Analysis of Walmart Sales & Sales Forecast

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Agenda

- PROJECT BACKGROUND
- MISSION STATEMENT
- DATASET
- DATA WRANGLING
- EXPLORATORY DATA ANALYSIS
- TIME SERIES ANALYSIS
- FORECAST MODELS
- CONCLUSION

Special Buy
$148
onn. 50" Class 4K Roku Smart TV
• 49.5" diagonal screen size
• Model #100005396, 100005843, 100007147
onn. Roku
NETFLIX HBO GO VUDU
Walmart
Special Buy
$98
onn. 40" Class 1080p Roku Smart TV
• 39.5" diagonal screen size
• Model #100005842, 100005395
onn. Roku
NETFLIX HBO GO VUDU
65" | 4K
Black Friday
Online Wed. 11/27 at 10pm ET
In stores Thanksgiving 11/28 at 6pm
PHILIPS
androidtv
NETFLIX HBO GO VUDU
Special Buy
$278
Philips 65" Class 4K Android Smart TV
• 64.5" diagonal screen size
• Model #65PFL5504/F7
Get up to
$700
in eGift Cards
Walmart eGift Card
with qualified activation & trade-in on select Apple & Samsung smartphones.
See page 9 for details.
Save $80
$249
iPad 7th Gen 32GB
• 10.2" Retina display
• Smart Keyboard & Apple Pencil
Save $70
$129
Apple Watch Series 3 (GPS)
• 38mm
Save $15
$129
Shop our
BUY NOW
selection

Project Background

- Walmart
  - an American multinational retail corporation
  - operates a chain of
    - hypermarkets
    - discount department stores
    - grocery stores
  - 45 stores across the U.S.
  - promotional markdown events
    - Super Bowl
    - Labor Day
    - Thanksgiving
    - Christmas

Mission Statement

- Assist Walmart’s management team in the decision-making process by:
  - Performing exploratory data analysis and time series analysis of Walmart’s sales data
  - Identifying the factors that impact sales
  - Developing machine learning algorithms to forecast sales

Dataset

- Collected on Kaggle at https://www.kaggle.com/c/walmart-recruiting-store-sales-forecasting/data
- Historical sales data
  - 45 Walmart stores in the United States
  - From 2/5/2010 to 11/1/2012
- 3 csv files
  - stores: 45 records
    - Columns: store, type, size
  - sales: 421,570 records
    - Columns: store, dept, date, weekly sales, isHoliday
  - features: 8,190 records
    - Columns: store, date, temp, fuel price, markdown 1-5, CPI, unemployment, isHoliday

Data Wrangling

MISSING VALUES | NEW COLUMNS | OUTLIERS

Missing Values

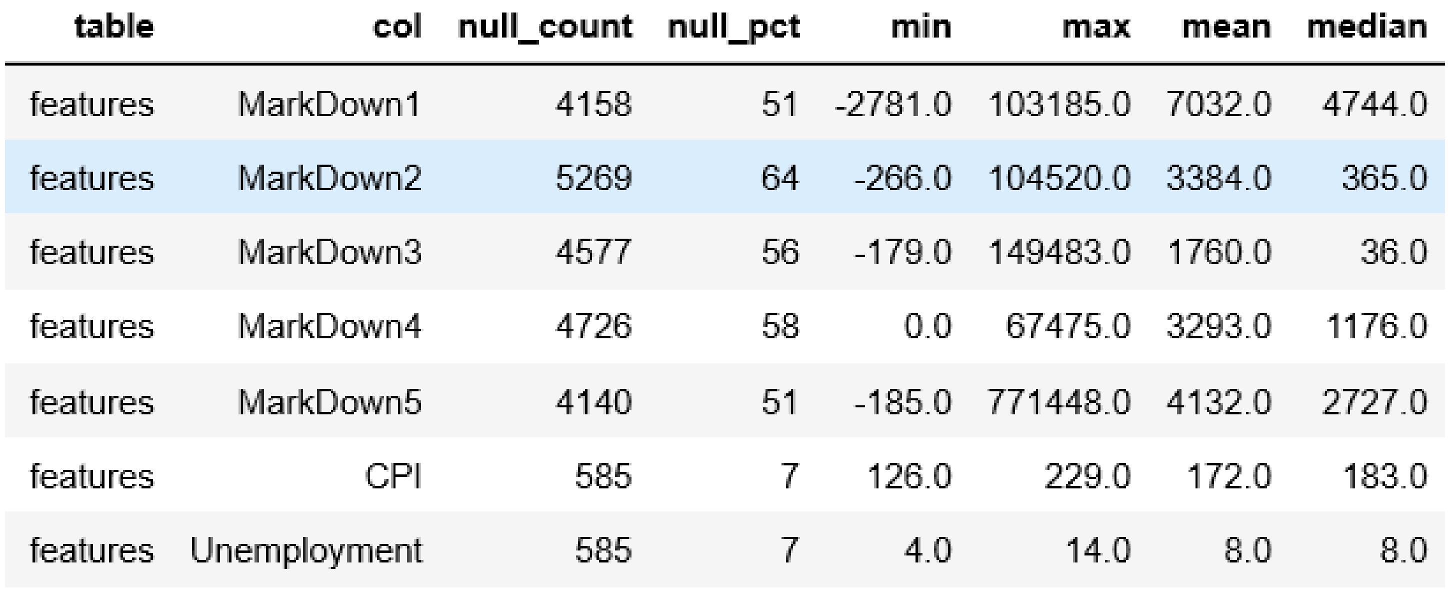
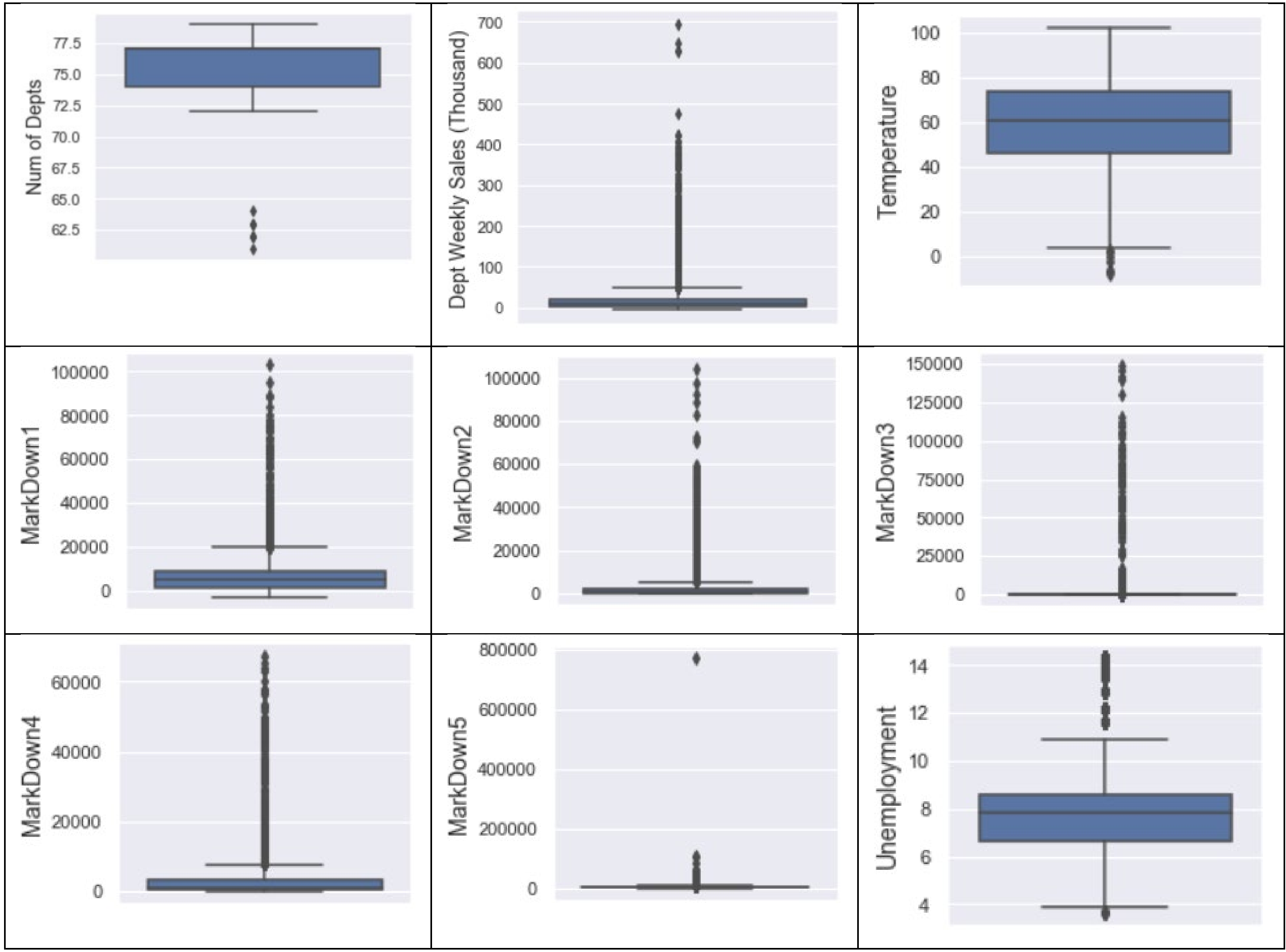


table	col	null_count	null_pct	min	max	mean	median
features	MarkDown1	4158	51	-2781.0	103185.0	7032.0	4744.0
features	MarkDown2	5269	64	-266.0	104520.0	3384.0	365.0
features	MarkDown3	4577	56	-179.0	149483.0	1760.0	36.0
features	MarkDown4	4726	58	0.0	67475.0	3293.0	1176.0
features	MarkDown5	4140	51	-185.0	771448.0	4132.0	2727.0
features	CPI	585	7	126.0	229.0	172.0	183.0
features	Unemployment	585	7	4.0	14.0	8.0	8.0

