3.6569724386483147
T-test between Tue and Thu: t-statistic: -2.3175322481010334, p-value: 0.0226217446976582, adjusted p-value: 0.22621744697658203
T-test between Tue and Fri: t-statistic: 3.206799993191735, p-value: 0.0018407886073648373, adjusted p-value: 0.018407886073648374
T-test between Wed and Thu: t-statistic: -3.1887275512858246, p-value: 0.001941576372525354, adjusted p-value: 0.01941576372525354
T-test between Wed and Fri: t-statistic: 2.2814581076913325, p-value: 0.024828309730710478, adjusted p-value: 0.2482830973071048
T-test between Thu and Fri: t-statistic: 5.435937314956718, p-value: 4.4483941337649793e-07, adjusted p-value: 4.4483941337649794e-06
```

ANOVA test is significant. We reject our null hypothesis.

Performed post hoc T-Test to observe which are the most different days.

T Test confirmed our observations for Thursday and Friday being different compared to the rest of the days of the week.

Exploratory Data Analysis

		Mean	Maximum	Standard Deviation	
	T - 28	34.261411	57	9.387610	
	T - 21	47.240664	73	11.321079	
	T - 14	64.439834	93	13.495891	
	T - 13	67.817427	99	14.200934	
	T - 12	70.502075	102	14.873109	
	T - 11	72.365145	106	14.970786	
	T - 10	74.946058	106	15.096674	
	T - 9	78.041494	112	15.054842	
	T - 8	82.336100	113	15.594841	
	T - 7	86.000000	118	16.089075	
	T - 6	89.269710	121	16.911962	
	T - 5	92.091286	121	17.370472	
	T - 4	94.688797	124	17.468264	
	T - 3	97.373444	127	17.589816	
	T - 2	101.165975	131	17.547004	
