Capstone Project

Problem Statement

A retail store that has multiple outlets across the country are facing issues in managing the inventory - to match the demand with respect to supply. You are a data scientist, who has to come up with useful insights using the data and make prediction models to forecast the sales for X number of months/years.

Dataset Information:

The `walmart.csv` file contains **6435 rows and 8 columns**.

Feature Name	Description
Store	Store number
Date	Week of Sales
Weekly_Sales	Sales for the given store in that week
Holiday_Flag	If it is a holiday week
Temperature	Temperature on the day of the sale
Fuel_Price	Cost of the fuel in the region
CPI	Consumer Price Index
Unemployment	Unemployment Rate

---

1. Using the above data, come up with useful insights that can be used by each of the stores to improve in various areas.
2. Forecast the sales for each store for the next 12 weeks.

In [1]:
```
# Importing the Libraries

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
# Importing the Dataset

df= pd.read_csv('Walmart.csv')
```

In [3]:
```
df.head()
```

Out[3]:

	Store	Date	Weekly_Sales	Holiday_Flag	Temperature	Fuel_Price	CPI	Unem
0	1	05-02-2010	1643690.90	0	42.31	2.572	211.096358	
1	1	12-02-2010	1641957.44	1	38.51	2.548	211.242170	
2	1	19-02-2010	1611968.17	0	39.93	2.514	211.289143	
3	1	26-02-2010	1409727.59	0	46.63	2.561	211.319643	
4	1	05-03-2010	1554806.68	0	46.50	2.625	211.350143	

Performing EDA

In [4]:
```
df.shape
```

Out[4]:
```
(6435, 8)
```

In [5]:
```
df.columns
```

Out[5]:
```
Index(['Store', 'Date', 'Weekly_Sales', 'Holiday_Flag', 'Temperature',
       'Fuel_Price', 'CPI', 'Unemployment'],
      dtype='object')
```

In [6]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6435 entries, 0 to 6434
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   Store         6435 non-null   int64  
 1   Date          6435 non-null   object 
 2   Weekly_Sales  6435 non-null   float64
 3   Holiday_Flag  6435 non-null   int64  
 4   Temperature   6435 non-null   float64
 5   Fuel_Price    6435 non-null   float64
 6   CPI           6435 non-null   float64
 7   Unemployment  6435 non-null   float64
dtypes: float64(5), int64(2), object(1)
memory usage: 402.3+ KB
```

In [7]:
```
df.describe()
```

Out[7]:

	Store	Weekly_Sales	Holiday_Flag	Temperature	Fuel_Price	CPI
count	6435.000000	6.435000e+03	6435.000000	6435.000000	6435.000000	6435.000000
mean	23.000000	1.046965e+06	0.069930	60.663782	3.358607	171.578394
std	12.988182	5.643666e+05	0.255049	18.444933	0.459020	39.356712
min	1.000000	2.099862e+05	0.000000	-2.060000	2.472000	126.064000
25%	12.000000	5.533501e+05	0.000000	47.460000	2.933000	131.735000
50%	23.000000	9.607460e+05	0.000000	62.670000	3.445000	182.616521
75%	34.000000	1.420159e+06	0.000000	74.940000	3.735000	212.743293
max	45.000000	3.818686e+06	1.000000	100.140000	4.468000	227.232807

In [8]:
```
df.isnull().sum()
```

Out[8]:
```
Store           0
Date            0
Weekly_Sales    0
Holiday_Flag    0
Temperature     0
Fuel_Price      0
CPI             0
Unemployment    0
dtype: int64
```

In [9]:
```
df.duplicated().sum()
```

Out[9]:
```
0
```

In [10]:
```
df['Store'].unique()
```

Out[10]:
```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17,
       18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34,
       35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45], dtype=int64)
```

In [11]:
```
df['Store'].nunique()
```

Out[11]:
```
45
```

In [12]:
```
df['Holiday_Flag'].unique()
```

Out[12]:
```
array([0, 1], dtype=int64)
```

In [13]:
```
df['Holiday_Flag'].nunique()
```

Out[13]:
```
2
```

In [14]:
```
df['Date'] = pd.to_datetime(df['Date'], format='%d-%m-%Y')