- features
  - Markdown 1-5
  - CPI
  - Unemployment

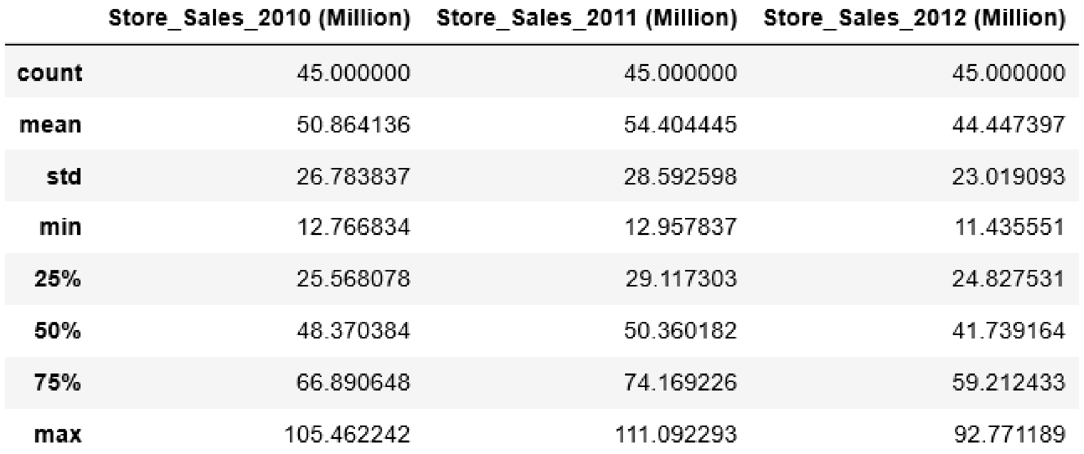
New Columns

- Num of Depts = counts of number of departments for each store
- Dept Weekly Sales (Thousand) = Weekly Sales / 1,000
- Avg Yearly Sales (Million) = average yearly sales
- Markdown = sum of MarkDown1-5
- Avg Yearly MarkDown (Thousand) = average annual markdown
- Year = year extracted from Date
- Quarter = quarter extracted from Date
- Month = month extracted from Date
- Week = week of year extracted from Date

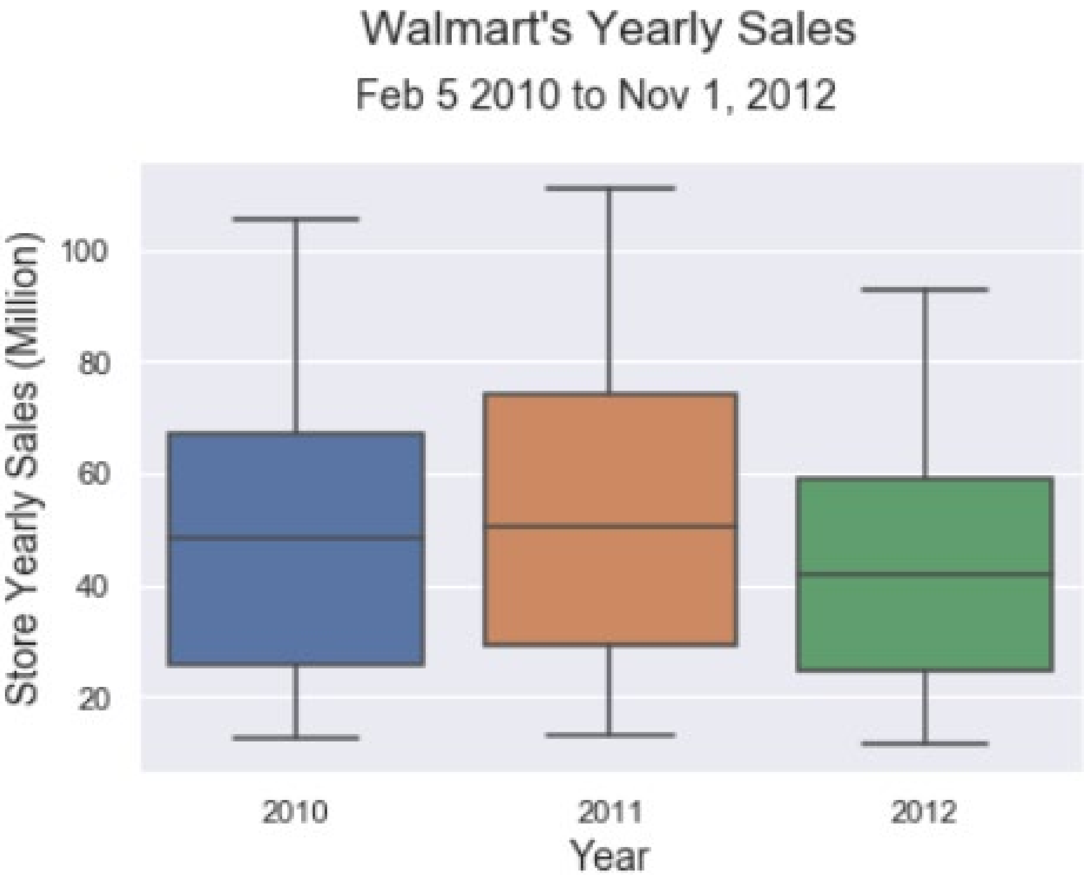

Num of Depts
77.5
75.0
72.5
70.0
67.5
65.0
62.5
Dept Weekly Sales (Thousand)
700
600
500
400
300
200
100
0
Temperature
100
80
60
40
20
0
MarkDown1
100000
80000
60000
40000
20000
0
MarkDown2
100000
80000
60000
40000
20000
0
MarkDown3
150000
125000
100000
75000
50000
25000
0
MarkDown4
60000
40000
20000
0
MarkDown5
800000
600000
400000
200000
0
Unemployment
14
12
10
8
6
4

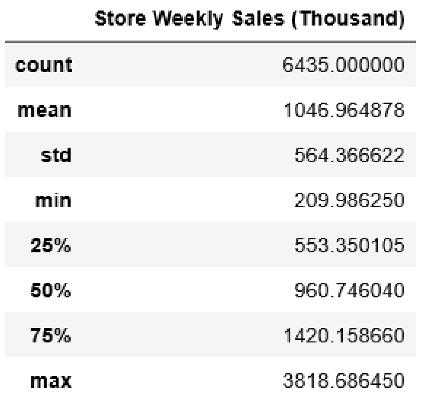
Outliers

Exploratory Data Analysis

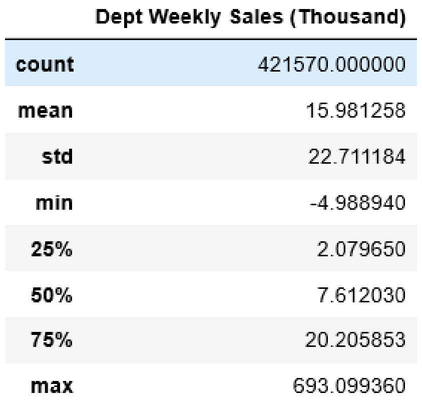


	Store_Sales_2010 (Million)	Store_Sales_2011 (Million)	Store_Sales_2012 (Million)
count	45.000000	45.000000	45.000000
mean	50.864136	54.404445	44.447397
std	26.783837	28.592598	23.019093
min	12.766834	12.957837	11.435551
25%	25.568078	29.117303	24.827531
50%	48.370384	50.360182	41.739164
75%	66.890648	74.169226	59.212433
max	105.462242	111.092293	92.771189

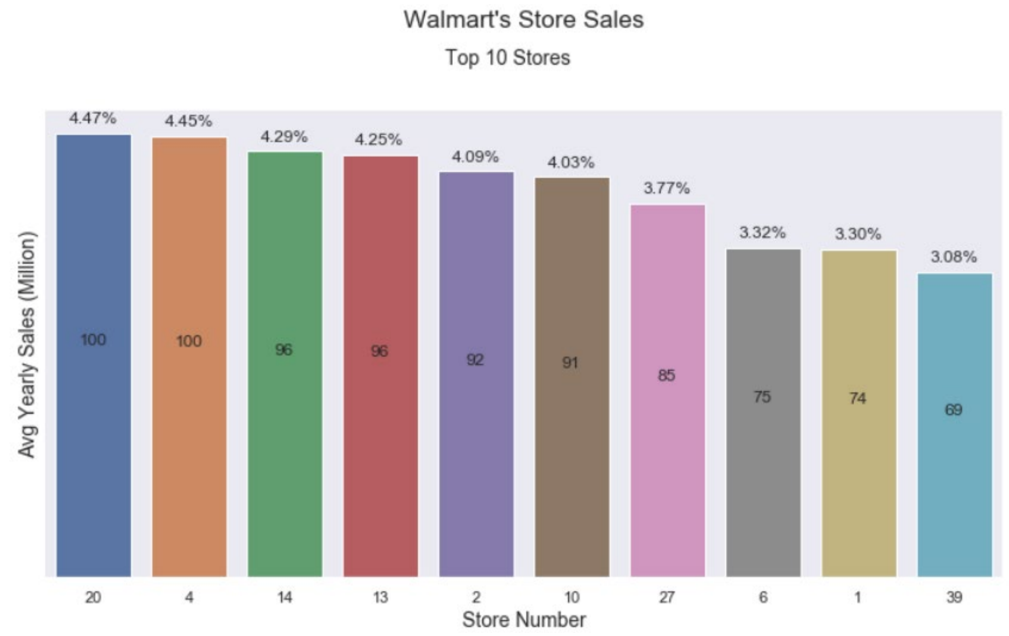




	Store Weekly Sales (Thousand)
count	6435.000000
mean	1046.964878
std	564.366622
min	209.986250
25%	553.350105
50%	960.746040
75%	1420.158660
max	3818.686450

