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

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

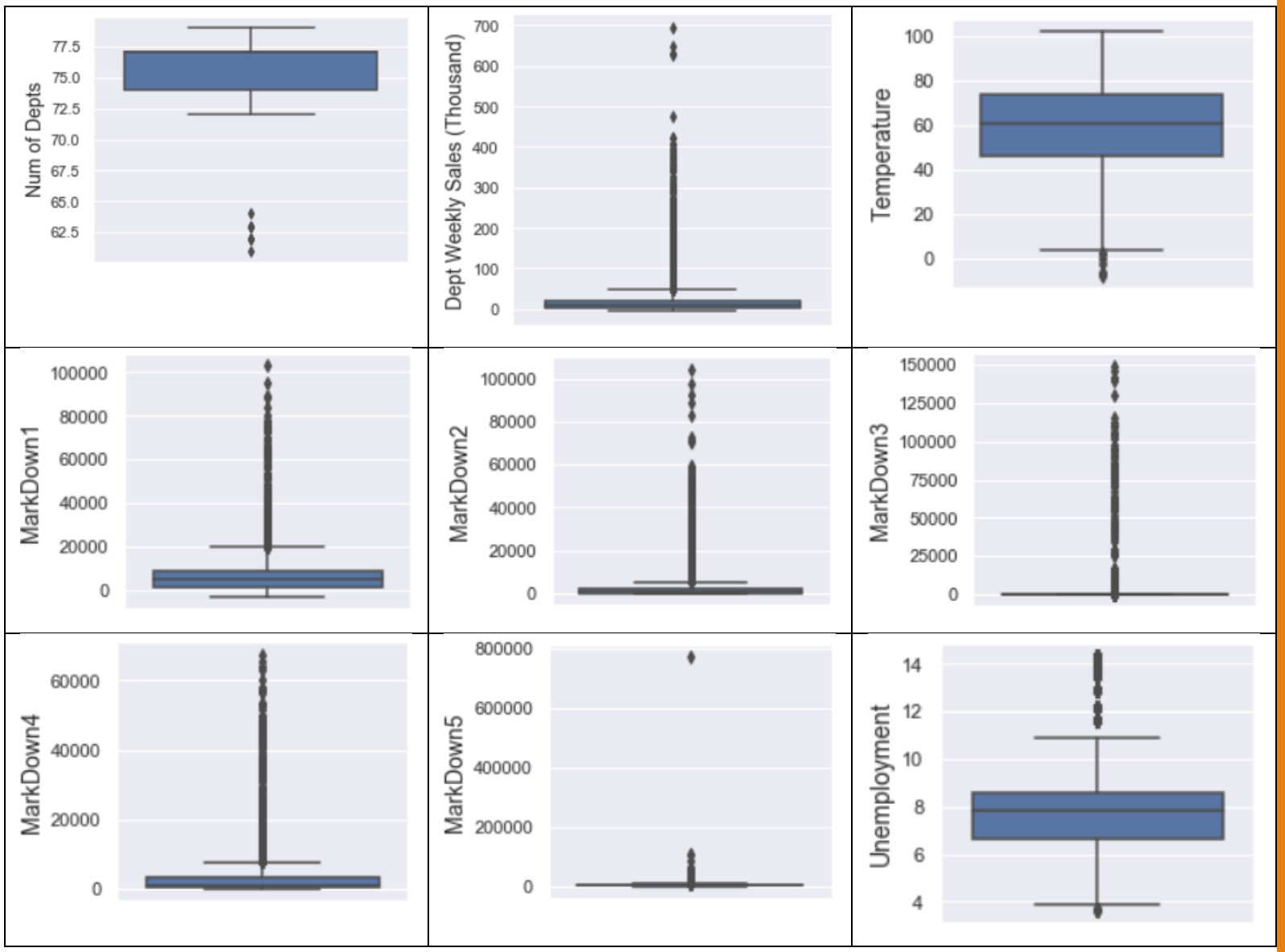
table	col	null_count	null_pct	min	max	mean	median
features	MarkDown1	4158	51	-2781.0	103185.0	7032.0	4744.0
features	MarkDown2	5269	64	-266.0	104520.0	3384.0	365.0
features	MarkDown3	4577	56	-179.0	149483.0	1760.0	36.0
features	MarkDown4	4726	58	0.0	67475.0	3293.0	1176.0
features	MarkDown5	4140	51	-185.0	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

Missing Values

- 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 by store
- Markdown = sum of MarkDown1-5
- Avg Yearly MarkDown (Thousand) = average yearly markdown by store
- 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