df['Day_of_Week'] = df['Date'].dt.dayofweek
df['Month'] = df['Date'].dt.month
df['Year'] = df['Date'].dt.year
```

In [15]:
```
df.head()
```

Out[15]:

	Store	Date	Weekly_Sales	Holiday_Flag	Temperature	Fuel_Price	CPI	Uner
0	1	2010-02-05	1643690.90	0	42.31	2.572	211.096358	
1	1	2010-02-12	1641957.44	1	38.51	2.548	211.242170	
2	1	2010-02-19	1611968.17	0	39.93	2.514	211.289143	
3	1	2010-02-26	1409727.59	0	46.63	2.561	211.319643	
4	1	2010-03-05	1554806.68	0	46.50	2.625	211.350143	

In [16]:
```
total_sales_by_store = df.groupby('Store')['Weekly_Sales'].sum().reset_index()
```

In [17]:
```
df.corr()
```

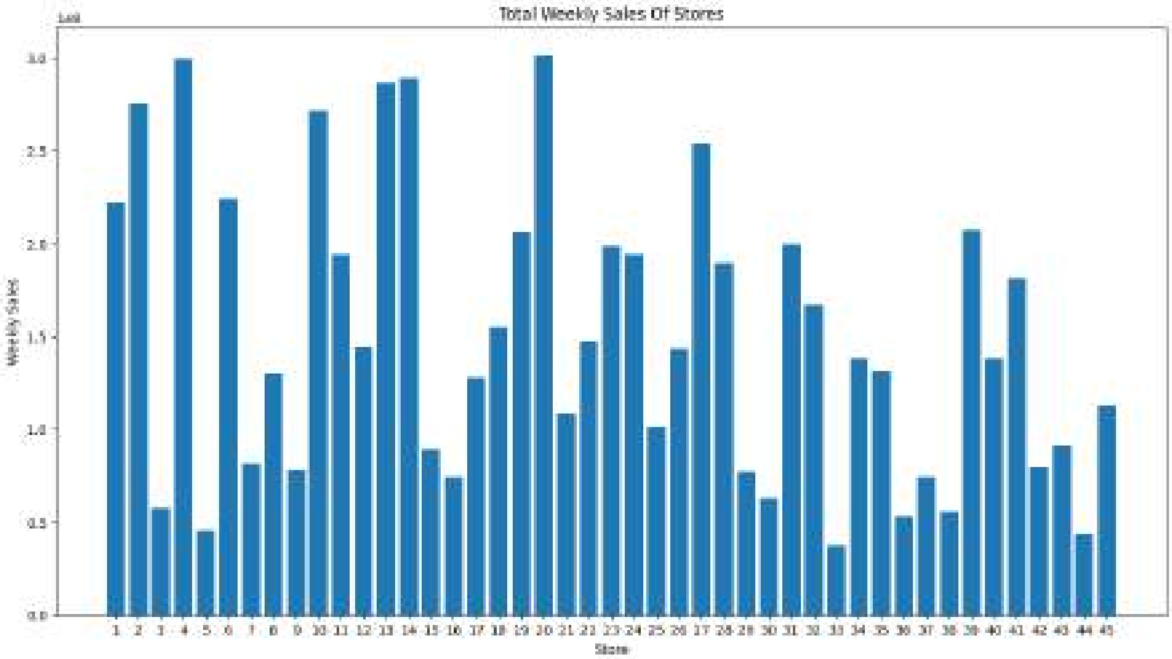
Out[17]:

	Store	Date	Weekly_Sales	Holiday_Flag	Temperature
Store	1.000000e+00	1.577299e-13	-0.335332	-4.386841e-16	-0.022659
Date	1.577299e-13	1.000000e+00	0.006949	-1.328524e-02	0.145357
Weekly_Sales	-3.353320e-01	6.949360e-03	1.000000	3.689097e-02	-0.063810
Holiday_Flag	-4.386841e-16	-1.328524e-02	0.036891	1.000000e+00	-0.155091
Temperature	-2.265908e-02	1.453566e-01	-0.063810	-1.550913e-01	1.000000
Fuel_Price	6.002295e-02	7.714439e-01	0.009464	-7.834652e-02	0.144982
CPI	-2.094919e-01	7.715746e-02	-0.072634	-2.162091e-03	0.176888
Unemployment	2.235313e-01	-2.482029e-01	-0.106176	1.096028e-02	0.101158
Day_of_Week	NaN	NaN	NaN	NaN	NaN
Month	2.910676e-15	1.456512e-01	0.076143	1.229958e-01	0.235862
Year	3.474318e-12	9.416680e-01	-0.018378	-5.678257e-02	0.064269

Visualization

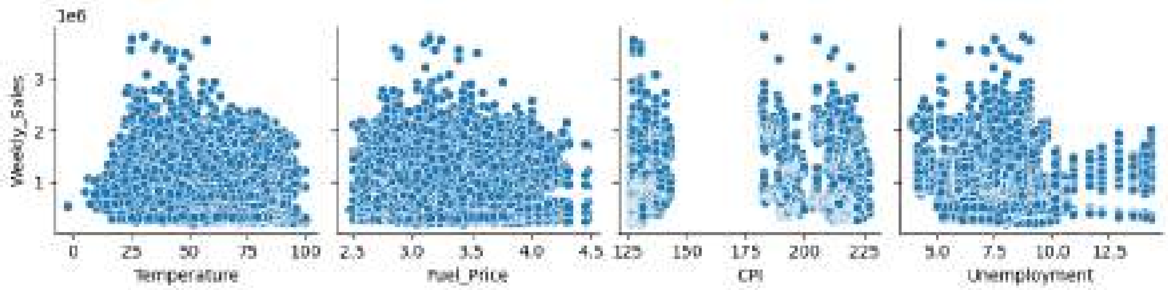
In [18]:
```
plt.figure(figsize = (15, 8))
plt.bar(total_sales_by_store['Store'], total_sales_by_store['Weekly_Sales'])
plt.xlabel("Store")
plt.ylabel("Weekly Sales")
plt.xticks(range(1, 46))
plt.title("Total Weekly Sales Of Stores")
```

Out[18]:
```
Text(0.5, 1.0, 'Total Weekly Sales Of Stores')
```



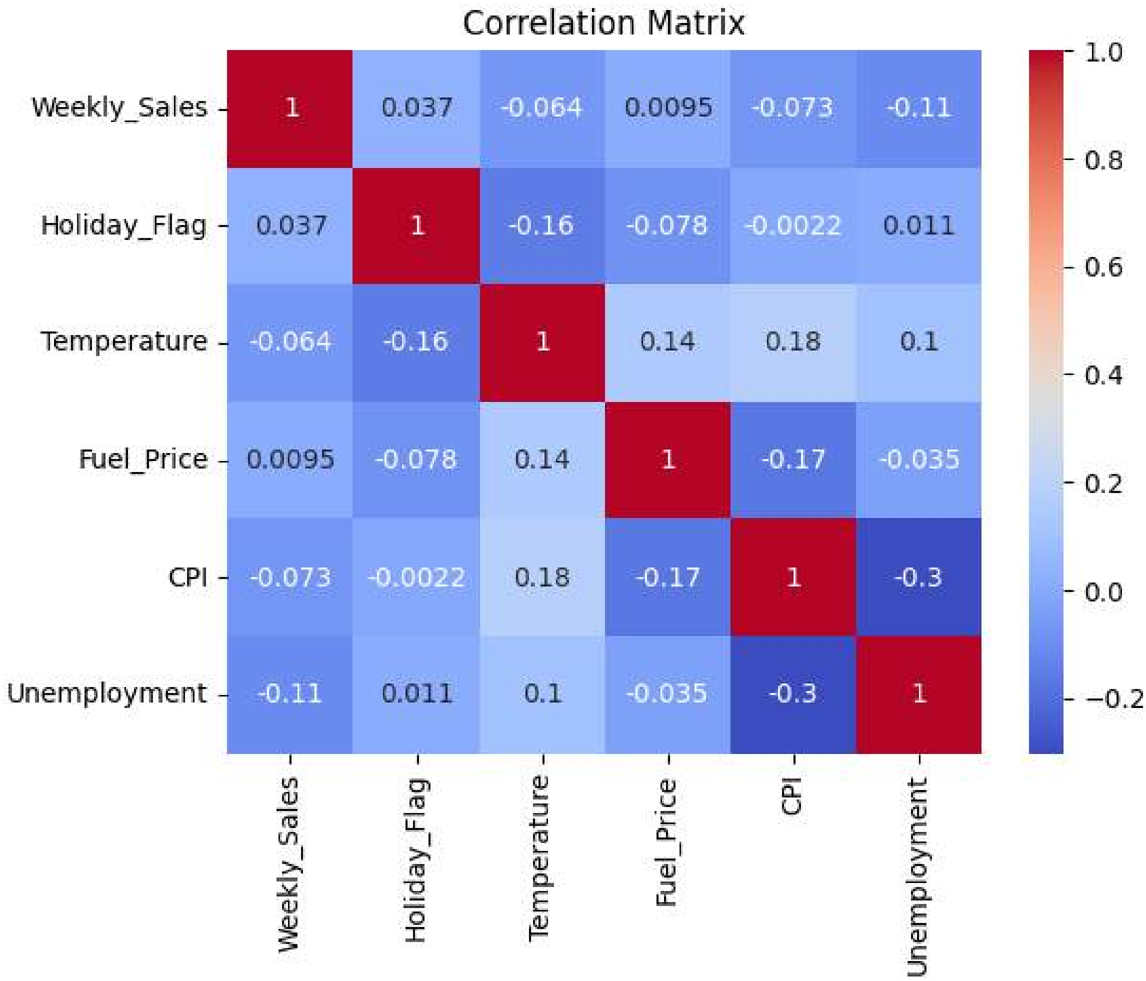
In [19]:
```
sns.pairplot(df,x_vars=['Temperature', 'Fuel_Price', 'CPI', 'Unemployment'], y_v
```

Out[19]:
```
<seaborn.axisgrid.PairGrid at 0x247409695e0>
```



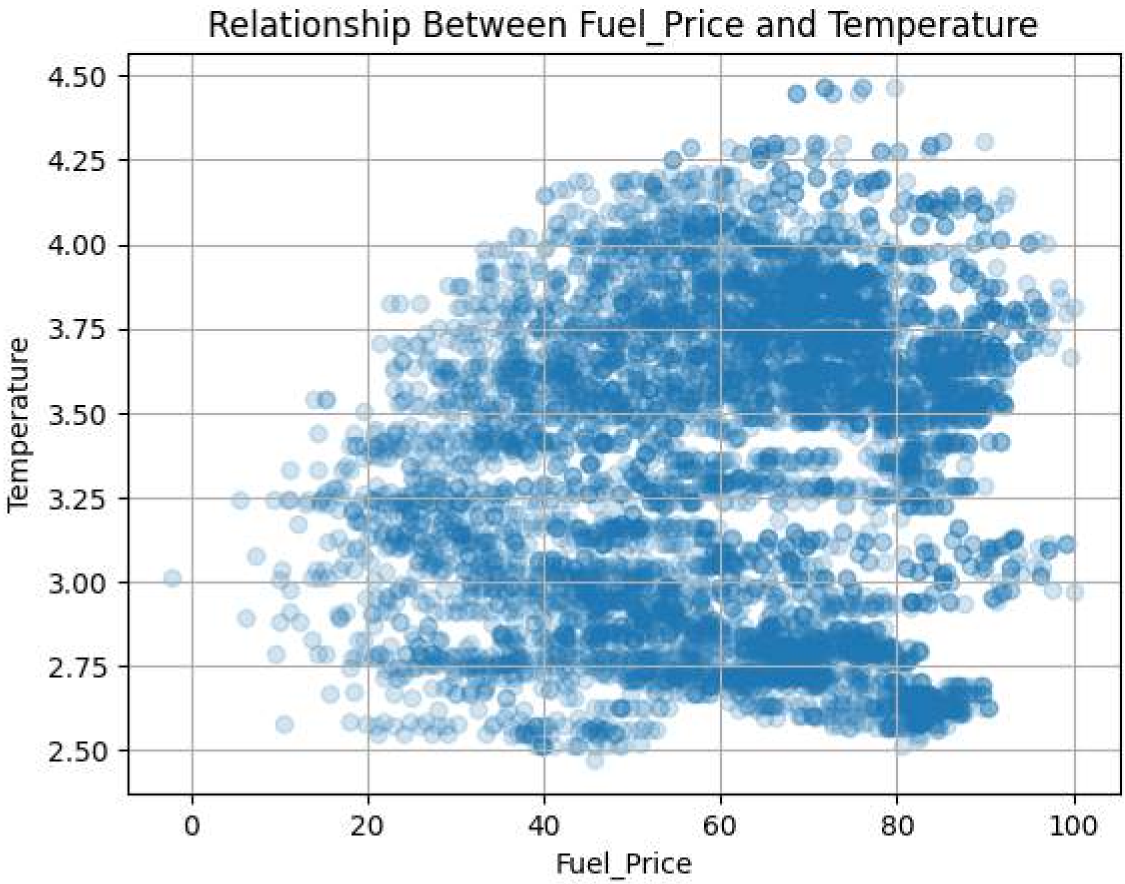
In [20]:
```
numeric_columns = ['Weekly_Sales', 'Holiday_Flag', 'Temperature', 'Fuel_Price',
corr_matrix = df[numeric_columns].corr()
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm')
plt.title("Correlation Matrix")
```

Out[20]:
```
Text(0.5, 1.0, 'Correlation Matrix')
```



In [21]:

```
plt.scatter(df['Temperature'], df['Fuel_Price'], alpha=0.2)
plt.title('Relationship Between Fuel_Price and Temperature')
plt.xlabel('Fuel_Price')
plt.ylabel('Temperature')
plt.grid(True)
```



In [22]:
```python
plt.figure(figsize=(20, 8))
sns.lineplot(x='Date', y='Weekly_Sales', data = df)
```

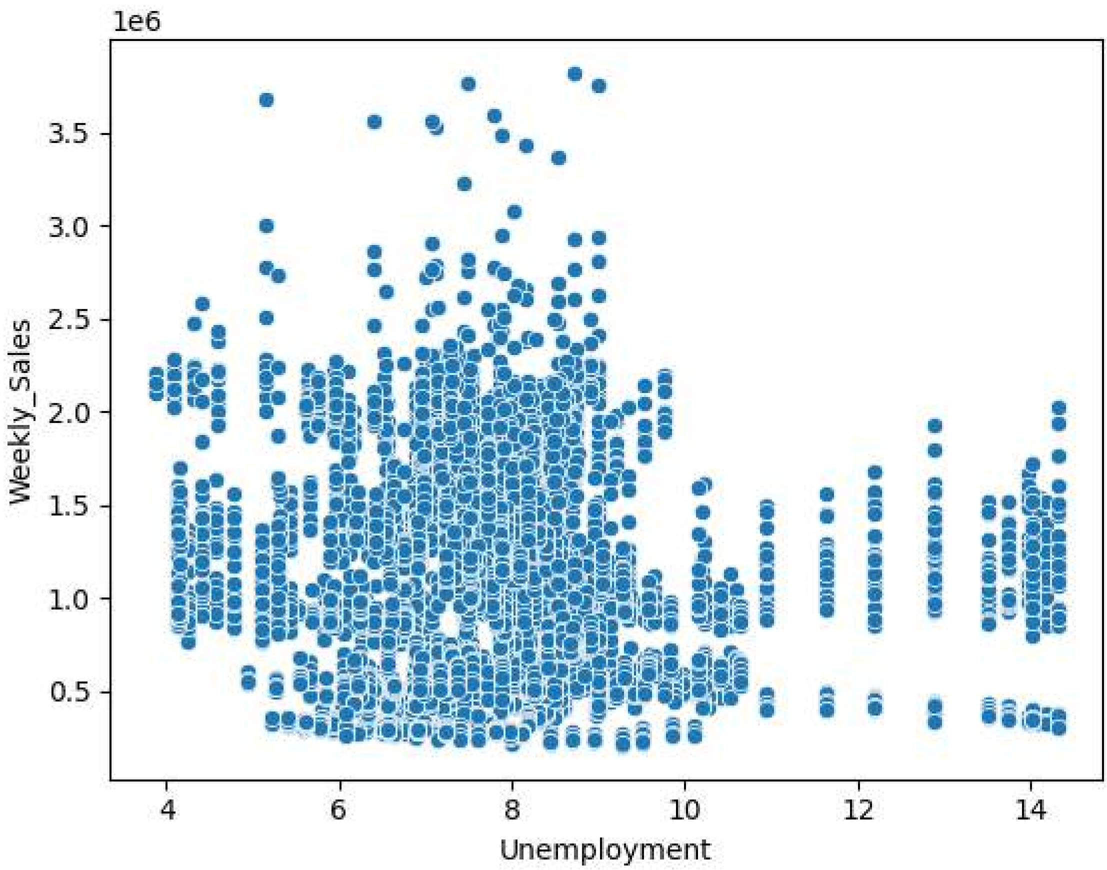
Out[22]: <Axes: xlabel='Date', ylabel='Weekly_Sales'>

Insights On Walmart Dataset

A) If the weekly sales are affected by the unemployment rate, if yes - which stores are suffering the most?

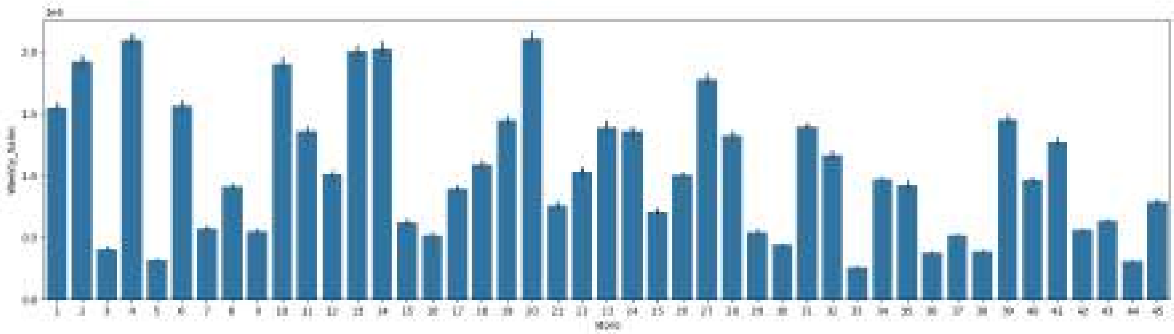
In [23]:
```python
sns.scatterplot(x=df['Unemployment'], y=df['Weekly_Sales'])
```

Out[23]: <Axes: xlabel='Unemployment', ylabel='Weekly_Sales'>



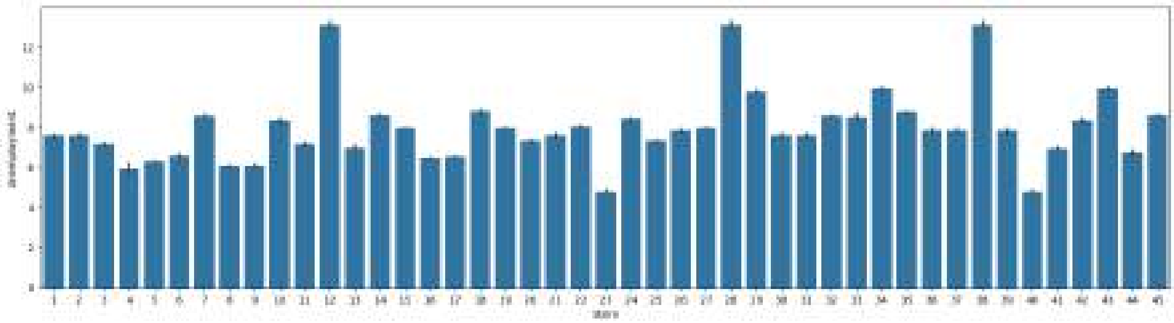
In [24]:
```
plt.figure(figsize=(20, 5))
sns.barplot(x=df['Store'], y=df['Weekly_Sales'])
```

Out[24]: <Axes: xlabel='Store', ylabel='Weekly_Sales'>



In [25]:
```
 plt.figure(figsize=(20, 5))
sns.barplot(x=df['Store'], y=df['Unemployment'])
```

Out[25]: <Axes: xlabel='Store', ylabel='Unemployment'>



In [26]:
```
df.groupby(by='Store').agg({'Weekly_Sales':'sum', 'Unemployment':'sum'})
```

Out[26]:

Store	Weekly_Sales	Unemployment
1	2.224028e+08	1088.290
2	2.753824e+08	1090.210
3	5.758674e+07	1026.309
4	2.995440e+08	852.951
5	4.547569e+07	900.243
6	2.237561e+08	944.787
7	8.159828e+07	1227.760
8	1.299512e+08	871.134
9	7.778922e+07	872.283
10	2.716177e+08	1195.904
11	1.939628e+08	1026.309
12	1.442872e+08	1875.657
13	2.865177e+08	1001.261
14	2.889999e+08	1236.771
15	8.913368e+07	1143.464
16	7.425243e+07	926.353
17	1.277821e+08	936.565
18	1.551147e+08	1263.877
19	2.066349e+08	1143.464
20	3.013978e+08	1054.112
21	1.081179e+08	1090.210
22	1.470756e+08	1153.920
23	1.987506e+08	685.830
24	1.940160e+08	1207.923
25	1.010612e+08	1054.112
26	1.434164e+08	1125.706
27	2.538559e+08	1144.250
28	1.892637e+08	1875.657
29	7.714155e+07	1402.313
30	6.271689e+07	1090.210
31	1.996139e+08	1090.210
32	1.668192e+08	1227.760

	Weekly_Sales	Unemployment
Store		
33	3.716022e+07	1220.241
34	1.382498e+08	1420.677
35	1.315207e+08	1256.766
36	5.341221e+07	1125.274
37	7.420274e+07	1125.274
38	5.515963e+07	1875.657
39	2.074455e+08	1125.274
40	1.378703e+08	685.830
41	1.813419e+08	997.193
42	7.956575e+07	1195.904