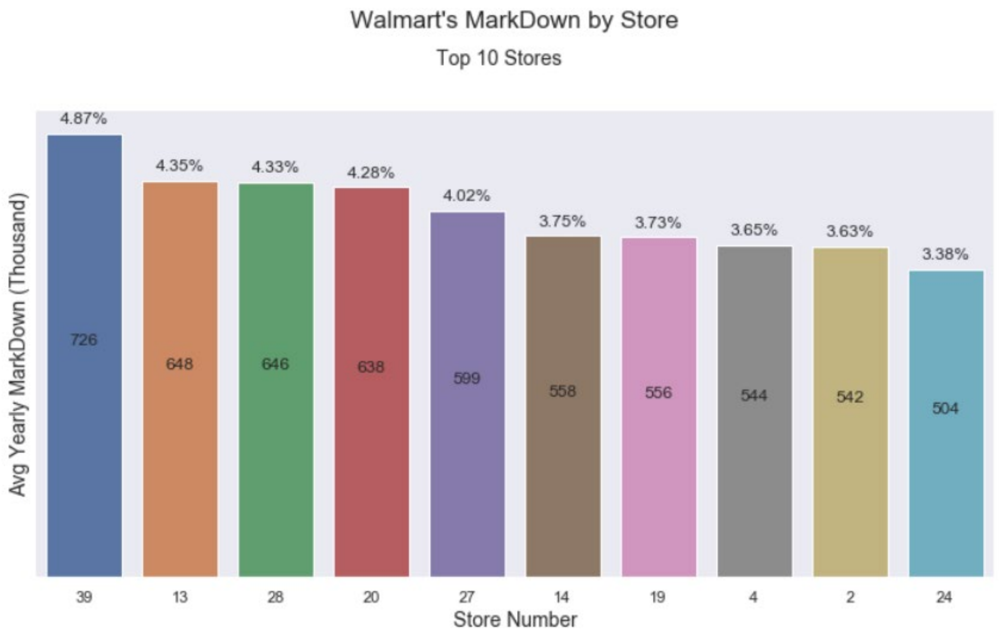


	Dept Weekly Sales (Thousand)
count	421570.000000
mean	15.981258
std	22.711184
min	-4.988940
25%	2.079650
50%	7.612030
75%	20.205853
max	693.099360