	T - 1	110.008299	139	17.785057	

Model Building

The goal is to predict the number of surgeries days before the surgery date.

Predicting it one week before and four days before the actual surgery data would be helpful for the management as it helps them understand the actual surgery load, schedule nurses, and order equipment accordingly.

- We are using the regression model as our first approach. We are flagging Thursdays and Fridays as they differ from the rest of the week regarding surgery load.
- The next approach would be the ARIMA model. ARIMA model would not be a good fit here as the days of the week are not correlated.
 - (Monday of one week is not correlated with the Monday of the other week.)

T - 7 Model

OLS Regression Results

Dep. Variable:	Actual	R-squared:	0.664
Model:	OLS	Adj. R-squared:	0.658
Method:	Least Squares	F-statistic:	106.1
Date:	Mon, 06 Mar 2023	Prob (F-statistic):	6.09e-38
Time:	04:05:52	Log-Likelihood:	-554.60
No. Observations:	165	AIC:	1117.
Df Residuals:	161	BIC:	1130.
Df Model:	3		
Covariance Type:	nonrobust		

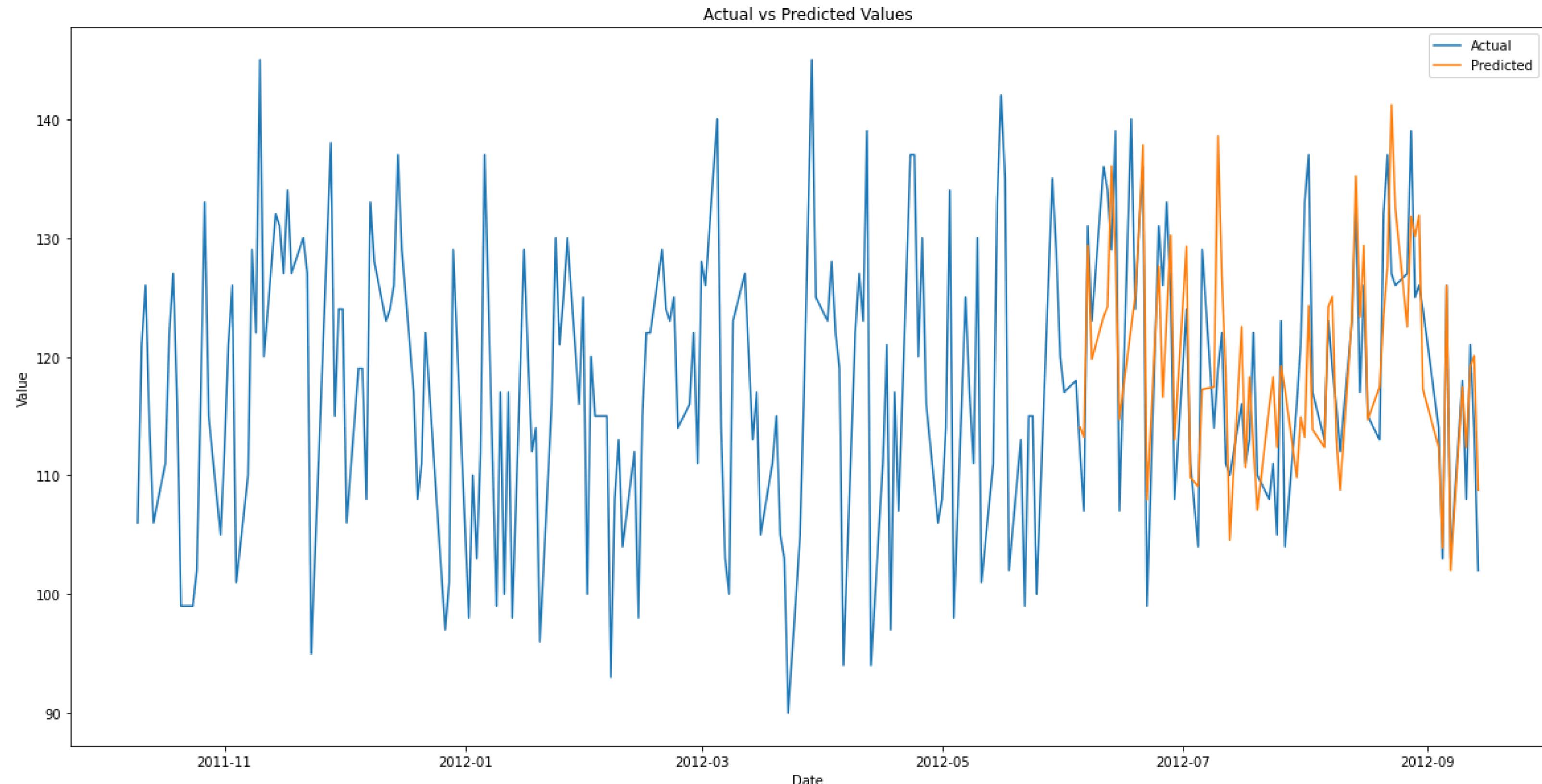
	coef	std err	t	P> t	[0.025	0.975]
const	44.7105	4.497	9.942	0.000	35.830	53.591
T - 7	0.8457	0.052	16.257	0.000	0.743	0.948
Thursday	-2.4560	1.533	-1.602	0.111	-5.484	0.572
Friday	-0.2001	1.490	-0.134	0.893	-3.143	2.742

Omnibus:	1.184	Durbin-Watson:	1.757
Prob(Omnibus):	0.553	Jarque-Bera (JB):	1.184
Skew:	0.201	Prob(JB):	0.553
Kurtosis:	2.896	Cond. No.	722.

Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Linear regression mean squared error: 53.52911058856202

T - 7 Model



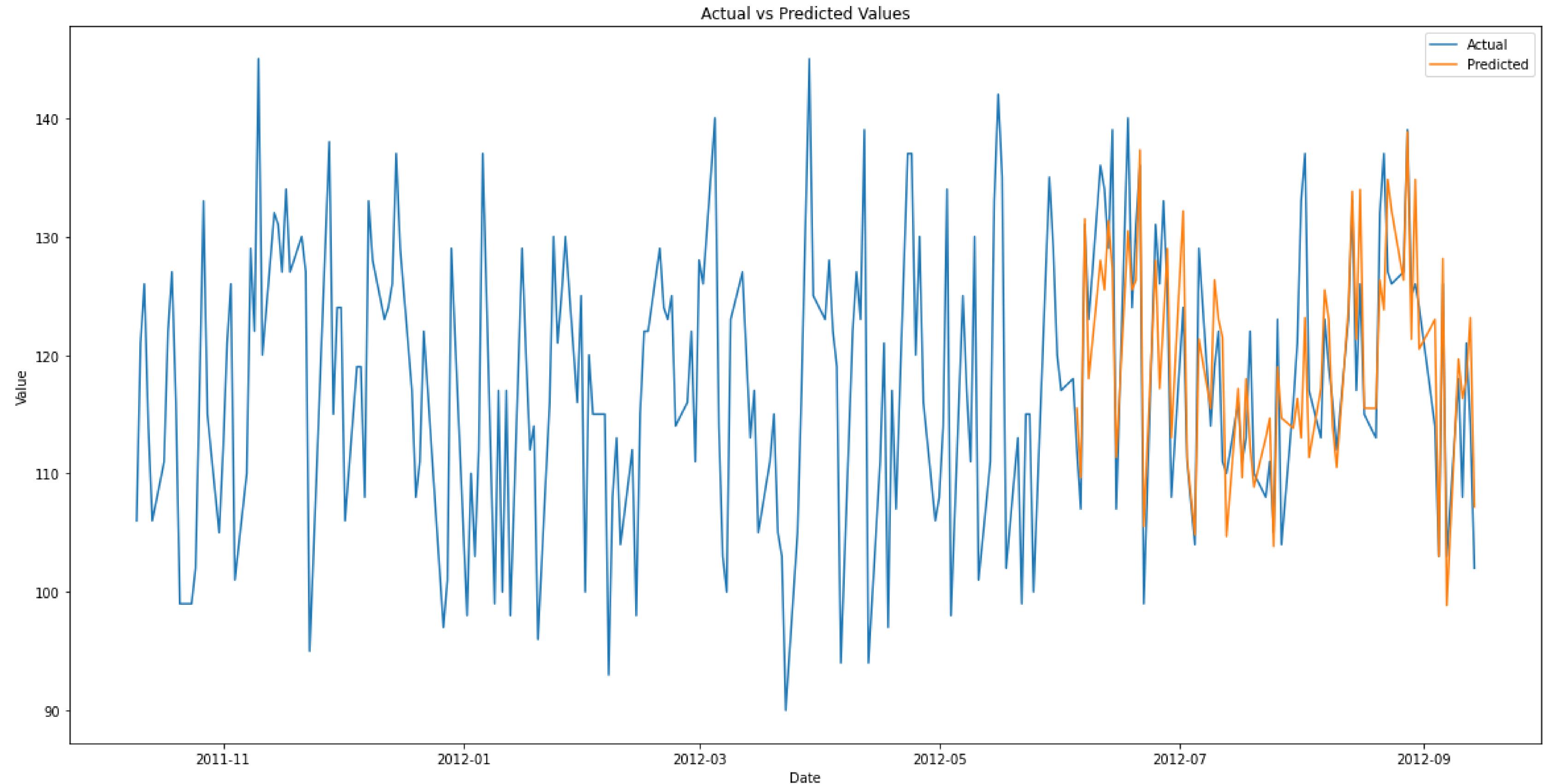
T - 4 Model

OLS Regression Results						
Dep. Variable:	Actual	R-squared:	0.714			
Model:	OLS	Adj. R-squared:	0.709			
Method:	Least Squares	F-statistic:	133.9			
Date:	Mon, 06 Mar 2023	Prob (F-statistic):	1.55e-43			
Time:	04:10:45	Log-Likelihood:	-541.37			
No. Observations:	165	AIC:	1091.			
Df Residuals:	161	BIC:	1103.			
Df Model:	3					
Covariance Type:	nonrobust					
coef	std err	t	P> t	[0.025	0.975]	
const	35.5566	4.471	7.953	0.000	26.728	44.386
T - 4	0.8327	0.045	18.394	0.000	0.743	0.922
Thursday	5.1546	1.311	3.932	0.000	2.566	7.743
Friday	6.6743	1.500	4.450	0.000	3.712	9.636
Omnibus:	0.794	Durbin-Watson:	1.822			
Prob(Omnibus):	0.672	Jarque-Bera (JB):	0.711			
Skew:	0.160	Prob(JB):	0.701			
Kurtosis:	2.975	Cond. No.	861.			