43	9.056544e+07	1420.677
44	4.329309e+07	963.194
45	1.123953e+08	1236.771

In [27]:
```
store_correlation=df.groupby('Store')[['Weekly_Sales', 'Unemployment']].corr()['
```

In [28]:
```
store_correlation
```

Out[28]:
```
Store
1      Weekly_Sales   -0.097955
       Unemployment    1.000000
2      Weekly_Sales    0.066325
       Unemployment    1.000000
3      Weekly_Sales   -0.230413
                         ...
43     Unemployment    1.000000
44     Weekly_Sales   -0.780076
       Unemployment    1.000000
45     Weekly_Sales   -0.004041
       Unemployment    1.000000
Name: Unemployment, Length: 90, dtype: float64
```

In [29]:
```
sorted_store_corr = store_correlation[:, 'Weekly_Sales'].abs().sort_values(ascen
```

In [30]:
```
sorted_store_corr.head(3)
```

Out[30]:
```
Store
36    0.833734
38    0.785290
44    0.780076
Name: Unemployment, dtype: float64
```

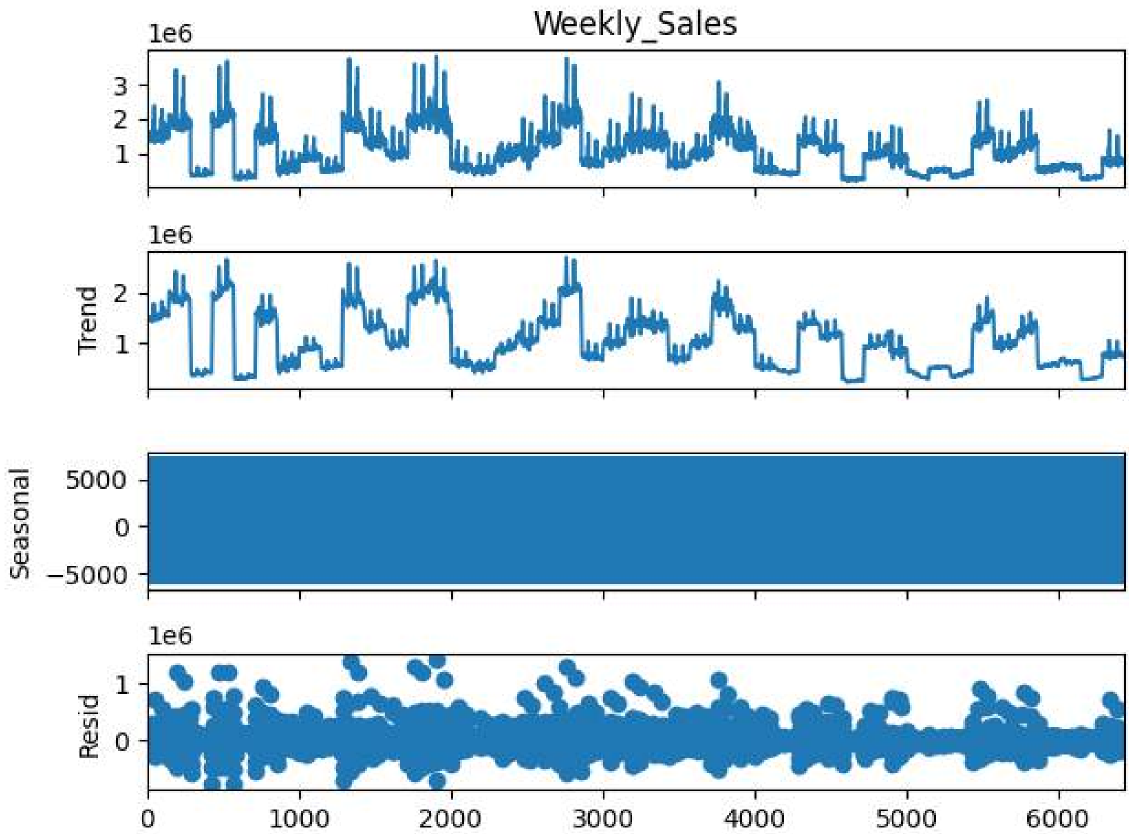
- Store 36, 38, 44 are more affected by Unemployment

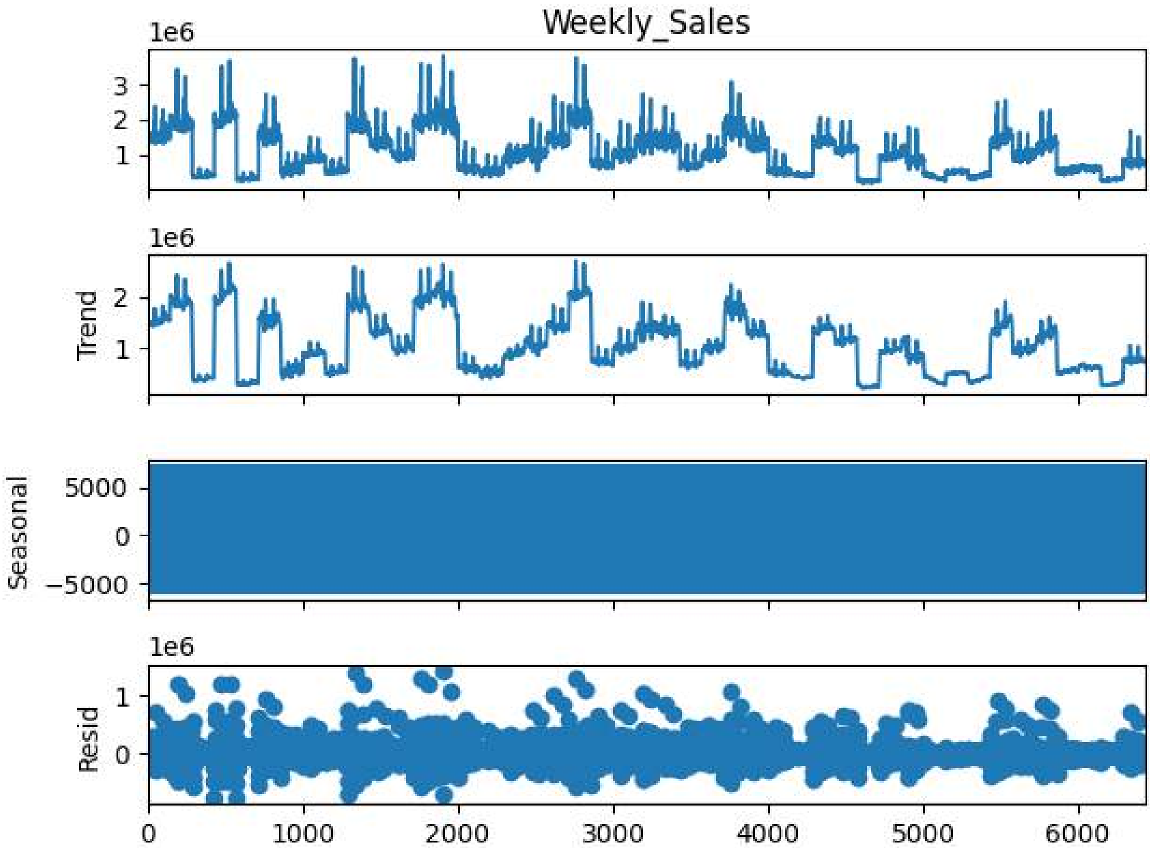
B) If the weekly sales show a seasonal trend, when and what could be the reason?

In [31]:
```
from statsmodels.tsa.stattools import adfuller
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.tsa.stattools import acf
from statsmodels.tsa.stattools import pacf
from statsmodels.graphics.tsaplots import plot_acf
from statsmodels.graphics.tsaplots import plot_pacf
import statsmodels.api as sm
from statsmodels.tsa.statespace.sarimax import SARIMAX, SARIMAXResults
```

In [32]:
```
result = seasonal_decompose(df['Weekly_Sales'], model = 'additive', period = 7)
result.plot()
```

Out[32]:





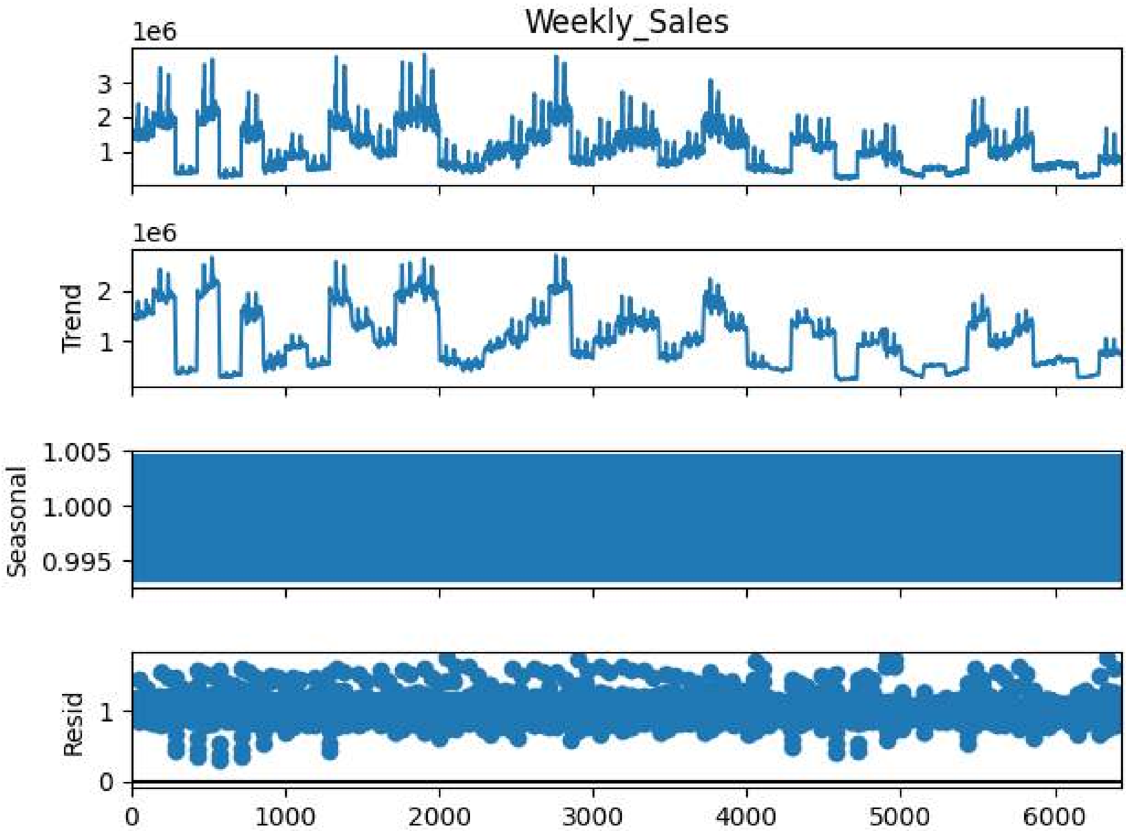
In [33]:
```
new_df_add=pd.concat([result.seasonal,result.trend,result.resid,result
.observed],axis=1)
new_df_add.columns=["seasonality","trend","residual","actual_values"]
new_df_add.head(5)
```

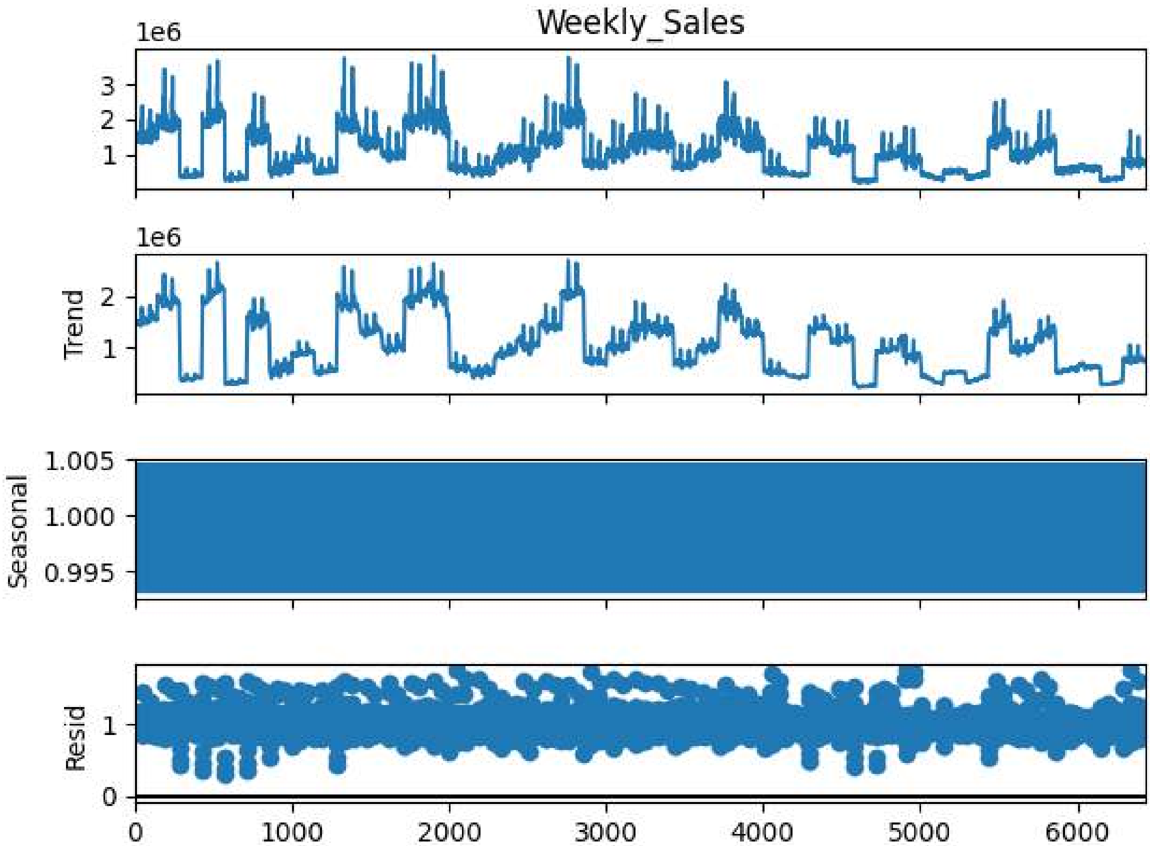
Out[33]:

	seasonality	trend	residual	actual_values
0	-3978.147451	NaN	NaN	1643690.90
1	7215.473014	NaN	NaN	1641957.44
2	5479.430196	NaN	NaN	1611968.17
3	1547.439597	1.539173e+06	-130992.443883	1409727.59
4	-1440.045828	1.504992e+06	51254.271542	1554806.68

In [34]:
```
result=seasonal_decompose(df['Weekly_Sales'],model='multiplicative',
period=7)
result.plot()
```

Out[34]:





In [35]:

```
new_df_mul=pd.concat([result.seasonal,result.trend,result.resid,result
.observed],axis=1)
new_df_mul.columns=["seasonality","trend","residual","actual_values"]
new_df_mul.head(5)
```

Out[35]:

	seasonality	trend	residual	actual_values
0	0.998500	NaN	NaN	1643690.90
1	1.003554	NaN	NaN	1641957.44
2	1.004503	NaN	NaN	1611968.17
3	1.003575	1.539173e+06	0.912637	1409727.59
4	0.998428	1.504992e+06	1.034726	1554806.68

In [36]:

```
sns.distplot(df['Weekly_Sales'],hist=True)
plt.plot()
```

```
C:\Users\zayna\AppData\Local\Temp\ipykernel_5580\642300183.py:1: UserWarning:

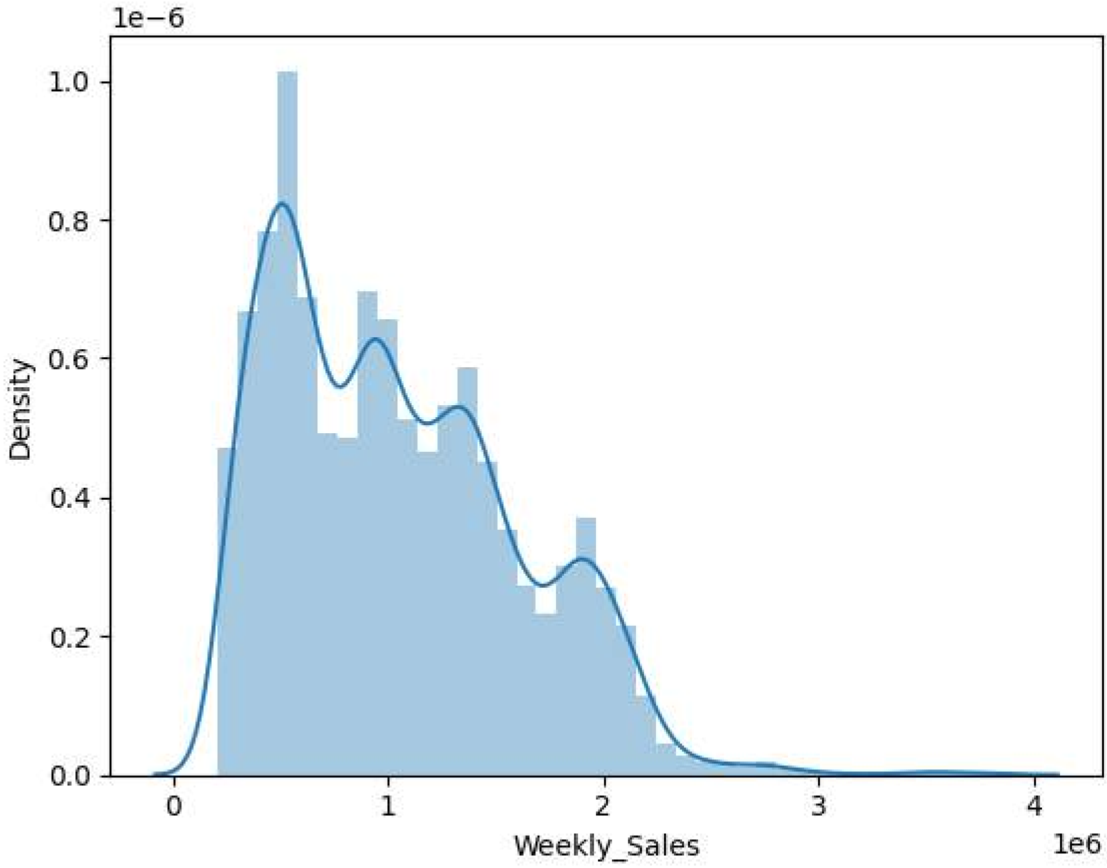
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(df['Weekly_Sales'],hist=True)
```

Out[36]: []



- Weekly Sales Show a Seasonal Trend

In [37]:

```
df.Holiday_Flag.value_counts()
```

Out[37]:
```
Holiday_Flag
0    5985
1     450
Name: count, dtype: int64
```

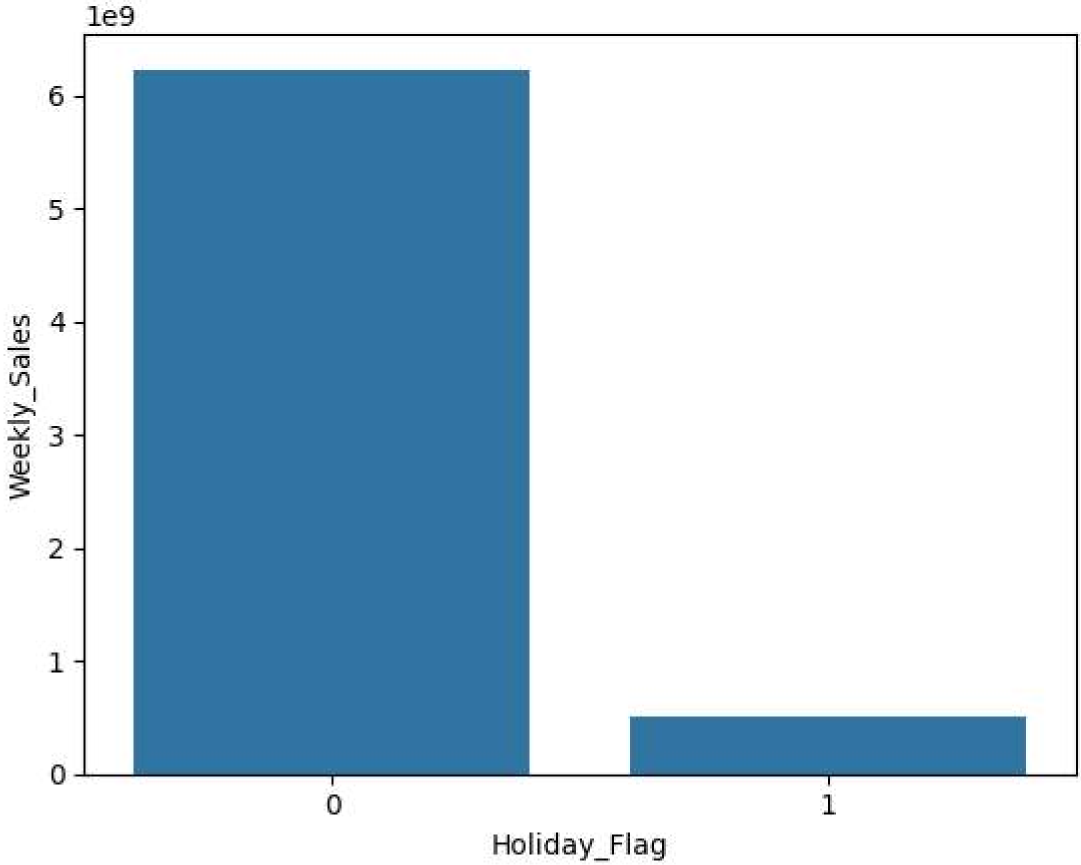
In [38]:
```
Total_by_store = df.groupby(['Holiday_Flag'],as_index=False).agg({'Weekly_Sales'
Total_by_store
```

Out[38]:

	Holiday_Flag	Weekly_Sales
0	0	6.231919e+09
1	1	5.052996e+08

In [39]:
```
sns.barplot(x=Total_by_store['Holiday_Flag'],y=Total_by_store['Weekly_Sales'])
```

Out[39]: <Axes: xlabel='Holiday_Flag', ylabel='Weekly_Sales'>



- Average Weekly Sales in Holiday Week are more that that of Non Holiday weeks

In [40]:
```
Total_by_store = df.groupby(['Store','Holiday_Flag'],as_index=False).agg({'Weekl
Total_by_store
```

Out[40]:

	Store	Holiday_Flag	Weekly_Sales	Temperature
0	1	0	2.057453e+08	69.087669
1	1	1	1.665748e+07	57.921000
2	2	0	2.545898e+08	69.025263
3	2	1	2.079267e+07	57.458000
4	3	0	5.320862e+07	72.076617
...	...	...	...	...
85	43	1	6.359463e+06	58.168000
86	44	0	4.033273e+07	54.503459
87	44	1	2.960356e+06	42.973000
88	45	0	1.040324e+08	58.561729
89	45	1	8.362937e+06	47.540000

90 rows × 4 columns

In [41]:
```
Total_by_store[Total_by_store["Weekly_Sales"]==Total_by_store["Weekly_Sales"].ma
```

Out[41]:

	Store	Holiday_Flag	Weekly_Sales	Temperature
38	20	0	2.789074e+08	56.242256

In [42]:
```
Total_by_store[Total_by_store["Weekly_Sales"]==Total_by_store["Weekly_Sales"].mi
```

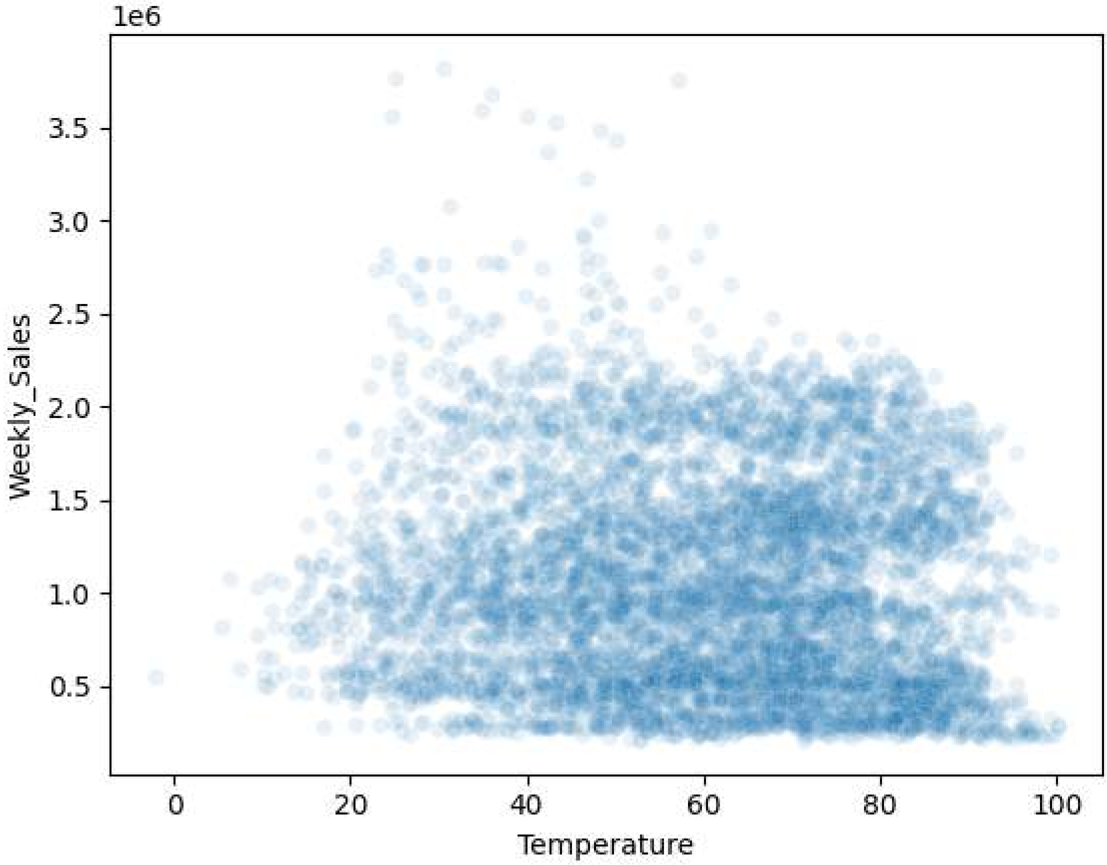
Out[42]:

	Store	Holiday_Flag	Weekly_Sales	Temperature
65	33	1	2625945.19	67.25

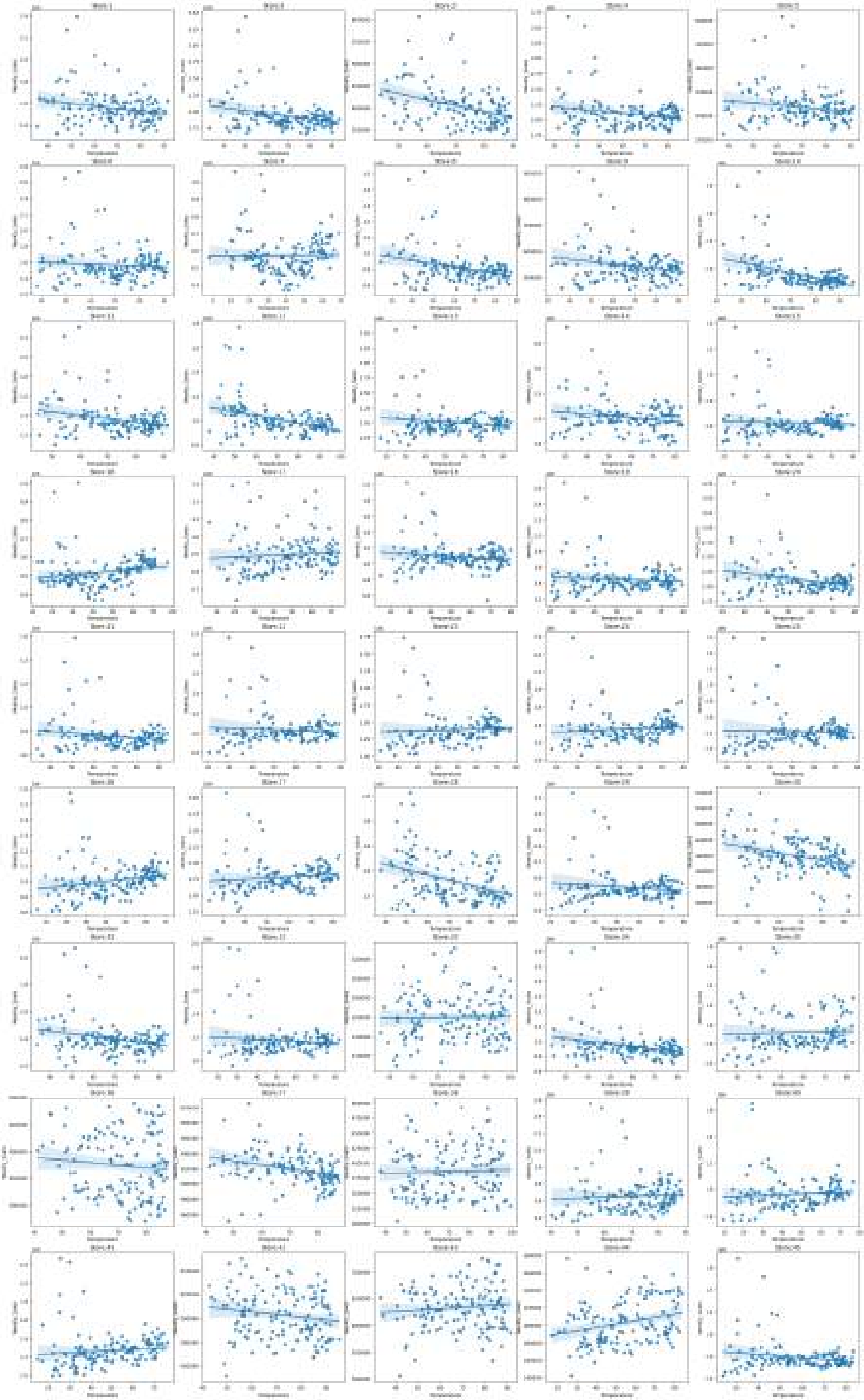
C)Does temperature affect the weekly sales in any manner?

In [43]:
```
sns.scatterplot(x = df['Temperature'],y = df['Weekly_Sales'], alpha=0.1)
```

Out[43]: <Axes: xlabel='Temperature', ylabel='Weekly_Sales'>



In [44]:
```
plt.subplots(9,5, figsize=(30,50))
for i in range (1,46):
 plt.subplot(9,5,i)
 sns.regplot(x='Temperature', y='Weekly_Sales',
data=df[df['Store']==i])
 plt.title(f'Store:{i}')
```



In [45]:
```
Total_by_temp =df.groupby('Temperature',as_index=False).agg({'Weekly_Sales': 'su
Total_by_temp
```

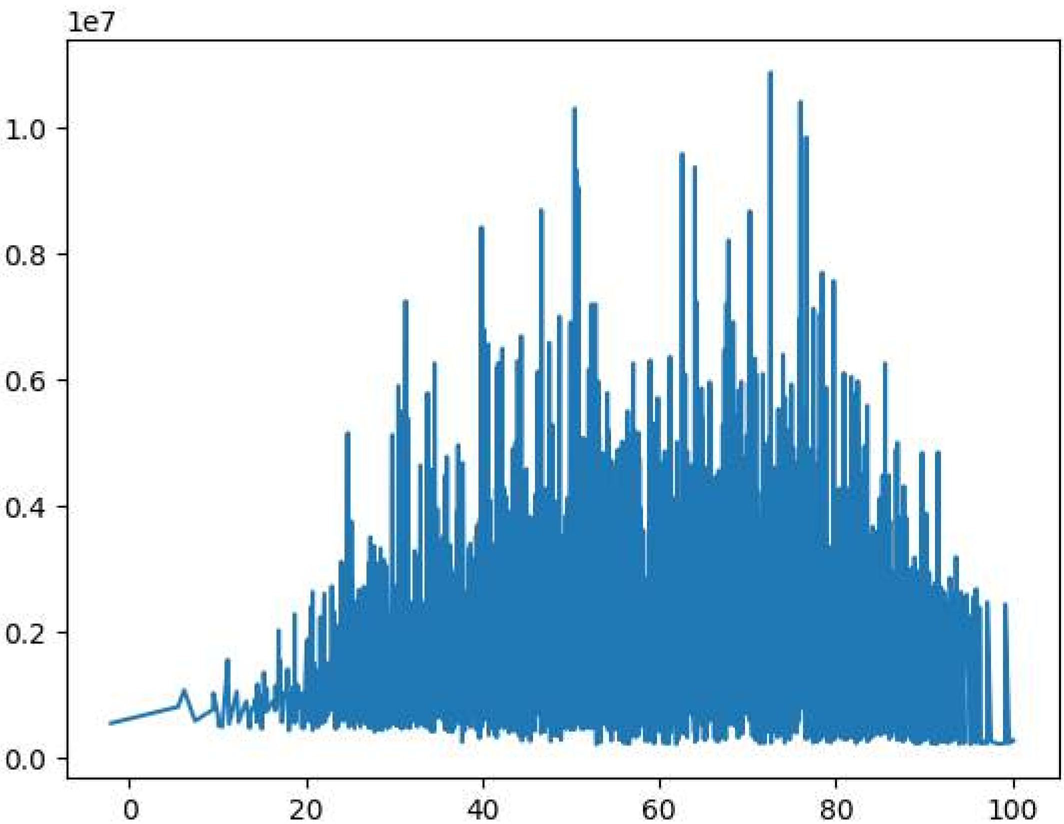
Out[45]:

	Temperature	Weekly_Sales
0	-2.06	558027.77
1	5.54	817485.14
2	6.23	1083071.14
3	7.46	593875.46
4	9.51	775910.43
...	...	...
3523	99.20	239198.36
3524	99.22	2446625.50
3525	99.66	237095.82
3526	100.07	297753.49
3527	100.14	280937.84

3528 rows × 2 columns

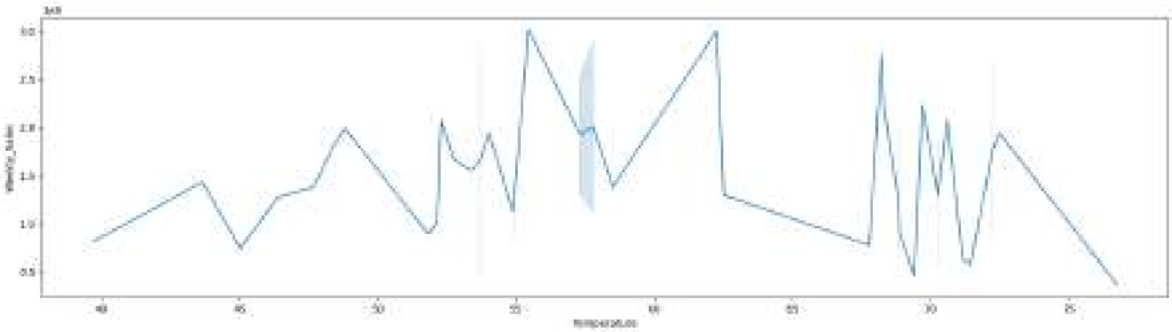
In [46]:
```
plt.plot(Total_by_temp['Temperature'],Total_by_temp['Weekly_Sales'])
```

Out[46]: [<matplotlib.lines.Line2D at 0x2474edd9520>]



In [47]:
```
Total_by_store = df.groupby(['Store'], as_index=False).agg({'Weekly_Sales': 'sum
plt.figure(figsize=(20, 5))
sns.lineplot(x='Temperature', y='Weekly_Sales', data=Total_by_store)
```

Out[47]: <Axes: xlabel='Temperature', ylabel='Weekly_Sales'>

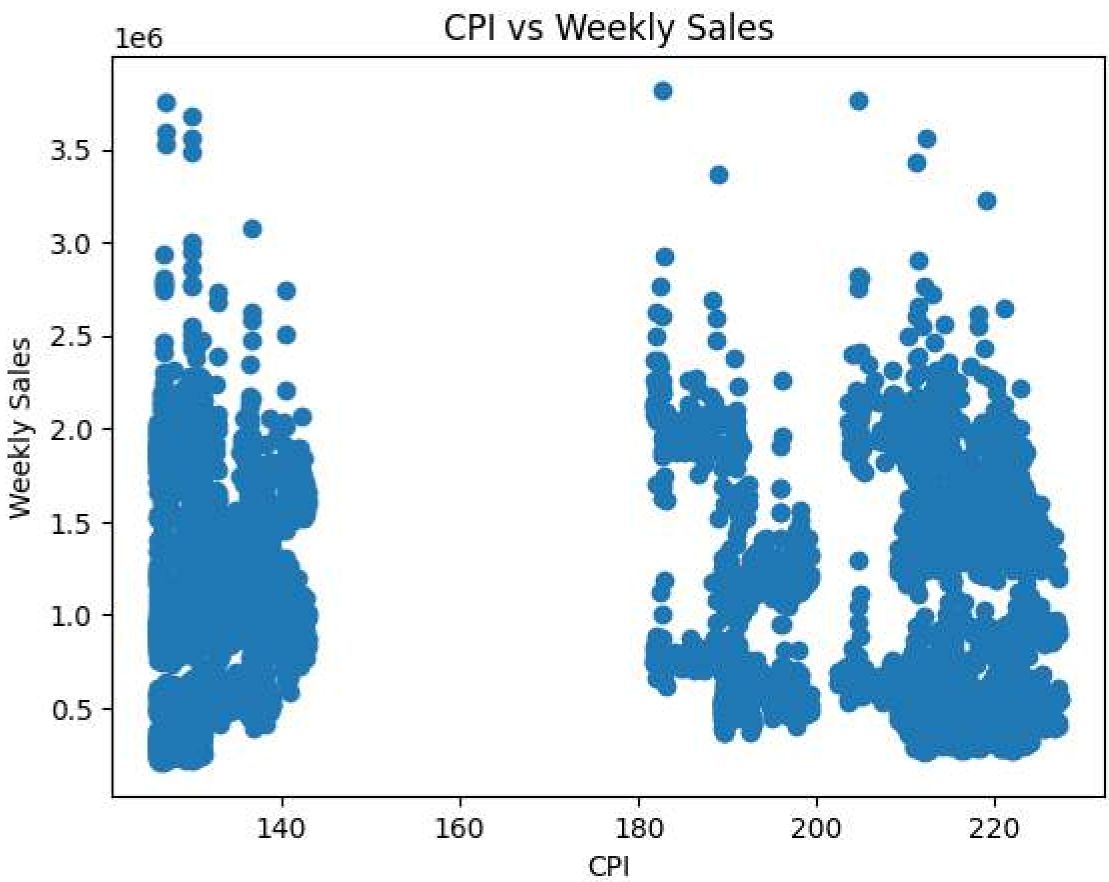


- Temperature affects the weekly sales