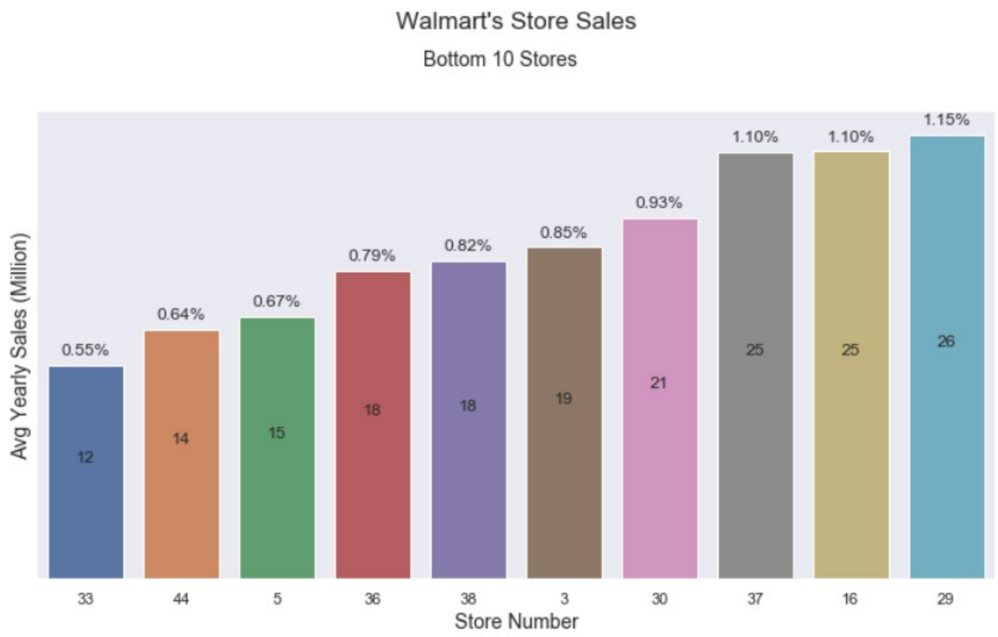
Walmart's Store Sales

Top 10 Stores



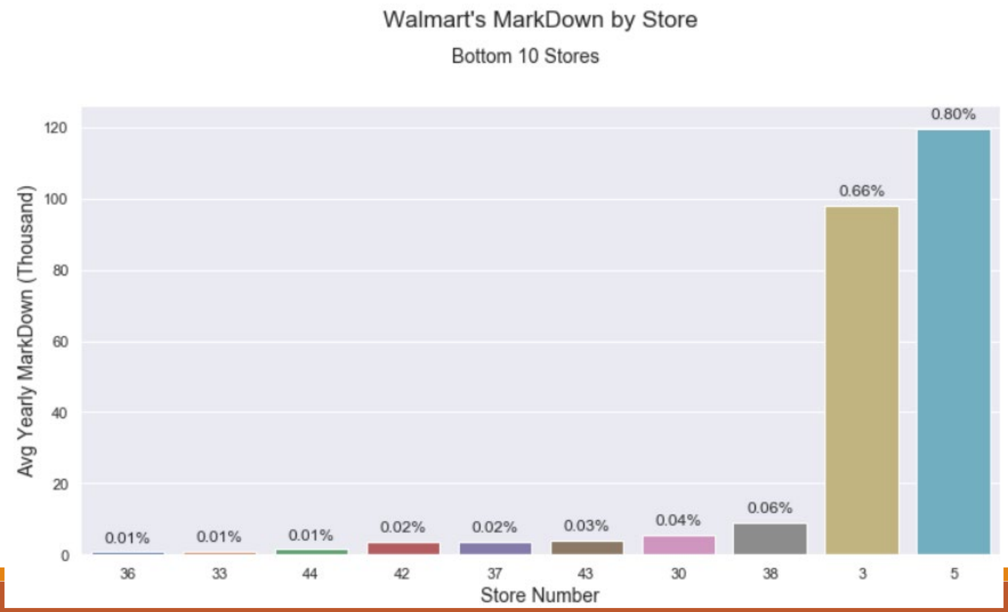
Walmart's MarkDown by Store

Top 10 Stores



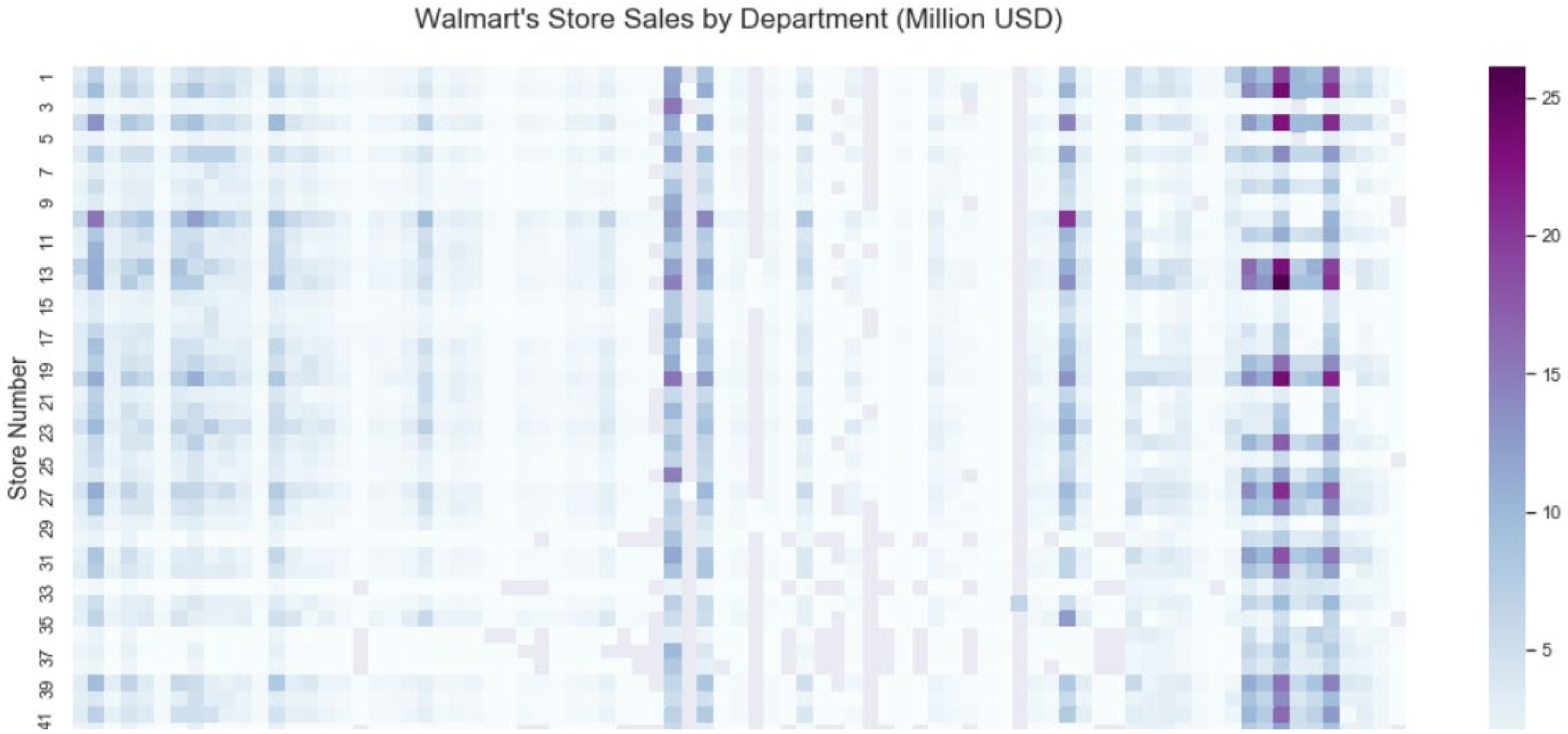
Walmart's Store Sales

Bottom 10 Stores

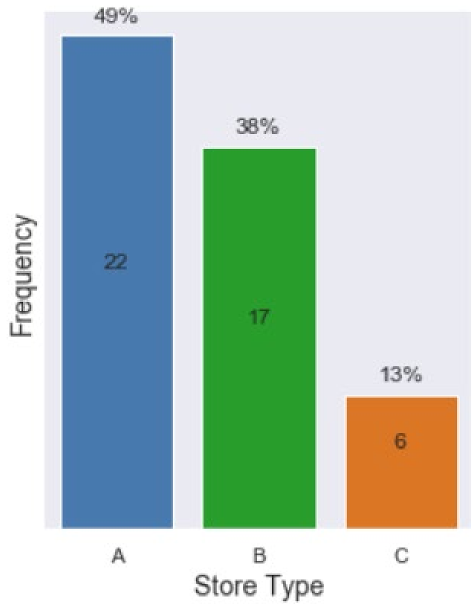


Walmart's MarkDown by Store

Bottom 10 Stores

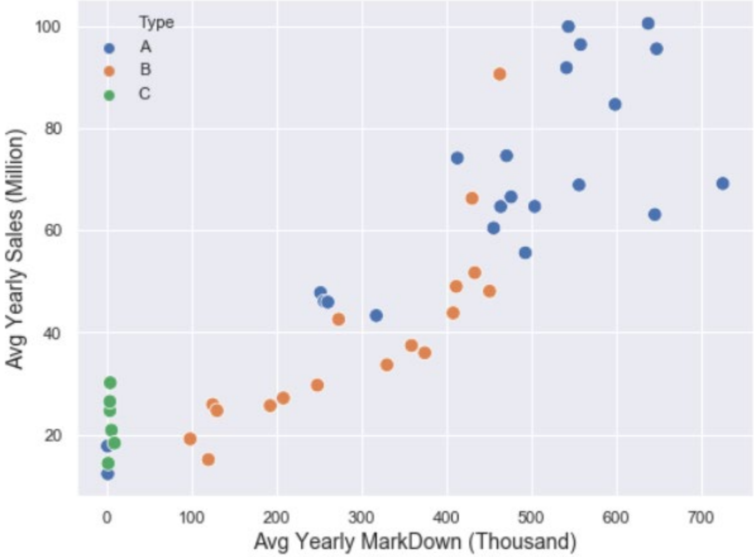

Walmart's Store Sales by Department (Million USD)
Store Number
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
25
20
15
10
5

Distribution of Walmart's Store Types



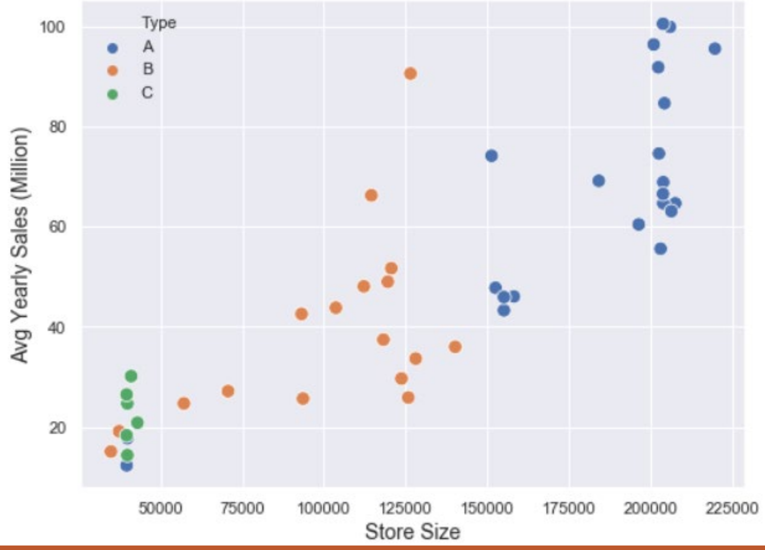
Walmart Sales

Avg Yearly MarkDown (Thousand) vs. Avg Yearly Sales (Million)
Correlation: 0.8778



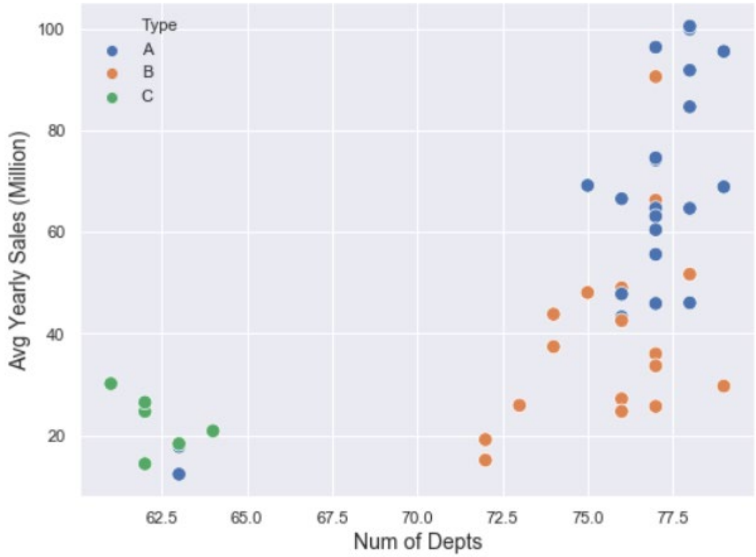
Walmart Sales

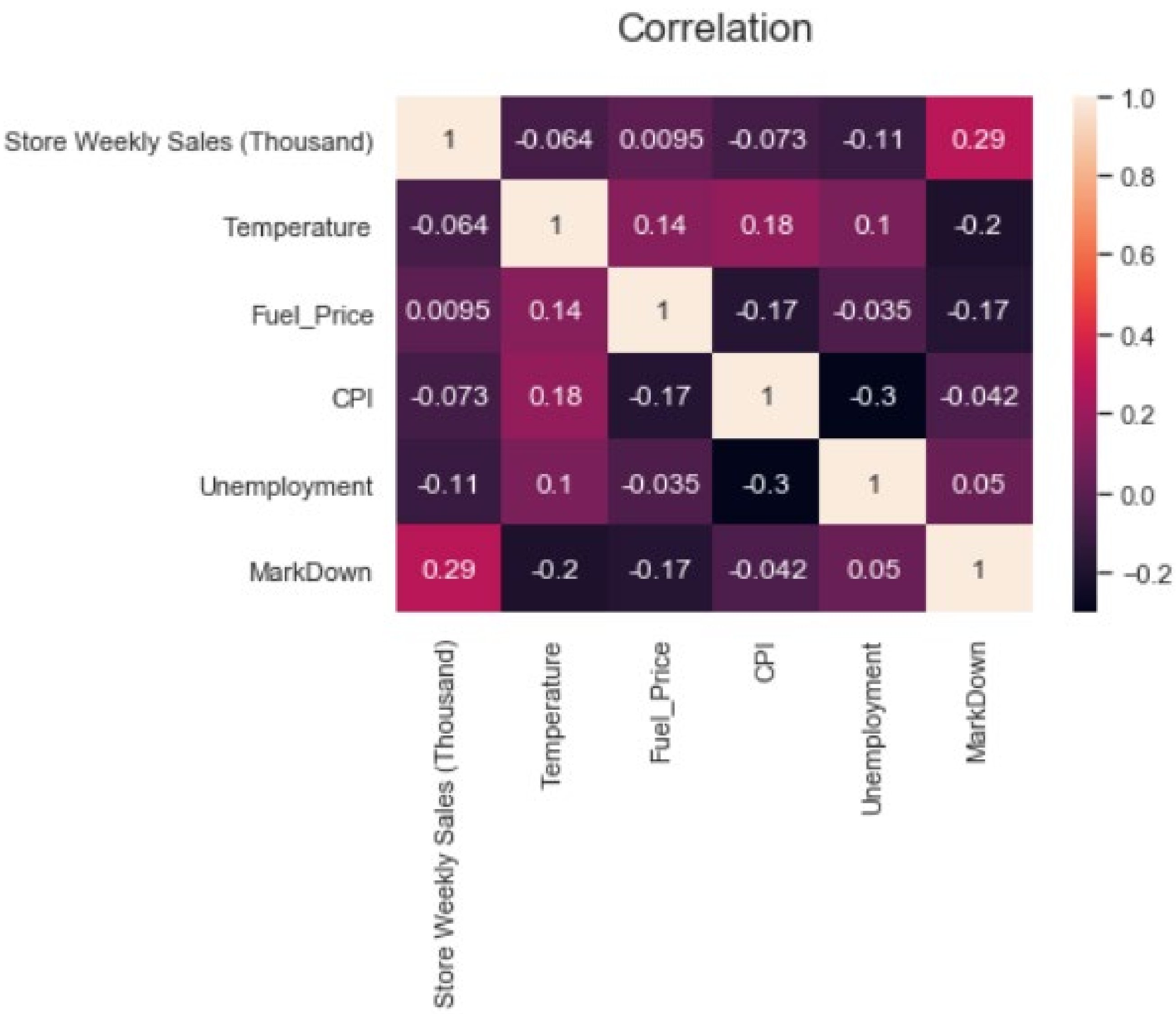
Size vs. Avg Yearly Sales (Million)
Correlation: 0.8462



Walmart Sales

Num of Depts vs. Avg Yearly Sales (Million)
Correlation: 0.6385





Correlation

	Store Weekly Sales (Thousand)	Temperature	Fuel_Price	CPI	Unemployment	MarkDown
Store Weekly Sales (Thousand)	1	-0.064	0.0095	-0.073	-0.11	0.29
Temperature	-0.064	1	0.14	0.18	0.1	-0.2
Fuel_Price	0.0095	0.14	1	-0.17	-0.035	-0.17
CPI	-0.073	0.18	-0.17	1	-0.3	-0.042
Unemployment	-0.11	0.1	-0.035	-0.3	1	0.05
MarkDown	0.29	-0.2	-0.17	-0.042	0.05	1