Notes:						
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.						
Linear regression mean squared error: 39.33481113239998						

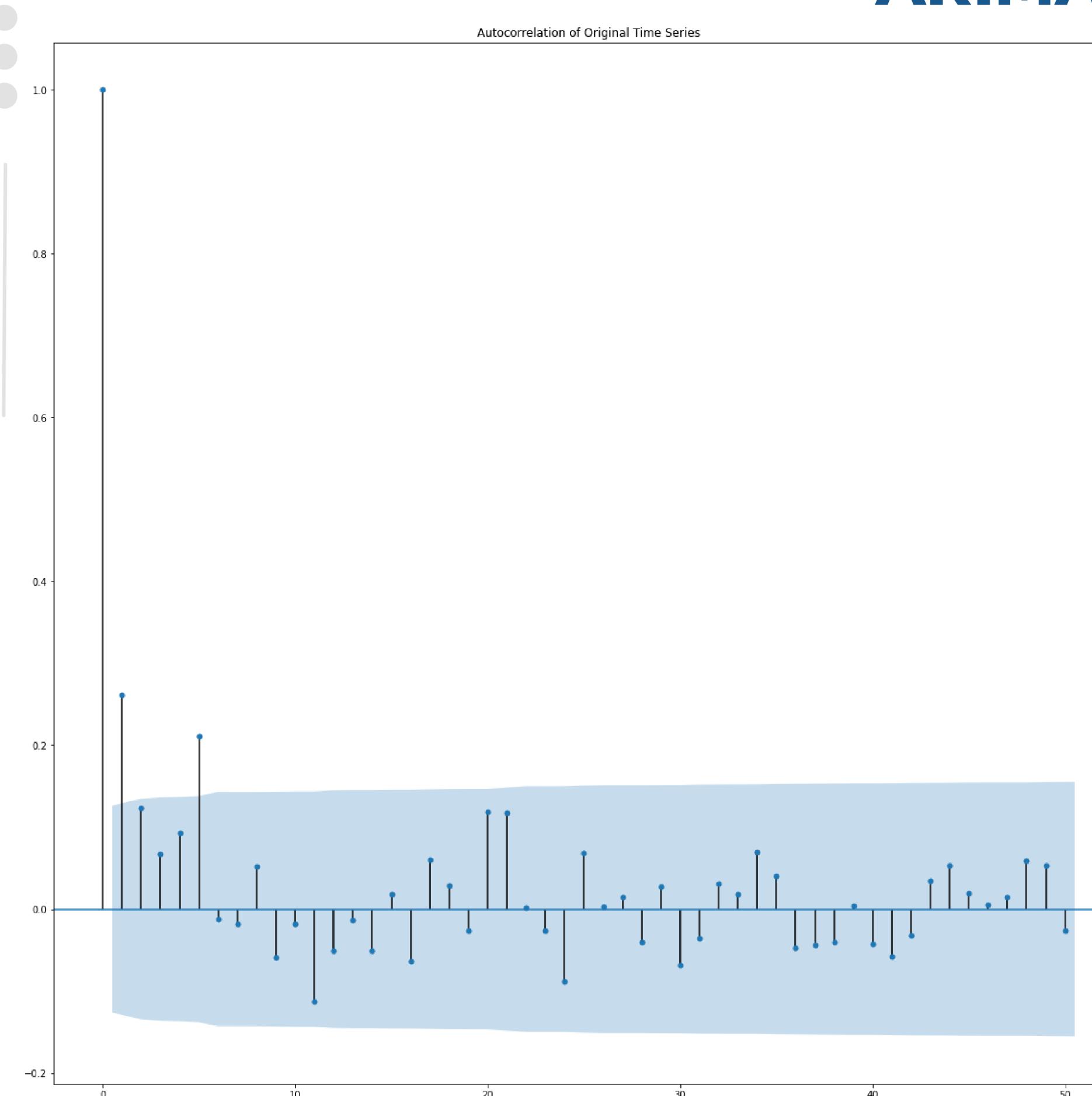
Observation:

Lower RSME score compared to the T7 model. It would help us deal