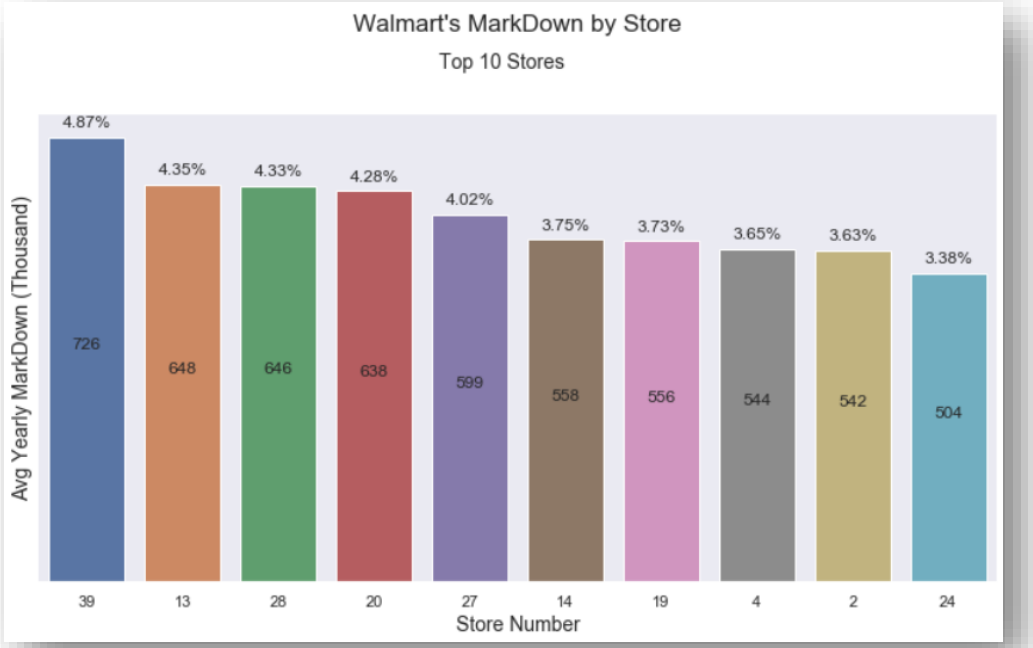
Exploratory Data Analysis

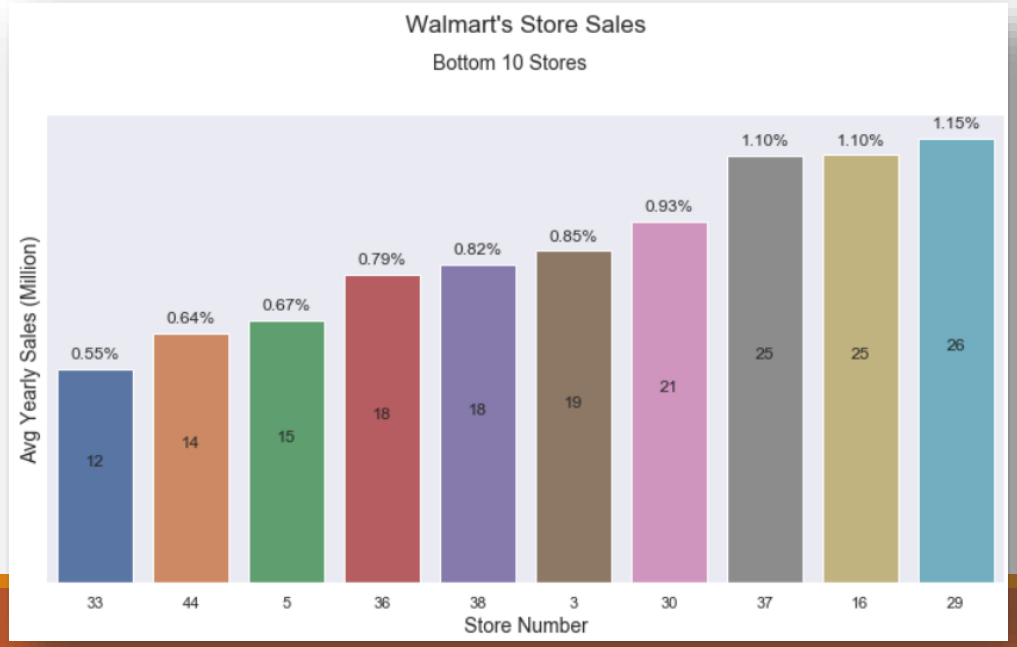
	Store_Sales_2010 (Million)	Store_Sales_2011 (Million)	Store_Sales_2012 (Million)
count	45.000000	45.000000	45.000000
mean	50.864136	54.404445	44.447397
std	26.783837	28.592598	23.019093
min	12.766834	12.957837	11.435551
25%	25.568078	29.117303	24.827531
50%	48.370384	50.360182	41.739164
75%	66.890648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

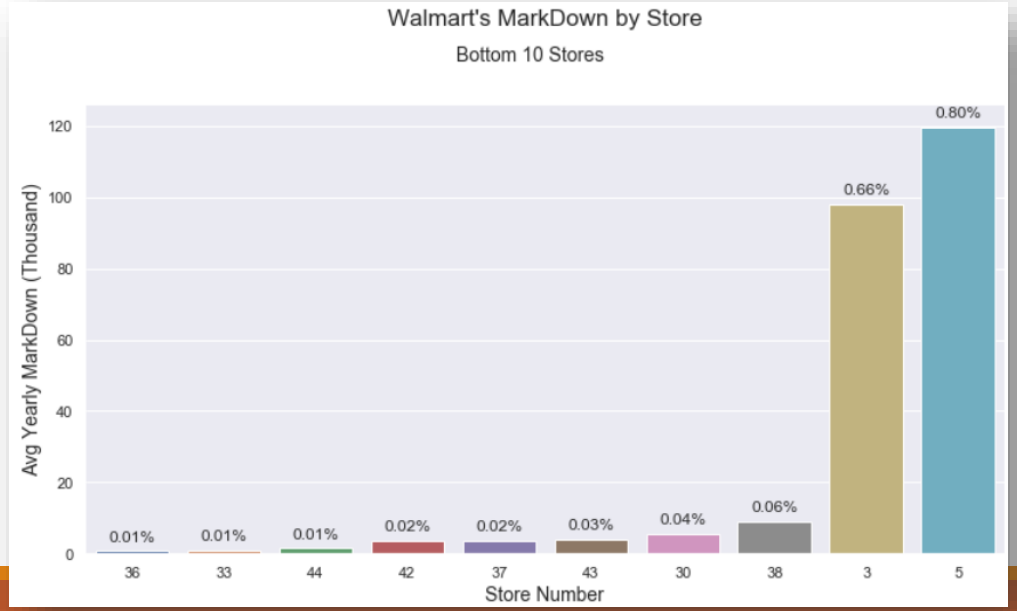
	Store Weekly Sales (Thousand)
count	6435.000000
mean	1046.964878
std	564.366622
min	209.986250
25%	553.350105
50%	960.746040
75%	1420.158660
max	3818.686450