Weak Correlation

Time Series Analysis

ORIGINAL TIME SERIES

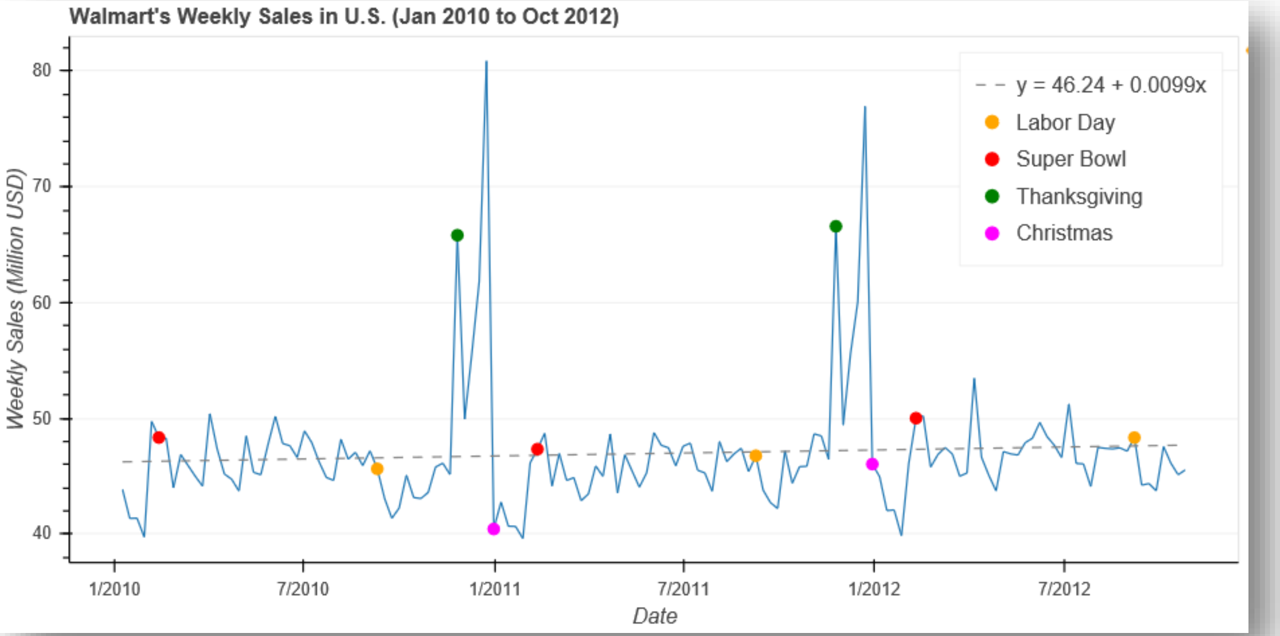
GENERAL TREND

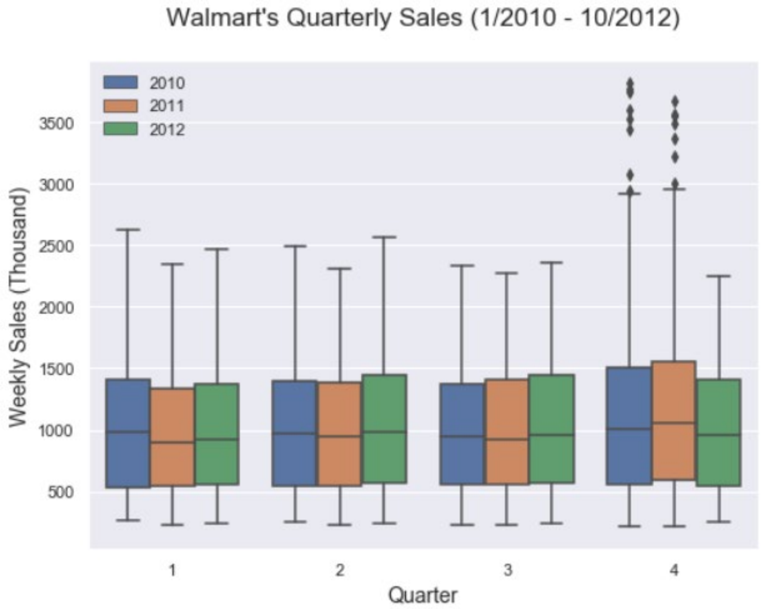
SEASONALITY

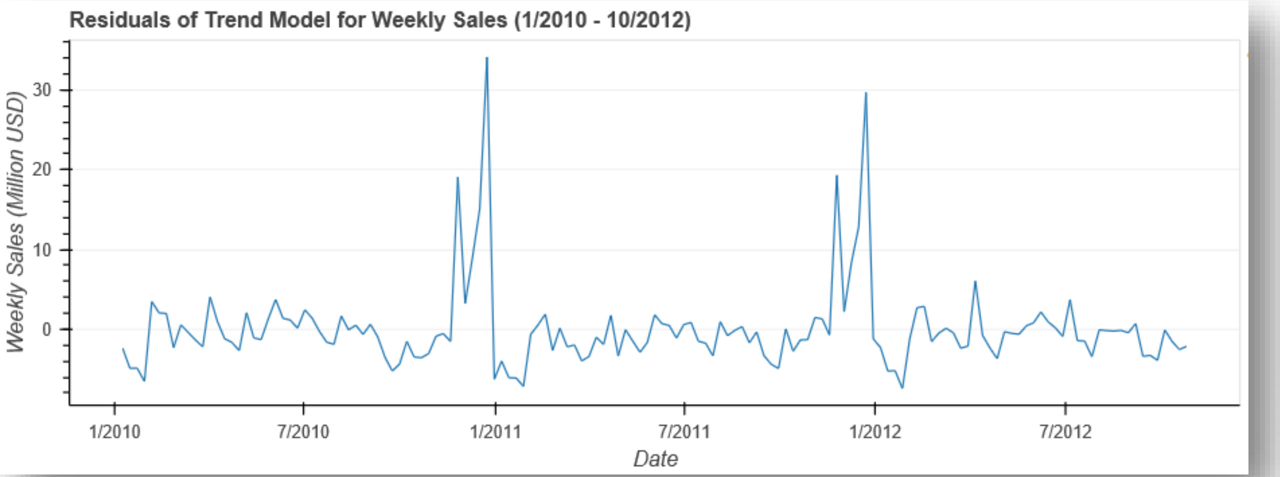
STATIONARITY

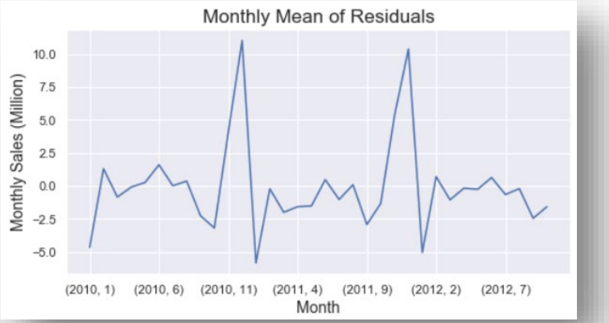
Original Time Series & General Trend (y)

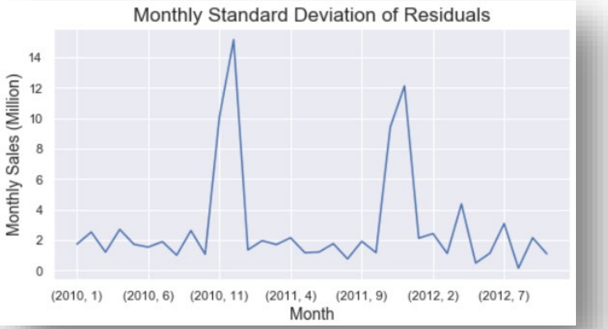
Seasonality

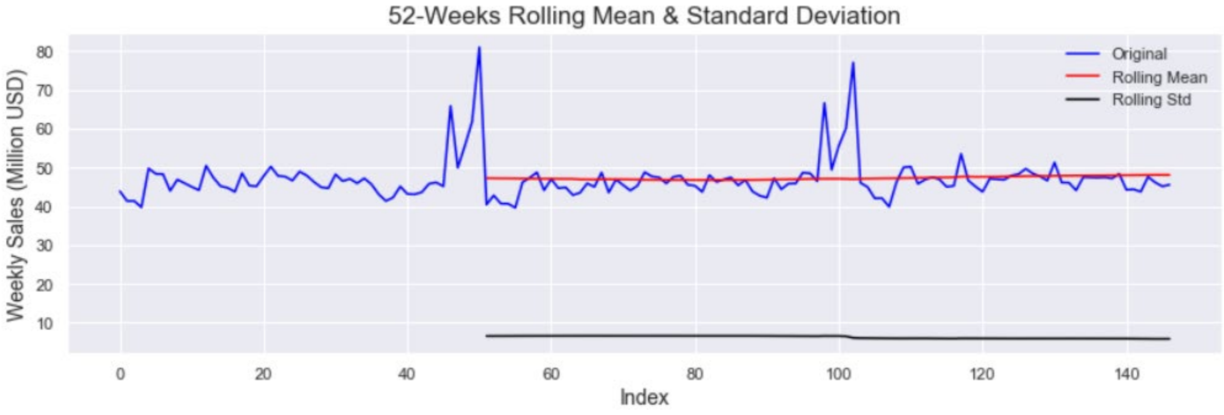


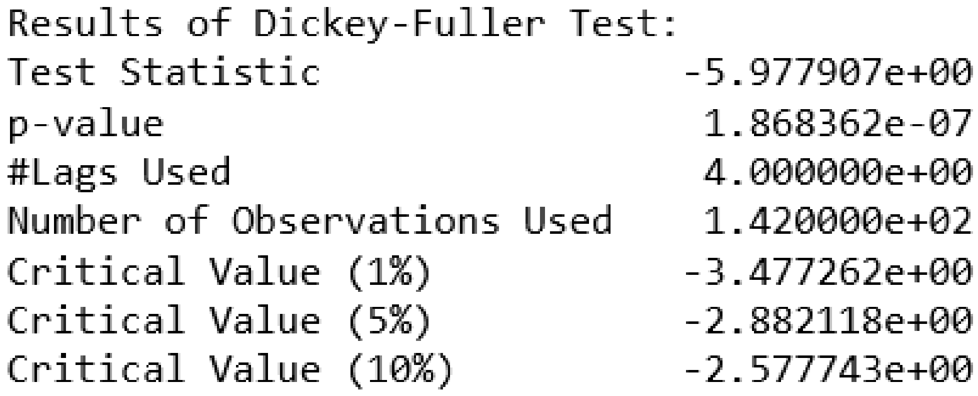












```
Results of Dickey-Fuller Test:
Test Statistic                 -5.977907e+00
p-value                         1.868362e-07
#Lags Used                      4.000000e+00
Number of Observations Used     1.420000e+02
Critical Value (1%)            -3.477262e+00
Critical Value (5%)            -2.882118e+00
Critical Value (10%)           -2.577743e+00
```