with any uncertainty in the prediction 4 days before surgery when comparing with 7 Days model predictions,

T - 4 Model

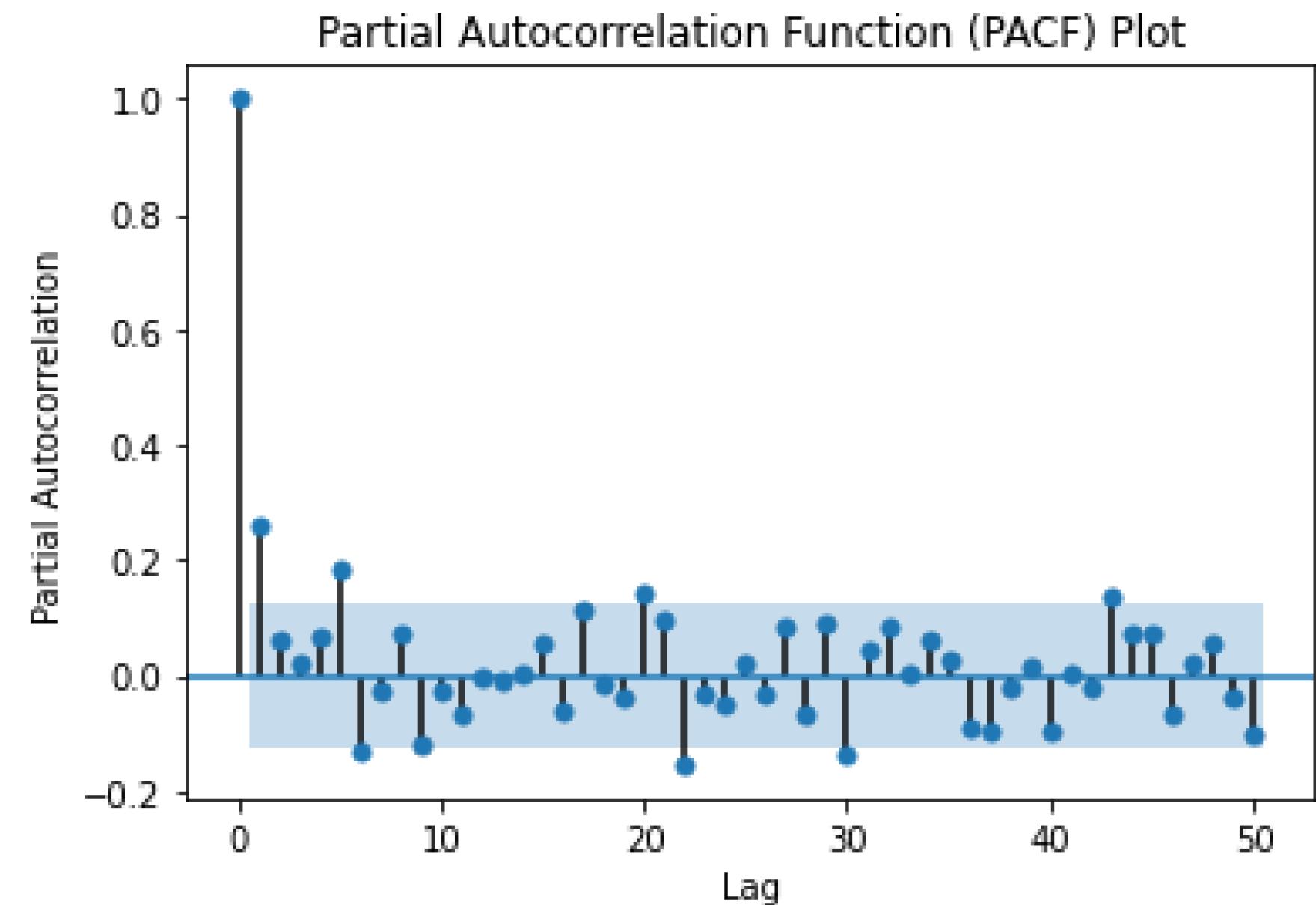


ARIMA



ADF Statistic: **-5.152404**
p-value: **0.000011**
The time series is stationary.