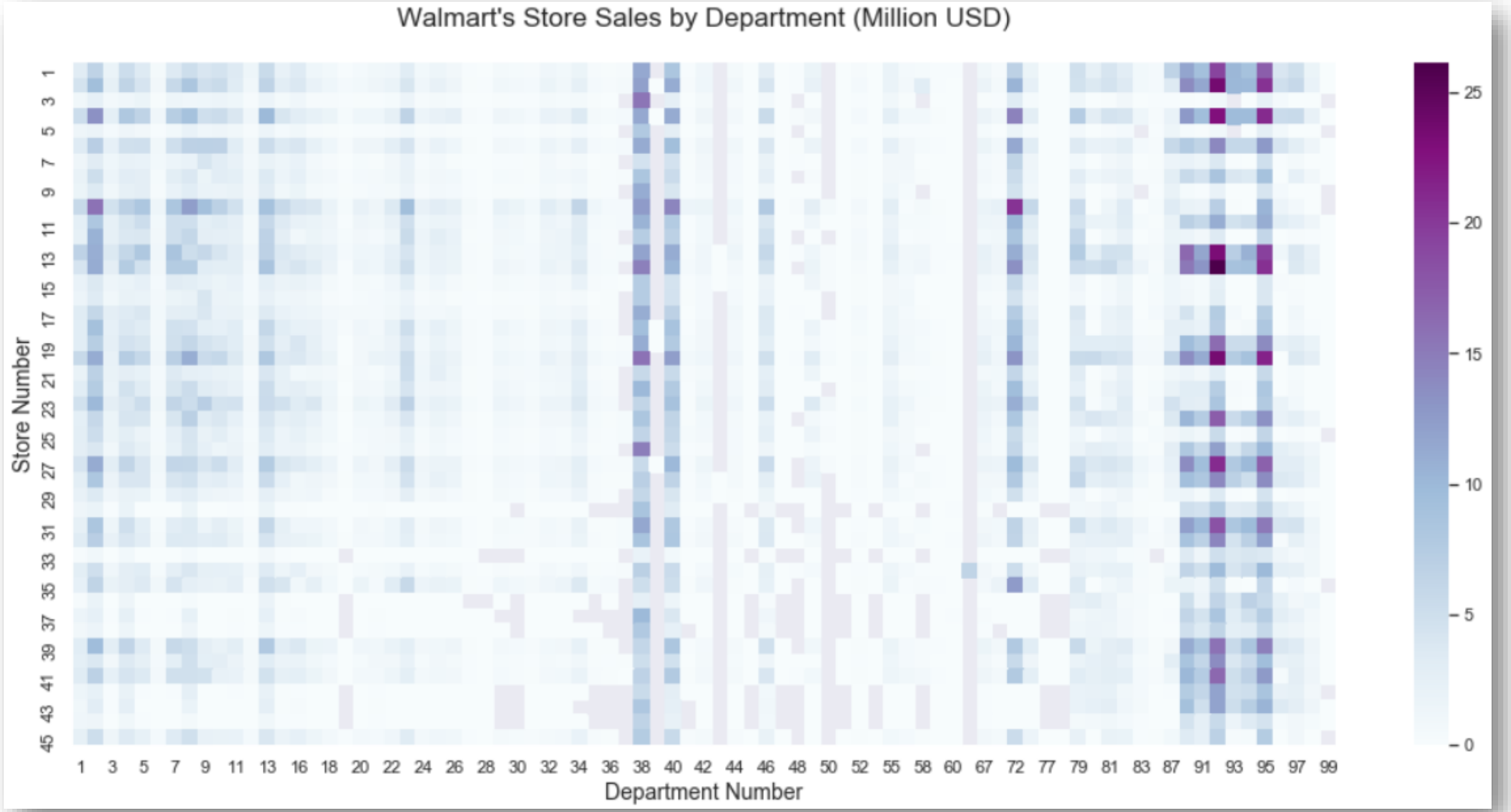
	Dept Weekly Sales (Thousand)
count	421570.000000
mean	15.981258
std	22.711184
min	-4.988940
25%	2.079650
50%	7.612030
75%	20.205853
max	693.099360

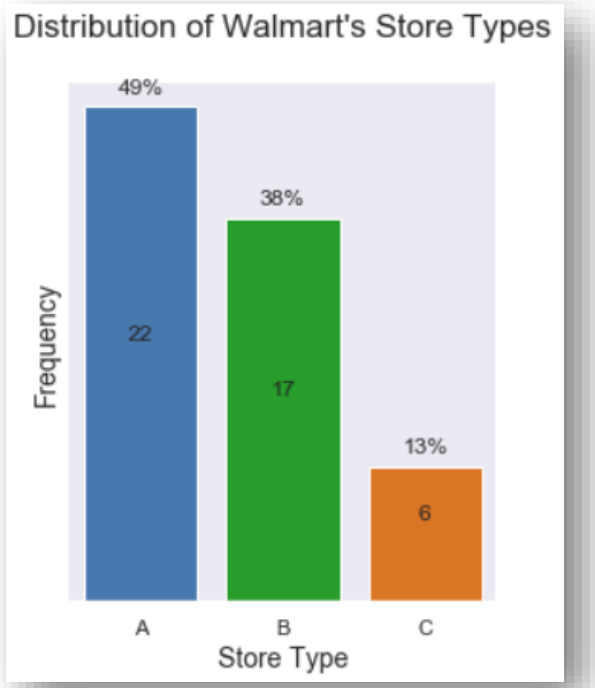

Walmart's Store Sales
Top 10 Stores
Avg Yearly Sales (Million)
4.47%
4.45%
4.29%
4.25%
4.09%
4.03%
3.77%
3.32%
3.30%
3.08%
100
100
96
96
92
91
85
75
74
69
20
4
14
13
2
10
27
6
1
39
Store Number