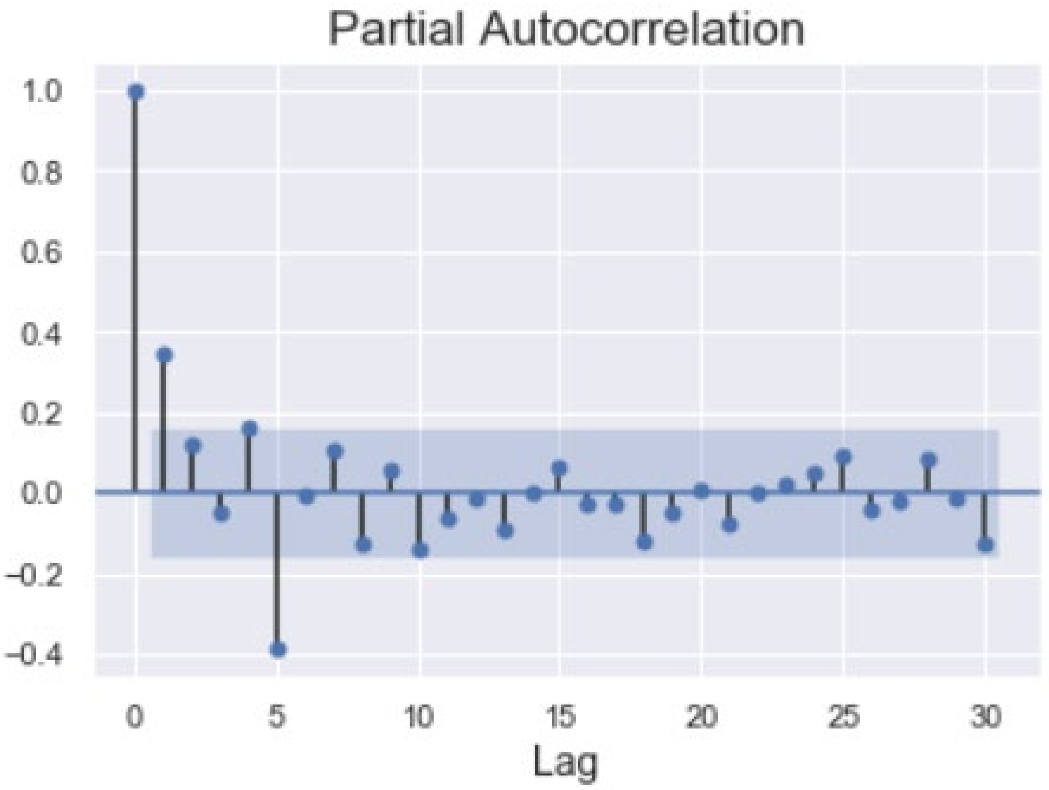
Stationarity

Model Development

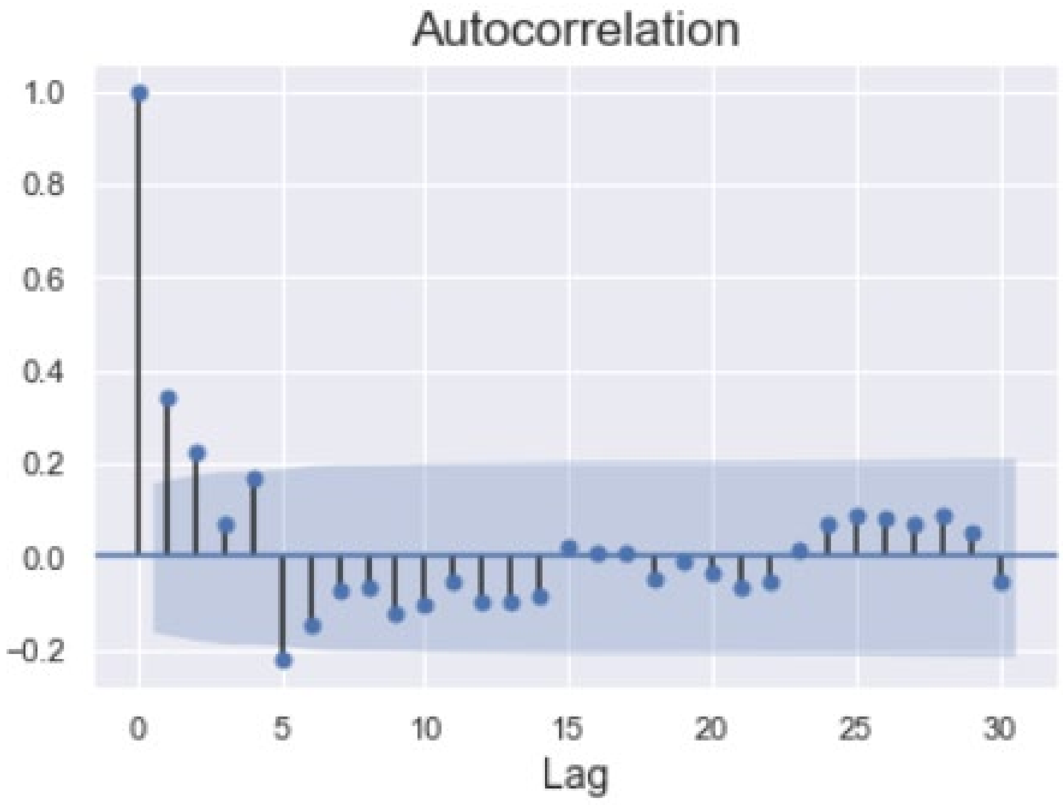
AUTOREGRESSIVE TERM | MOVING AVERAGE TERM