ARIMA

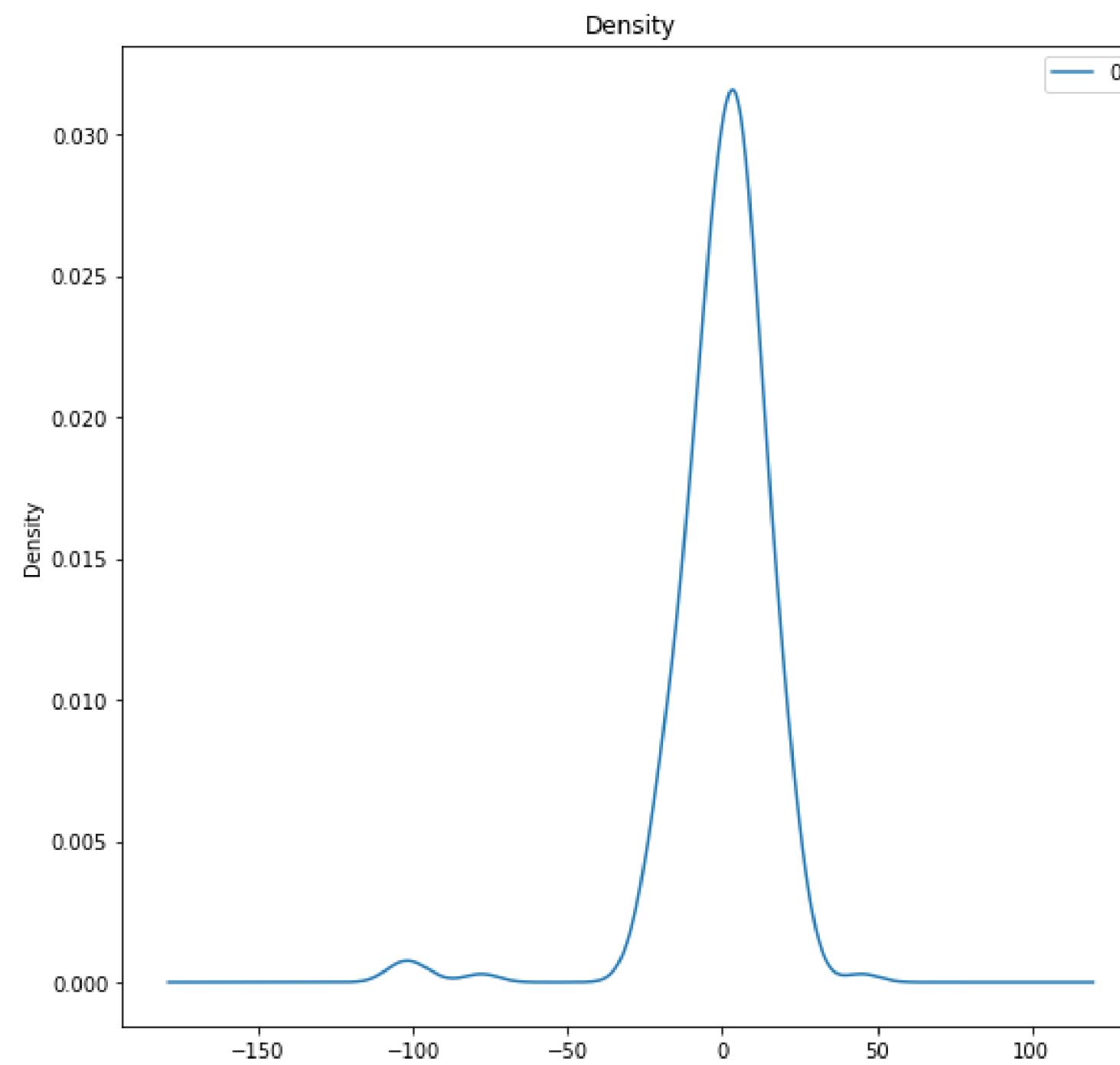
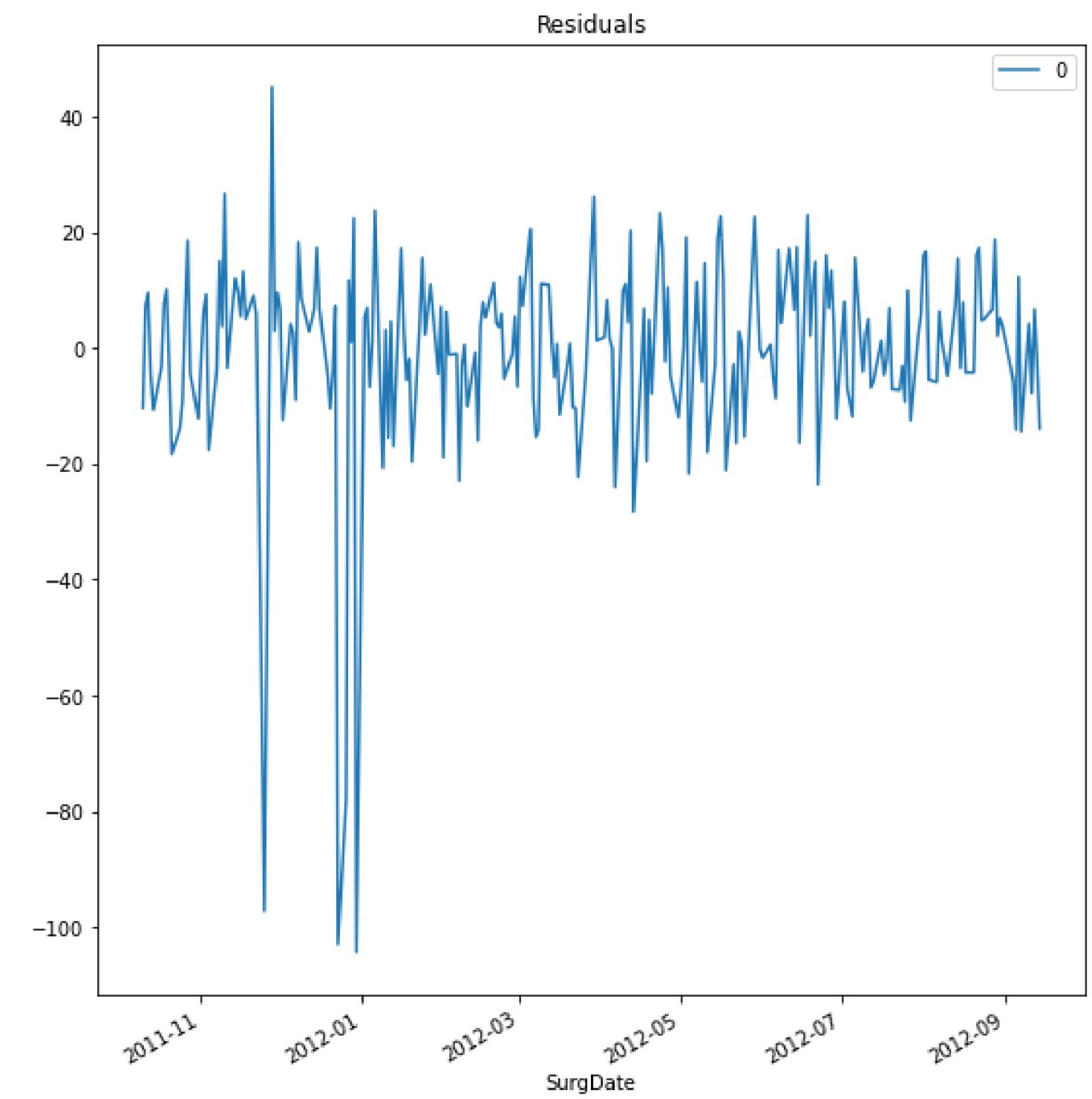


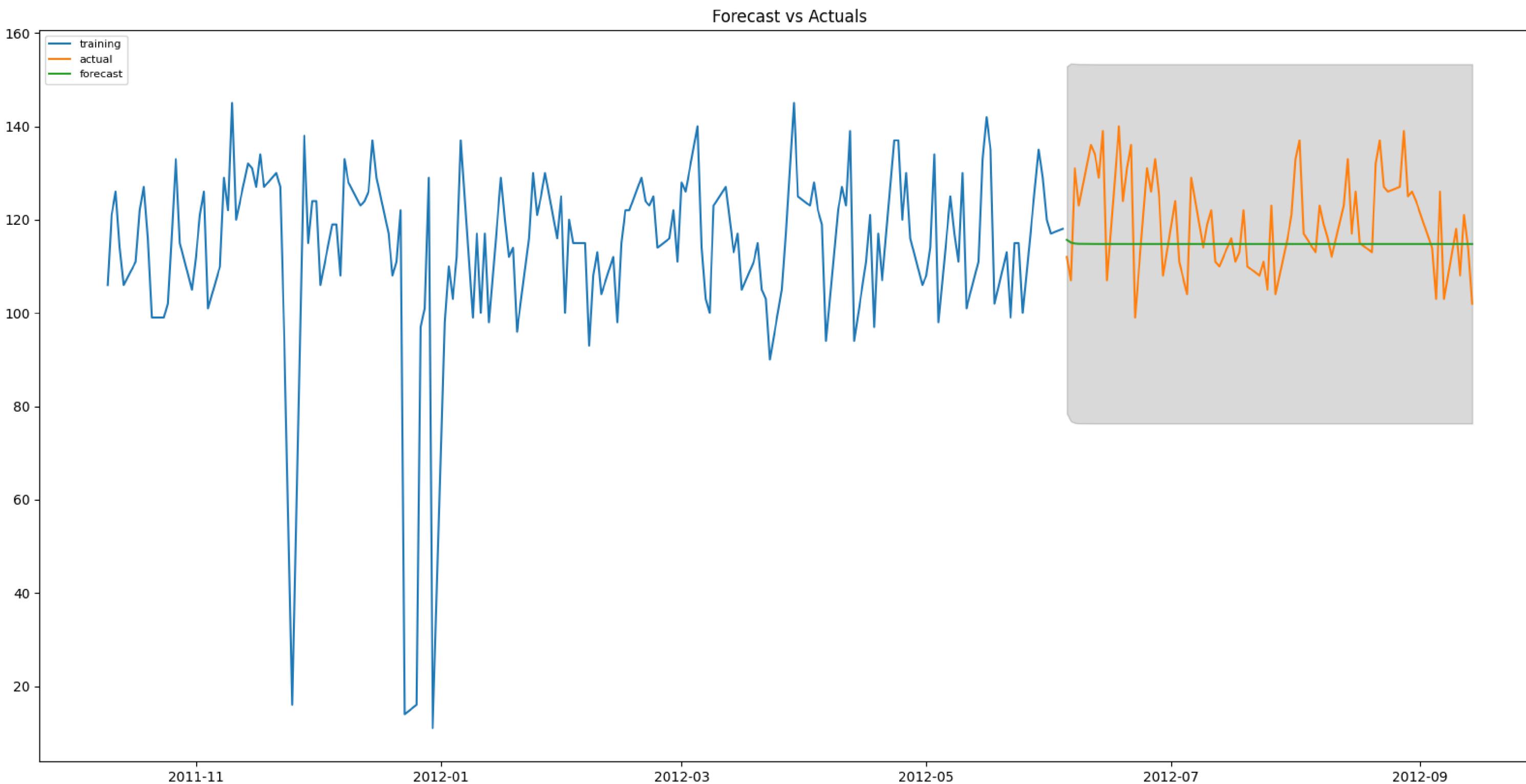
ARMA Model Results

Dep. Variable:	Actual	No. Observations:	241
Model:	ARMA(1, 1)	Log Likelihood	-1023.866
Method:	css-mle	S.D. of innovations	16.933
Date:	Tue, 21 Feb 2023	AIC	2055.733
Time:	19:09:50	BIC	2069.672
Sample:	0	HQIC	2061.348

	coef	std err	z	P> z	[0.025	0.975]
const	116.3283	1.708	68.104	0.000	112.981	119.676
ar.L1.Actual	0.6121	0.267	2.295	0.022	0.089	1.135
ma.L1.Actual	-0.3902	0.319	-1.223	0.222	-1.016	0.235

Roots





Mean Absolute Error (MAE): 9.651272973676344
Root Mean Squared Error (RMSE): 11.69619903355198
Mean Absolute Percentage Error (MAPE): 7.803470431994783
Akaike Information Criterion (AIC): 2055.7325090566173

Thank You! Any Questions?