Walmart's MarkDown by Store
Top 10 Stores
Avg Yearly MarkDown (Thousand)
4.87%
4.35%
4.33%
4.28%
4.02%
3.75%
3.73%
3.65%
3.63%
3.38%
726
648
646
638
599
558
556
544
542
504
39
13
28
20
27
14
19
4
2
24
Store Number

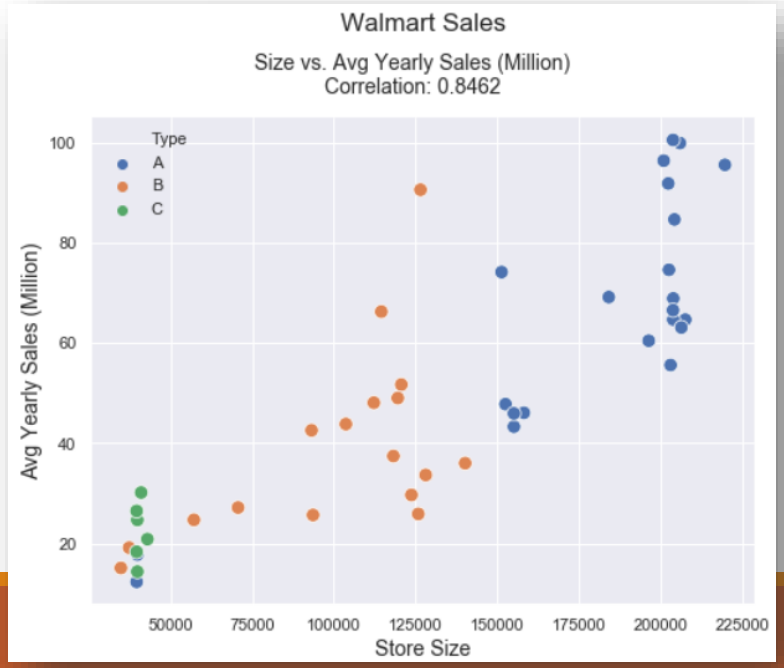

Walmart's Store Sales
Bottom 10 Stores
Avg Yearly Sales (Million)
0.55%
0.64%
0.67%
0.79%
0.82%
0.85%
0.93%
1.10%
1.10%
1.15%
12
14
15
18
18
19
21
25
25
26
33
44
5
36
38
3
30
37
16
29
Store Number


Walmart's MarkDown by Store
Bottom 10 Stores
Avg Yearly MarkDown (Thousand)
0
20
40
60
80
100
120
0.01%
0.01%
0.01%
0.02%
0.02%
0.03%
0.04%
0.06%
0.66%
0.80%
36
33
44
42
37
43
30
38
3
5
Store Number