ARIMA | SARIMAX

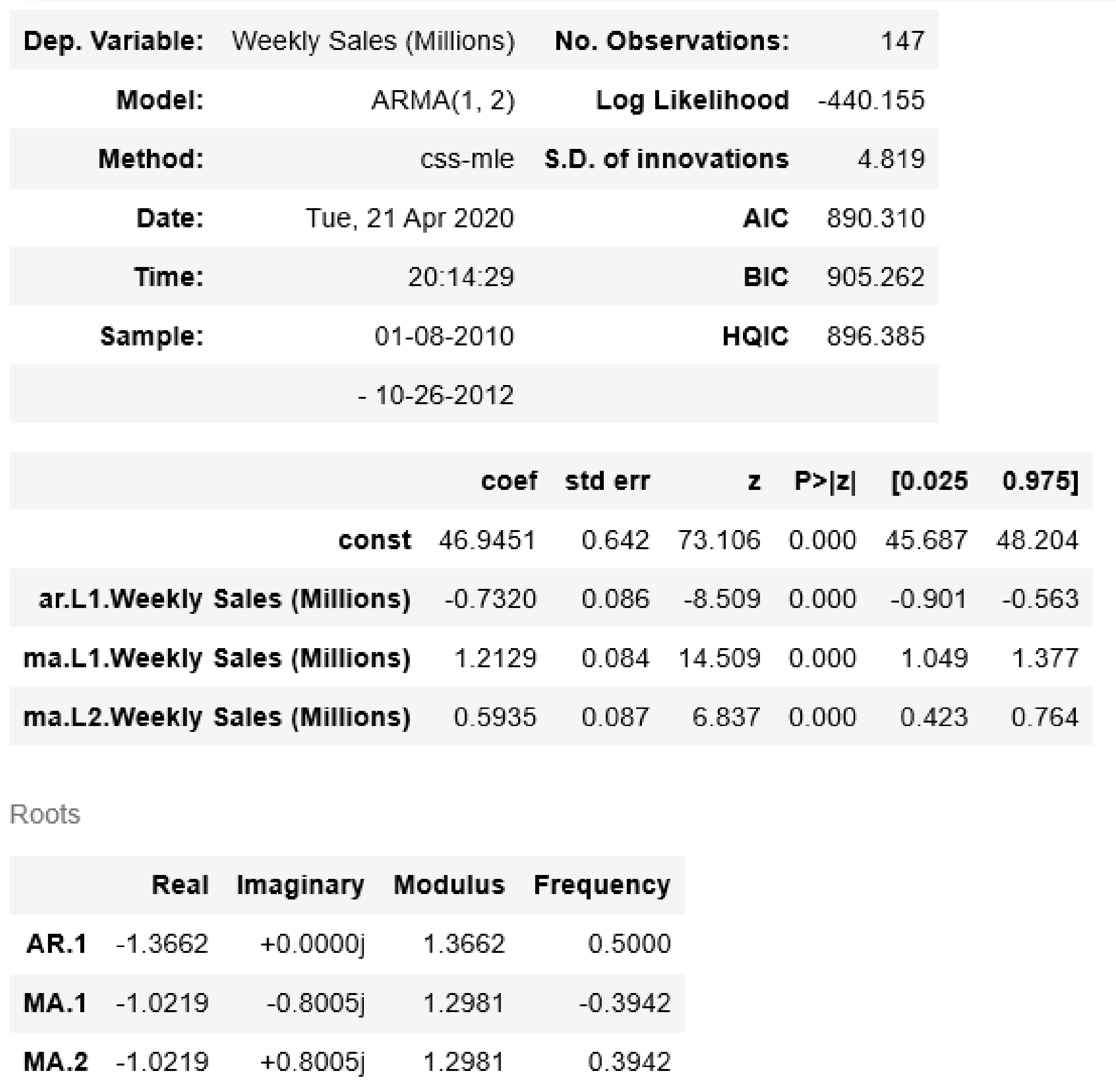
Autoregressive Term



Moving Average Term



ARIMA Model

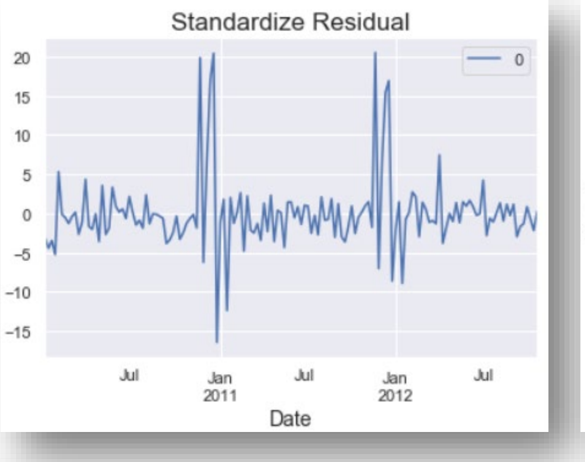


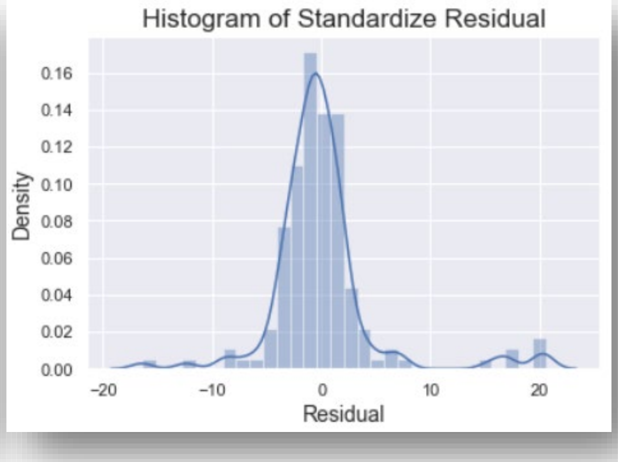
Dep. Variable:	Weekly Sales (Millions)	**No. Observations:**	147
Model:	ARMA(1, 2)	**Log Likelihood**	-440.155
Method:	css-mle	**S.D. of innovations**	4.819
Date:	Tue, 21 Apr 2020	**AIC**	890.310
Time:	20:14:29	**BIC**	905.262
Sample:	01-08-2010	**HQIC**	896.385
	- 10-26-2012		

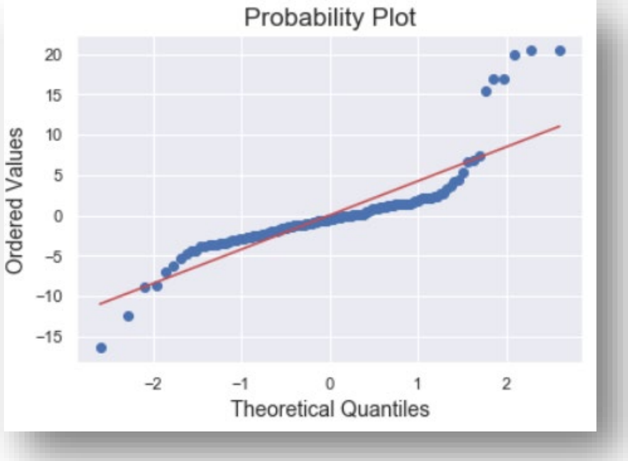
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
const	46.9451	0.642	73.106	0.000	45.687	48.204
ar.L1.Weekly Sales (Millions)	-0.7320	0.086	-8.509	0.000	-0.901	-0.563
ma.L1.Weekly Sales (Millions)	1.2129	0.084	14.509	0.000	1.049	1.377
ma.L2.Weekly Sales (Millions)	0.5935	0.087	6.837	0.000	0.423	0.764

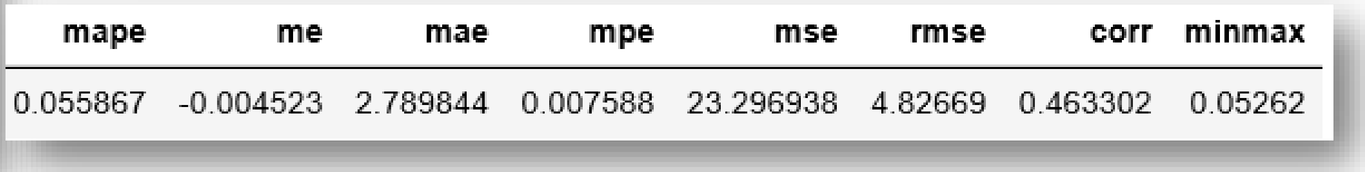
Roots

	Real	**Imaginary**	**Modulus**	**Frequency**
AR.1	-1.3662	+0.0000j	1.3662	0.5000
MA.1	-1.0219	-0.8005j	1.2981	-0.3942
MA.2	-1.0219	+0.8005j	1.2981	0.3942



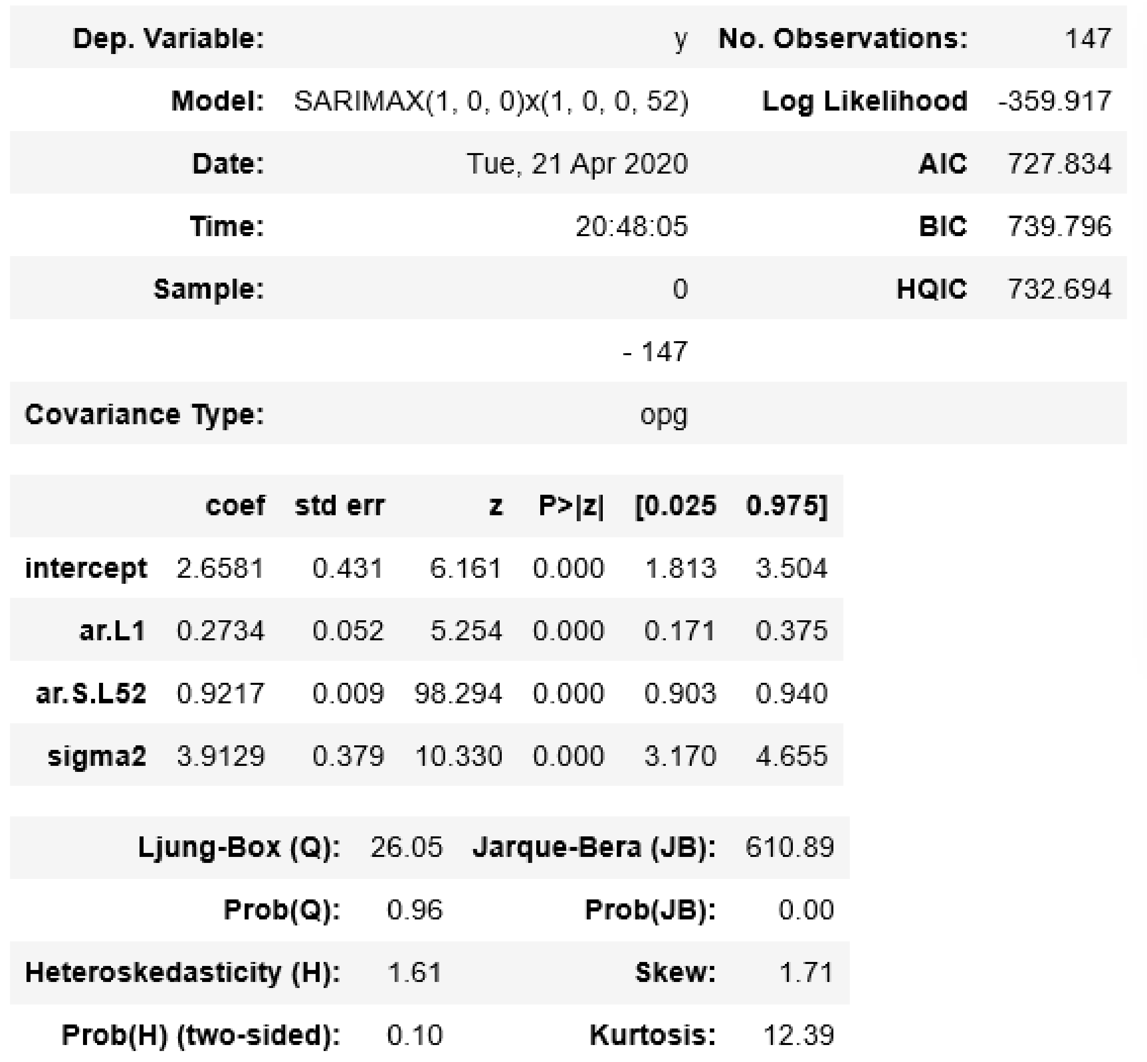






mape	me	mae	mpe	mse	rmse	corr	minmax
0.055867	-0.004523	2.789844	0.007588	23.296938	4.82669	0.463302	0.05262