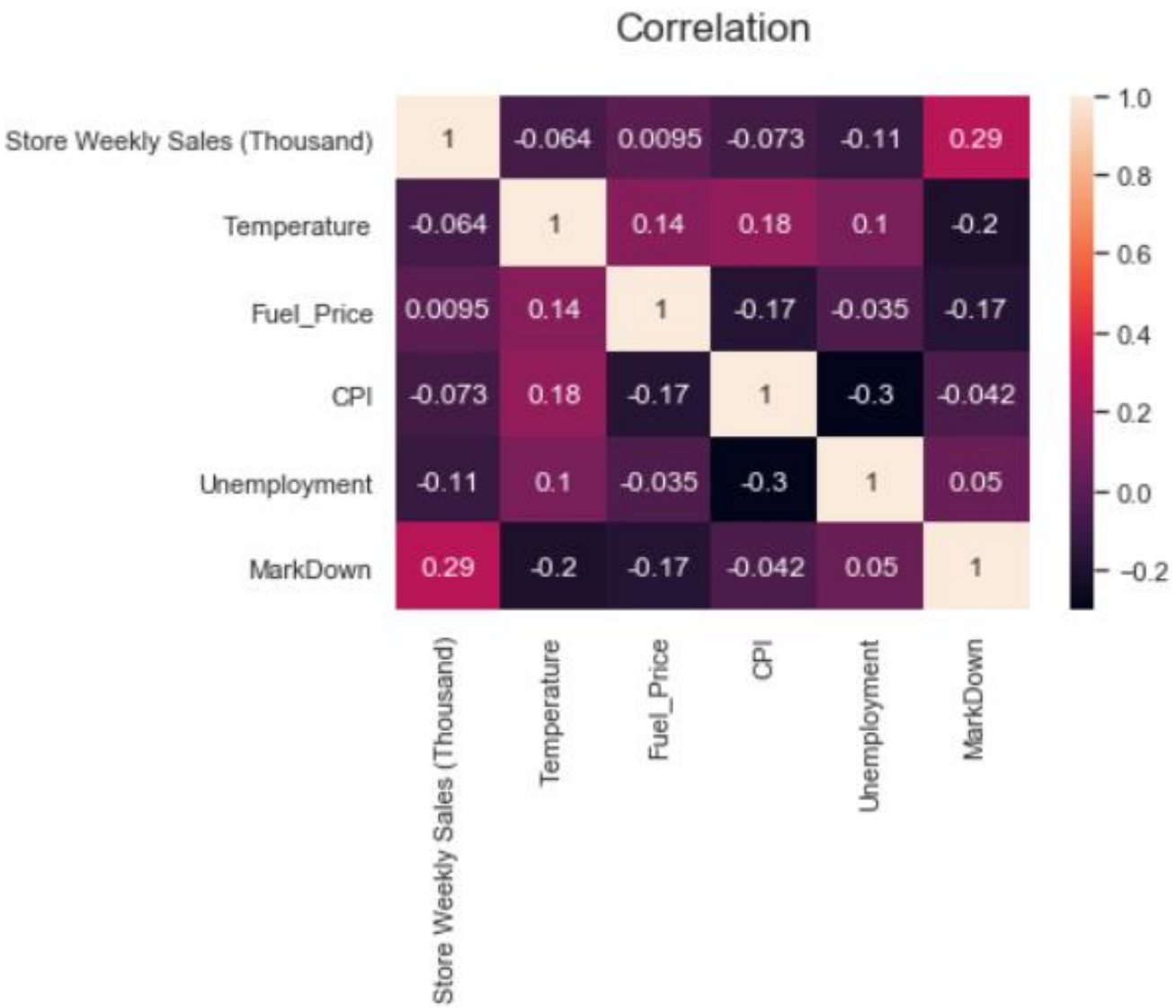

Walmart's Store Sales by Department (Million USD)
Store Number
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45
Department Number
1 3 5 7 9 11 13 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 55 58 60 67 72 77 79 81 83 87 91 93 95 97 99
25
20
15
10
5
0


Distribution of Walmart's Store Types
49%
38%
13%
22
17
6
Frequency
A
B
C
Store Type


Walmart Sales
Avg Yearly MarkDown (Thousand) vs. Avg Yearly Sales (Million)
Correlation: 0.8778
Type
A
B
C
Avg Yearly Sales (Million)
Avg Yearly MarkDown (Thousand)


Walmart Sales
Size vs. Avg Yearly Sales (Million)
Correlation: 0.8462
Type
A
B
C
Avg Yearly Sales (Million)
Store Size


Walmart Sales
Num of Depts vs. Avg Yearly Sales (Million)
Correlation: 0.6385
Type
A
B
C
Avg Yearly Sales (Million)
Num of Depts



Weak Correlation

Time Series Analysis

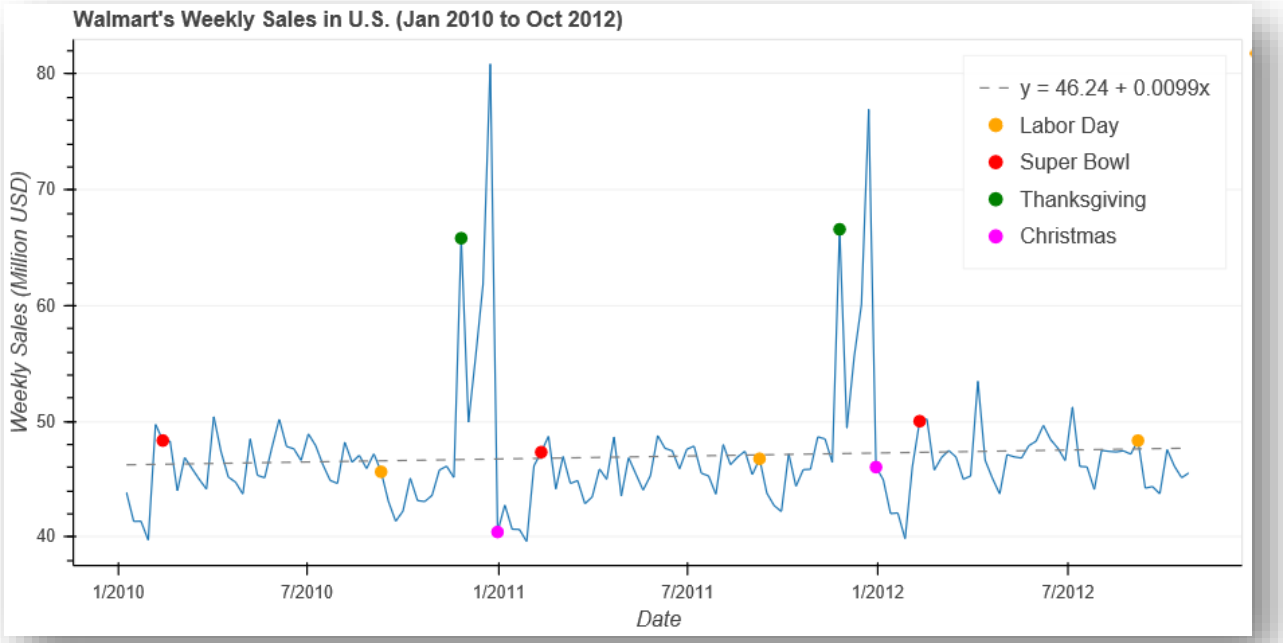
ORIGINAL TIME SERIES

GENERAL TREND

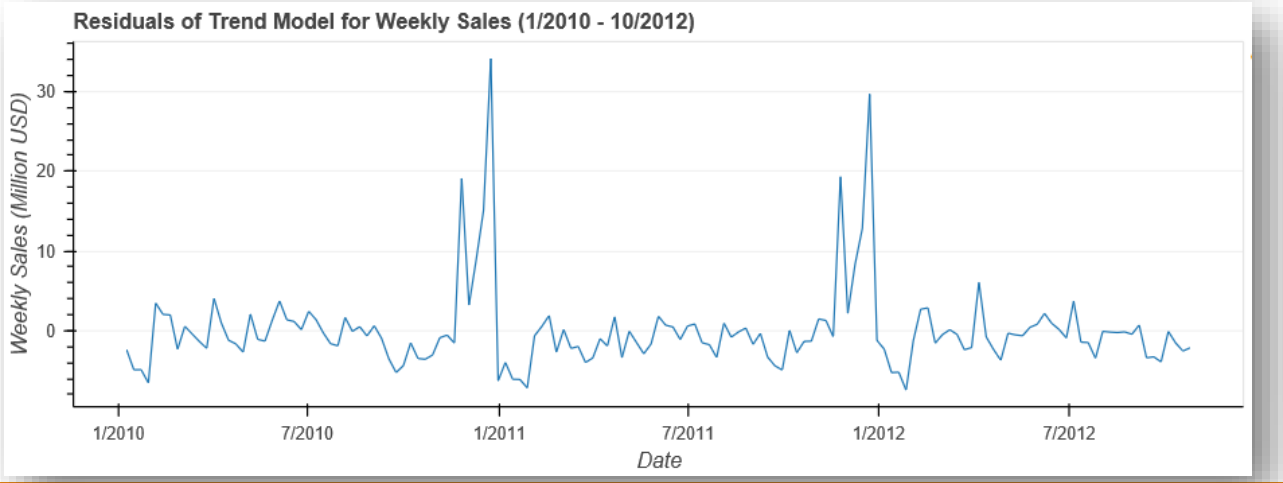
SEASONALITY

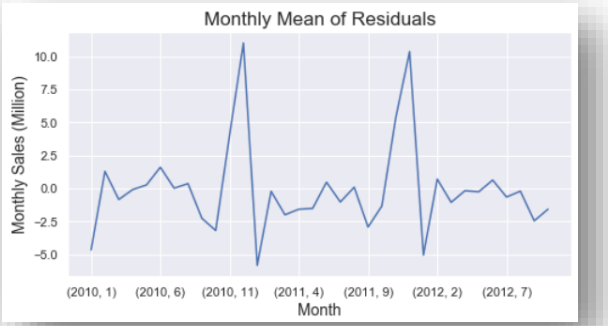
STATIONARITY

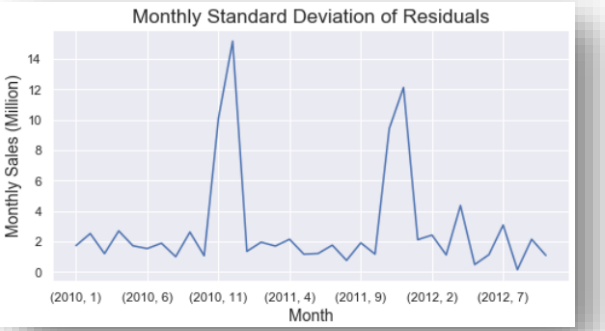
Original Time Series & General Trend (y)