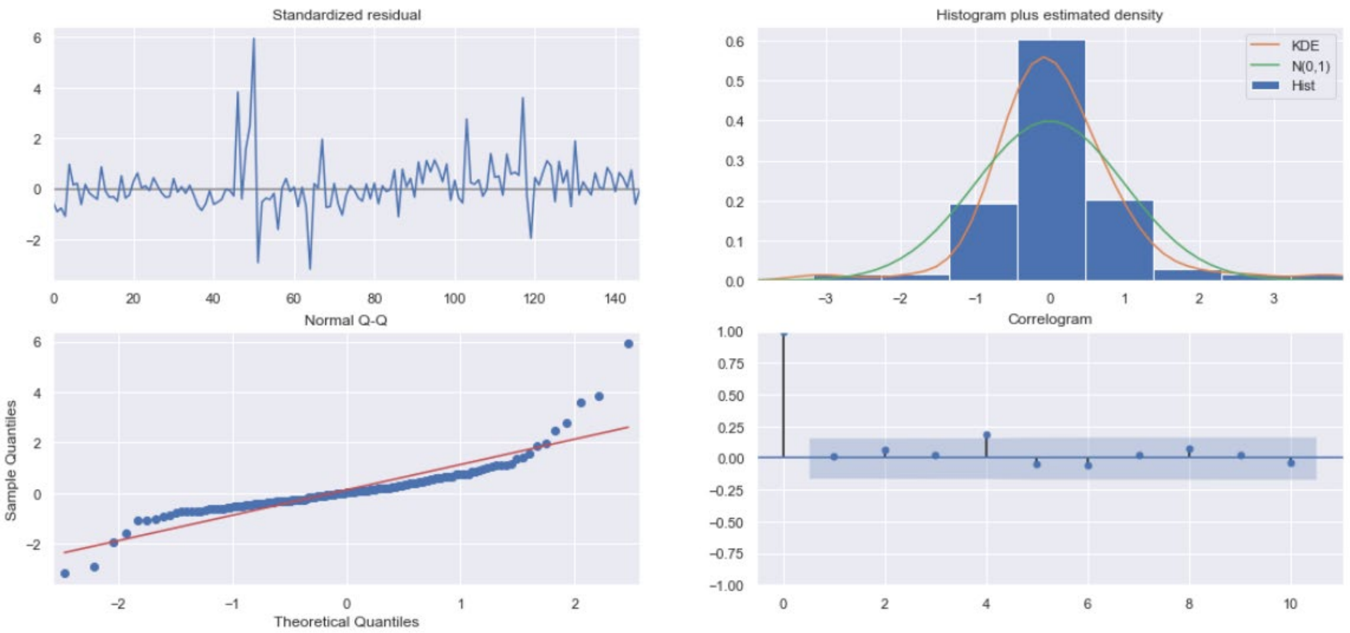
SARIMAX Model



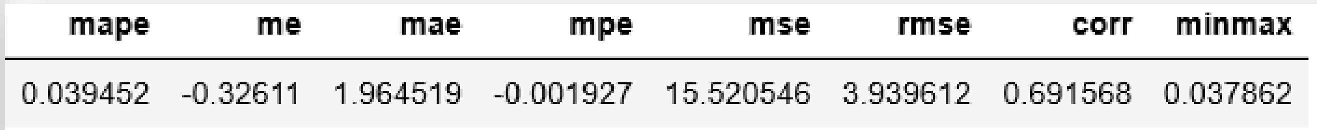
Dep. Variable:	y	**No. Observations:**	147
Model:	SARIMAX(1, 0, 0)x(1, 0, 0, 52)	**Log Likelihood**	-359.917
Date:	Tue, 21 Apr 2020	**AIC**	727.834
Time:	20:48:05	**BIC**	739.796
Sample:	0	**HQIC**	732.694
	- 147		
Covariance Type:	opg		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
intercept	2.6581	0.431	6.161	0.000	1.813	3.504
ar.L1	0.2734	0.052	5.254	0.000	0.171	0.375
ar.S.L52	0.9217	0.009	98.294	0.000	0.903	0.940
sigma2	3.9129	0.379	10.330	0.000	3.170	4.655

Ljung-Box (Q):	26.05	**Jarque-Bera (JB):**	610.89
Prob(Q):	0.96	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.61	**Skew:**	1.71
Prob(H) (two-sided):	0.10	**Kurtosis:**	12.39



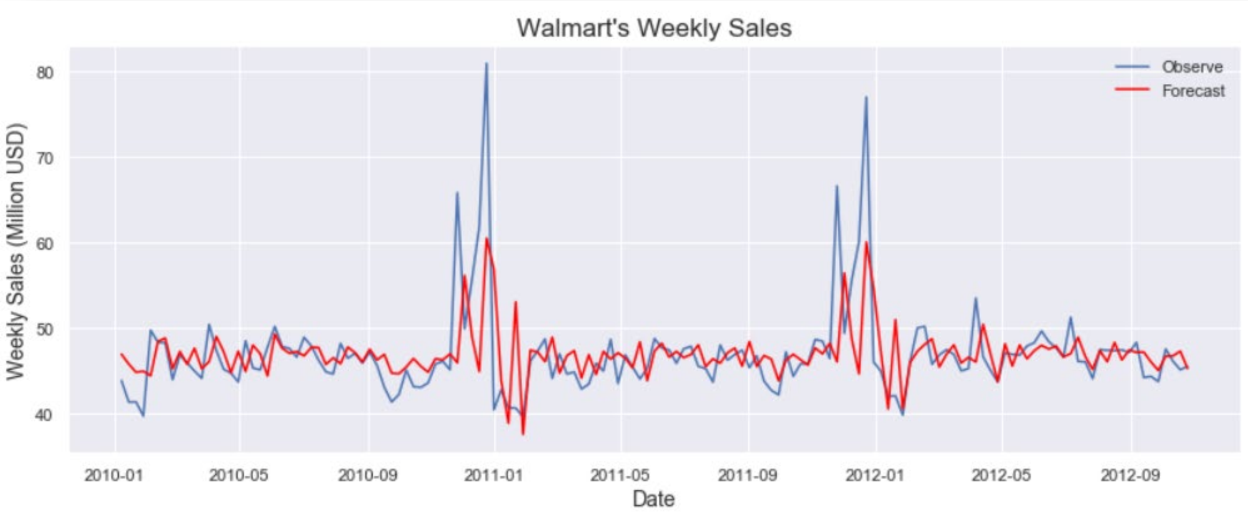
Evaluation Metrics



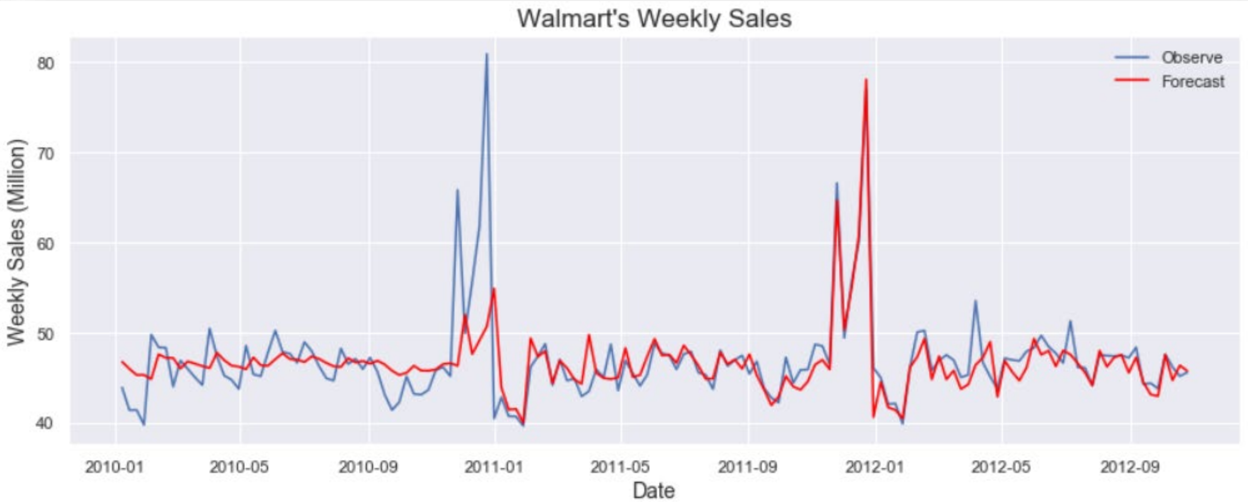
mape	me	mae	mpe	mse	rmse	corr	minmax
0.039452	-0.32611	1.964519	-0.001927	15.520546	3.939612	0.691568	0.037862

Sales Forecast

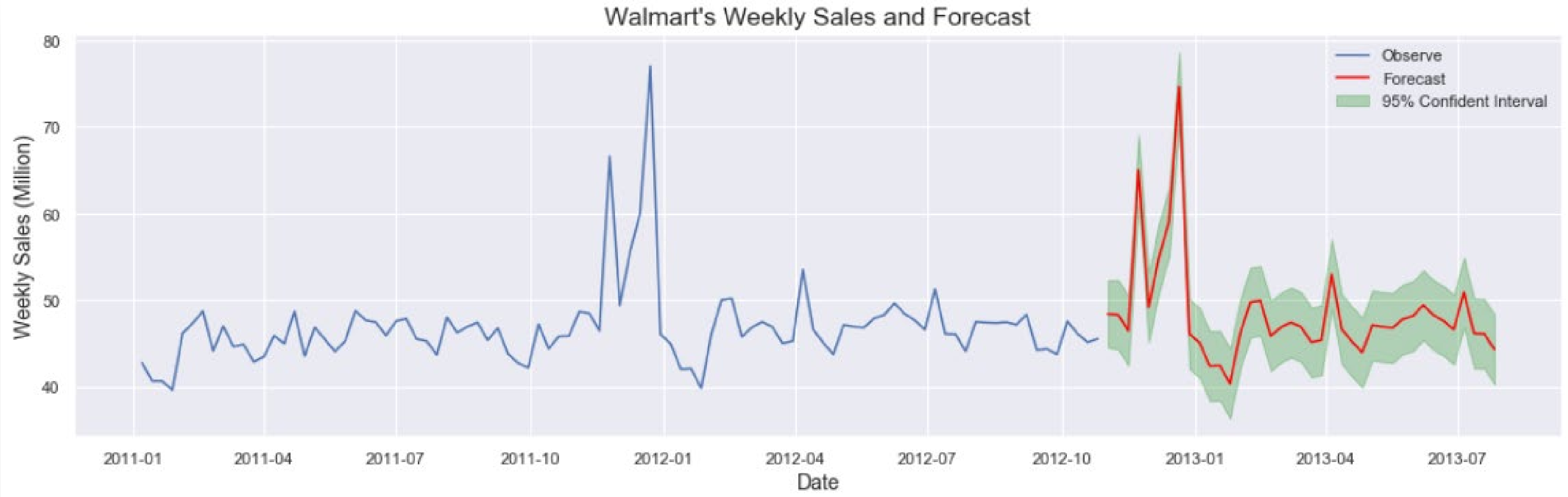
Sales Forecast from ARIMA Model



Sales Forecast from SARIMAX Model



Future Sales Forecast from SARIMAX Model



Conclusion

- Holidays does not seem to impact sales except for Thanksgiving
- Sales seems to be highest
  - During the week of Thanksgiving
  - 2-3 weeks after Thanksgiving
- Stores with high sales
  - Big size
  - Big number of departments
  - High markdown values
- Stores with low sales
  - Small size
  - Small number of departments
  - Low markdown values

Thank You!