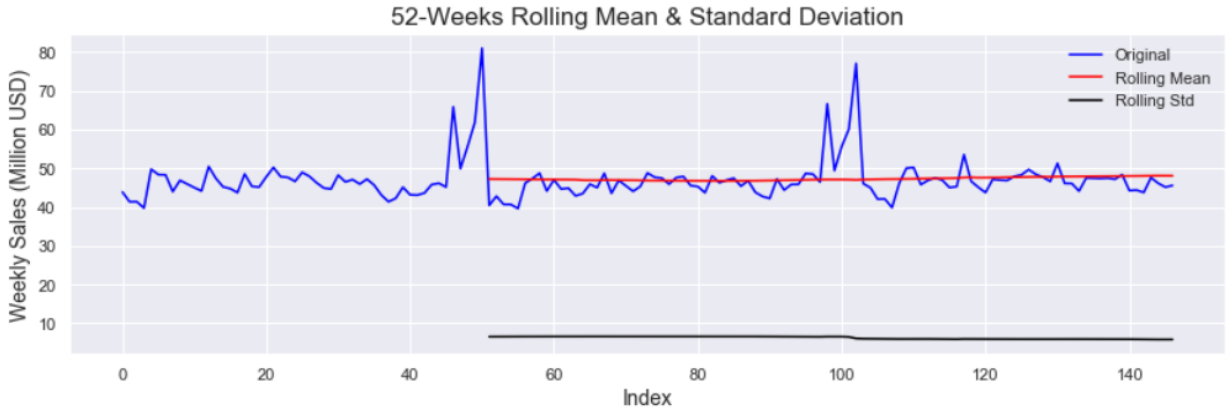


Seasonality










```
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
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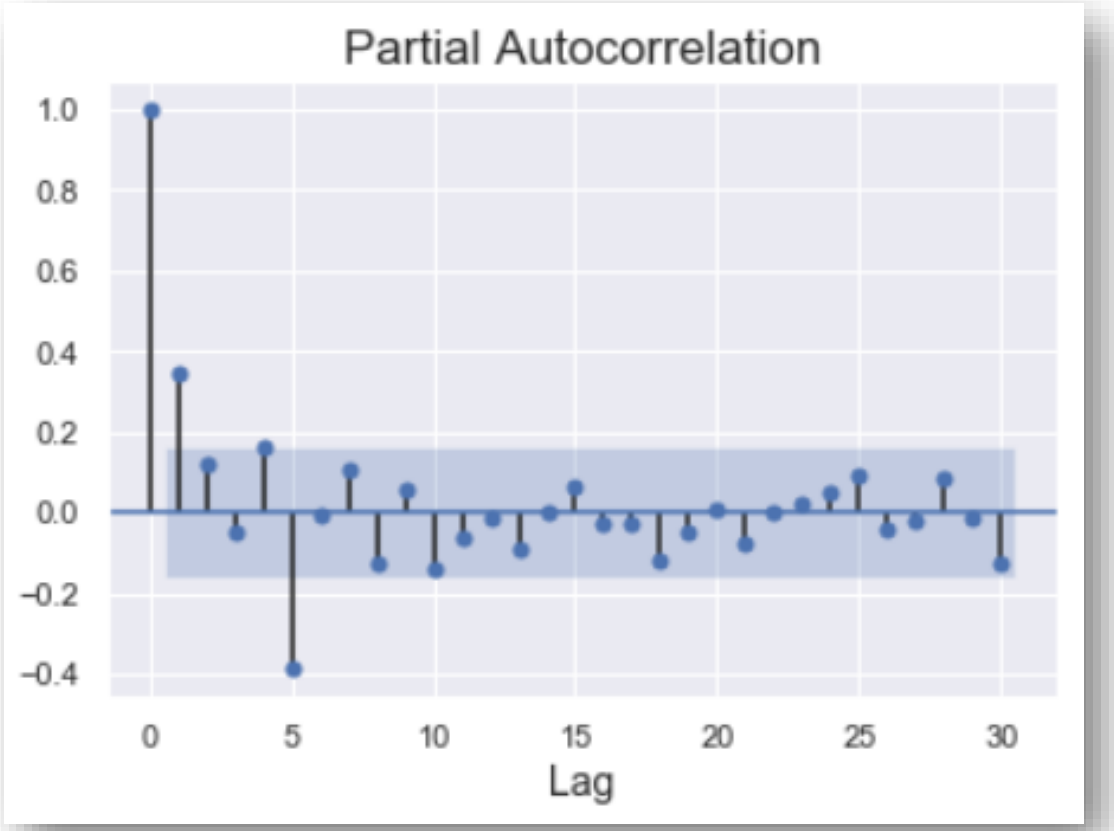
Stationarity

Model Development

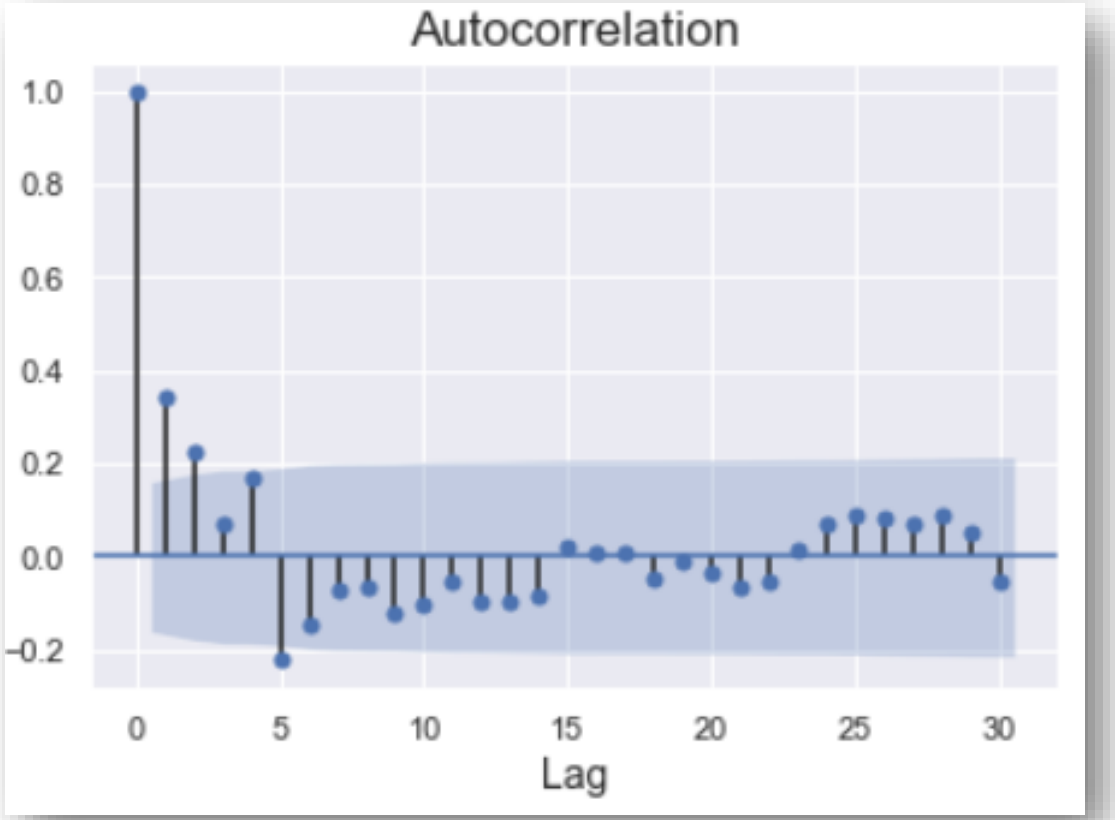
AUTOREGRESSIVE TERM | MOVING AVERAGE TERM

ARIMA | SARIMAX

Autoregressive Term



Moving Average Term



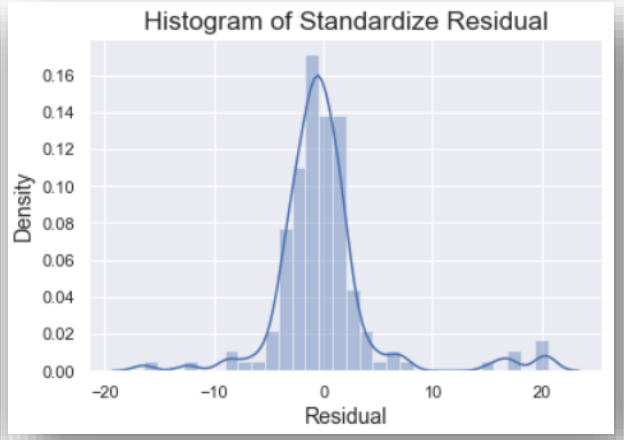
ARIMA Model

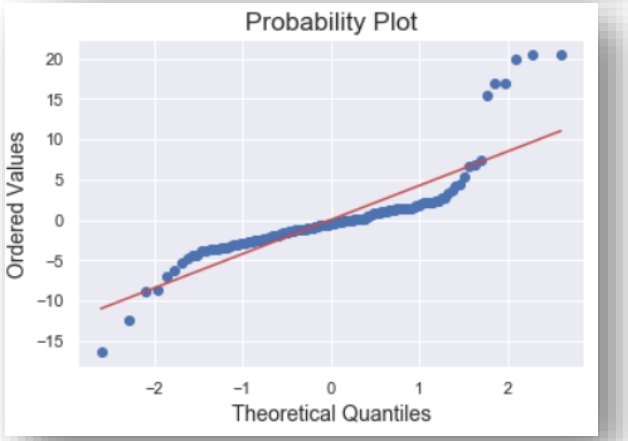
Dep. Variable:	Weekly Sales (Millions)	**No. Observations:**	147
Model:	ARMA(1, 2)	**Log Likelihood**	-440.155
Method:	css-mle	**S.D. of innovations**	4.819
Date:	Tue, 21 Apr 2020	**AIC**	890.310
Time:	20:14:29	**BIC**	905.262
Sample:	01-08-2010	**HQIC**	896.385
	- 10-26-2012		

	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





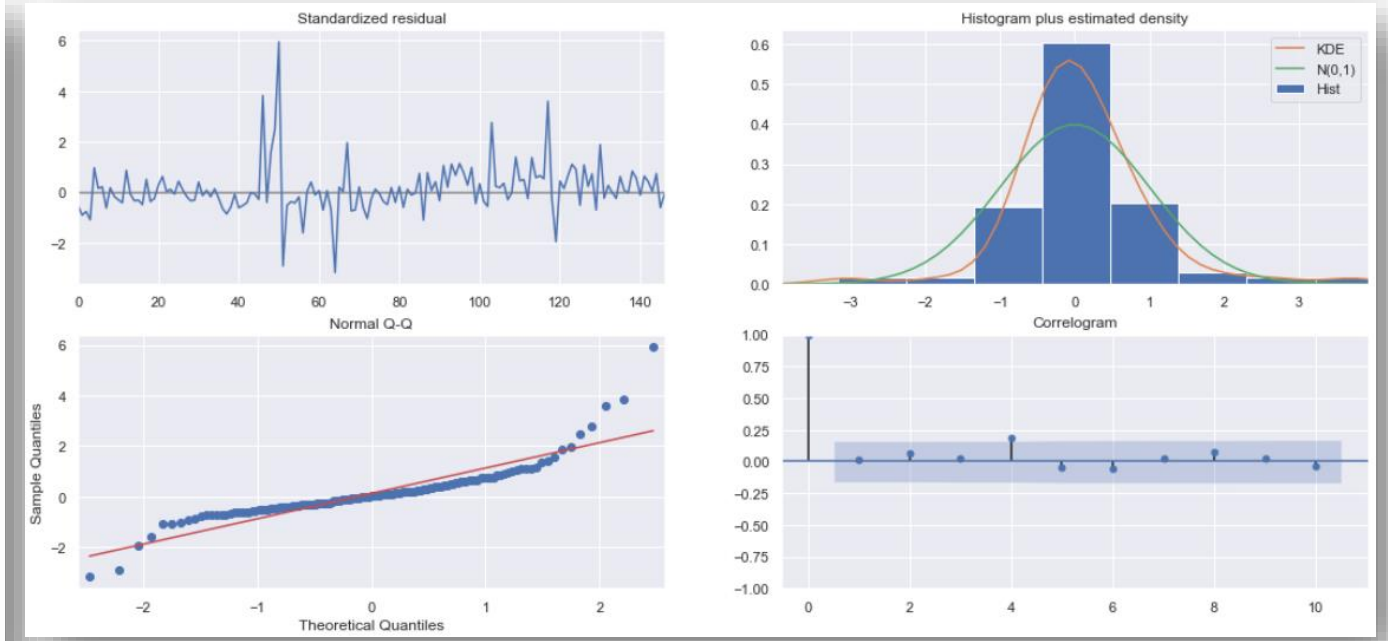
mape	me	mae	mpe	mse	rmse	corr	minmax
0.055867	-0.004523	2.789844	0.007588	23.296938	4.82669	0.463302	0.05262

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

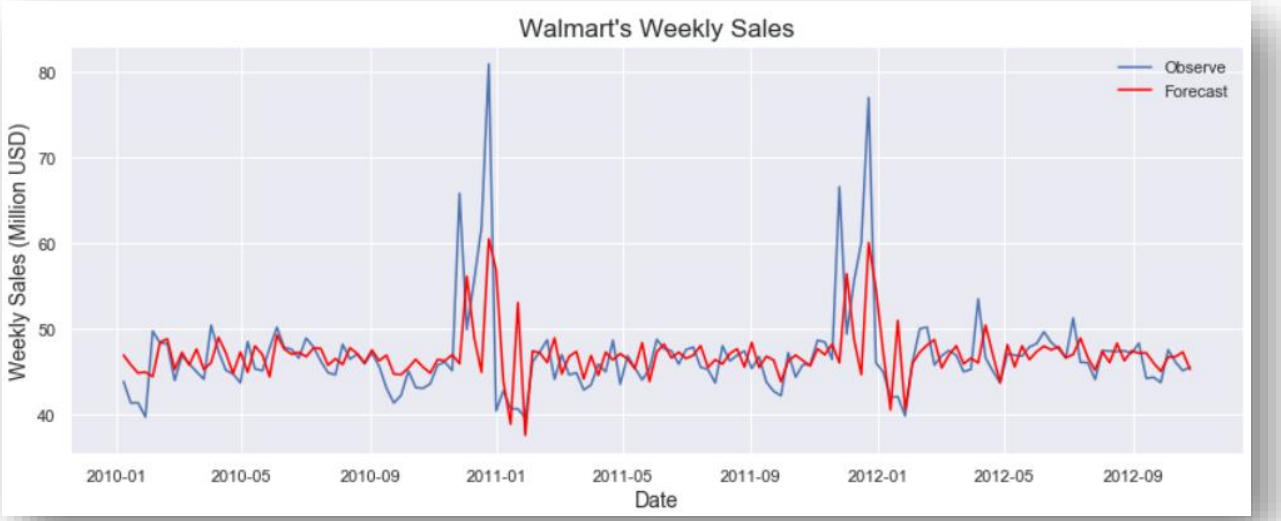


Evaluation Metrics

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 have high impact on 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!