- At Low and High Temperatures the weekly sales are lower
- At moderate temperatures the Weekly sales are higher

D) How is the Consumer Price index affecting the weekly sales of various stores?

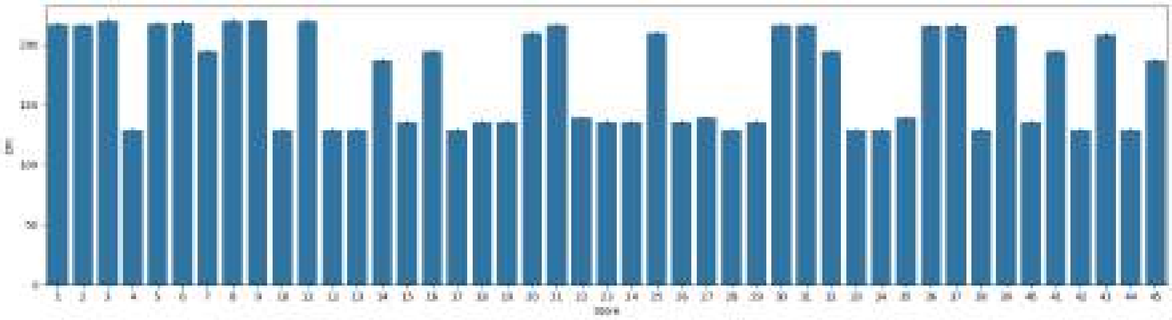
In [48]:
```
plt.scatter(df["CPI"],df['Weekly_Sales'])
plt.xlabel('CPI')
plt.ylabel('Weekly Sales')
plt.title("CPI vs Weekly Sales")
```

Out[48]: `Text(0.5, 1.0, 'CPI vs Weekly Sales')`



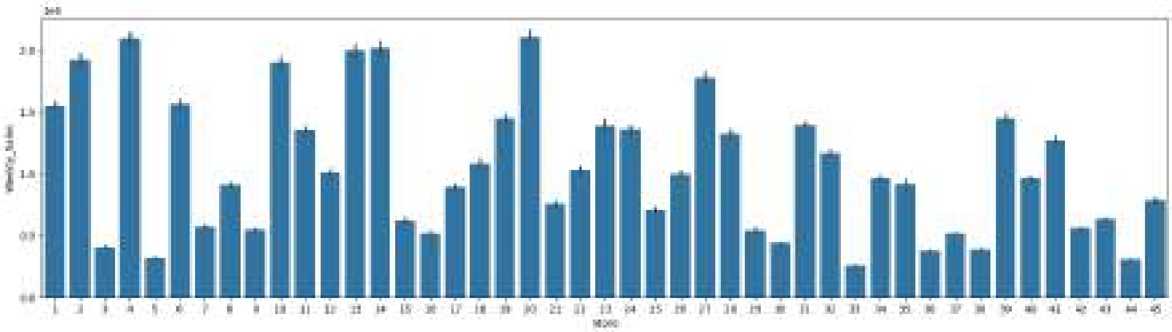
In [49]:
```
plt.figure(figsize=(20, 5))
sns.barplot(x = df['Store'], y=df['CPI'])
```

Out[49]: `<Axes: xlabel='Store', ylabel='CPI'>`



In [50]:
```
plt.figure(figsize=(20, 5))
sns.barplot(x = df['Store'], y=df['Weekly_Sales'])
```

Out[50]: <Axes: xlabel='Store', ylabel='Weekly_Sales'>



In [51]:
```
Total_by_store = df.groupby('Store').agg({'Weekly_Sales': 'sum', 'CPI': 'sum'})
Total_by_store
```

Out[51]:

Store	Weekly_Sales	CPI
1	2.224028e+08	30887.555523
2	2.753824e+08	30837.422420
3	5.758674e+07	31372.988971
4	2.995440e+08	18401.192733
5	4.547569e+07	30968.878137
6	2.237561e+08	31110.107182
7	8.159828e+07	27693.986741
8	1.299512e+08	31379.780750
9	7.778922e+07	31406.616557
10	2.716177e+08	18401.192733
11	1.939628e+08	31372.988971
12	1.442872e+08	18401.192733
13	2.865177e+08	18401.192733
14	2.889999e+08	26638.851959
15	8.913368e+07	19318.242848
16	7.425243e+07	27693.986741
17	1.277821e+08	18401.192733
18	1.551147e+08	19318.242848
19	2.066349e+08	19318.242848
20	3.013978e+08	29892.452680
21	1.081179e+08	30837.422420
22	1.470756e+08	19878.613542
23	1.987506e+08	19318.242848
24	1.940160e+08	19318.242848
25	1.010612e+08	29892.452680
26	1.434164e+08	19318.242848
27	2.538559e+08	19878.613542
28	1.892637e+08	18401.192733
29	7.714155e+07	19318.242848
30	6.271689e+07	30837.422420
31	1.996139e+08	30837.422420
32	1.668192e+08	27693.986741

	Weekly_Sales	CPI
Store		
33	3.716022e+07	18401.192733
34	1.382498e+08	18401.192733
35	1.315207e+08	19878.613542
36	5.341221e+07	30706.256907
37	7.420274e+07	30706.256907
38	5.515963e+07	18401.192733
39	2.074455e+08	30706.256907
40	1.378703e+08	19318.242848
41	1.813419e+08	27693.986741
42	7.956575e+07	18401.192733
43	9.056544e+07	29706.128216
44	4.329309e+07	18401.192733
45	1.123953e+08	26638.851959

In [52]:
```
Total_by_store[Total_by_store.CPI==Total_by_store.CPI.max()]
```

Out[52]:

	Weekly_Sales	CPI
Store		
9	77789218.99	31406.616557

In [53]:
```
Total_by_store[Total_by_store.CPI==Total_by_store.CPI.min()]
```

Out[53]:

Store	Weekly_Sales	CPI
4	2.995440e+08	18401.192733
10	2.716177e+08	18401.192733
12	1.442872e+08	18401.192733
13	2.865177e+08	18401.192733
17	1.277821e+08	18401.192733
28	1.892637e+08	18401.192733
33	3.716022e+07	18401.192733
34	1.382498e+08	18401.192733
38	5.515963e+07	18401.192733
42	7.956575e+07	18401.192733
44	4.329309e+07	18401.192733

- When CPI is higher Weekly Sales are Lower

E) Top performing stores according to the historical data

In [54]:

```
Total_data_by_store=df.groupby('Store',as_index=False).agg({"Weekly_Sales":"sum"
Top_sales_store=Total_data_by_store.sort_values(by='Weekly_Sales',ascending=Fals
Top_sales_store
```

Out[54]:

	Store	Weekly_Sales
19	20	3.013978e+08
3	4	2.995440e+08
13	14	2.889999e+08
12	13	2.865177e+08
1	2	2.753824e+08
9	10	2.716177e+08
26	27	2.538559e+08
5	6	2.237561e+08
0	1	2.224028e+08
38	39	2.074455e+08
18	19	2.066349e+08
30	31	1.996139e+08
22	23	1.987506e+08
23	24	1.940160e+08
10	11	1.939628e+08
27	28	1.892637e+08
40	41	1.813419e+08
31	32	1.668192e+08
17	18	1.551147e+08
21	22	1.470756e+08
11	12	1.442872e+08
25	26	1.434164e+08
33	34	1.382498e+08
39	40	1.378703e+08
34	35	1.315207e+08
7	8	1.299512e+08
16	17	1.277821e+08
44	45	1.123953e+08
20	21	1.081179e+08
24	25	1.010612e+08
42	43	9.056544e+07
14	15	8.913368e+07
6	7	8.159828e+07

	Store	Weekly_Sales
41	42	7.956575e+07
8	9	7.778922e+07
28	29	7.714155e+07
15	16	7.425243e+07
36	37	7.420274e+07
29	30	6.271689e+07
2	3	5.758674e+07
37	38	5.515963e+07
35	36	5.341221e+07
4	5	4.547569e+07
43	44	4.329309e+07
32	33	3.716022e+07

In [55]:
```
Top_sales_store.head()
```

Out[55]:

	Store	Weekly_Sales
19	20	3.013978e+08
3	4	2.995440e+08
13	14	2.889999e+08
12	13	2.865177e+08
1	2	2.753824e+08

- The Top Performing stores are Stor number 20, 4, 14, 13, 2

F) The worst performing store, and how significant is the difference between the highest and lowest performing stores.

In [56]:
```
Top_sales_store.tail(1)
```

Out[56]:

	Store	Weekly_Sales
32	33	37160221.96

- The Worst Performing store is Store No 33

In [57]:
```
Top_sales_store.max()['Weekly_Sales'] - Top_sales_store.min()['Weekly_Sales']
```

Out[57]:
```
264237570.49999997
```

- The Difference Between the best and the worst performing store is 264237570.49999997

In [58]:
```
df.Date=pd.to_datetime(df.Date,format="%d-%m-%Y")
```

In [59]:
```
df=df.set_index("Date")
```

2. Use predictive modeling techniques to forecast the sales for each store for the next 12 weeks.

Time Series Analysis

In [60]:
```
df_target=df.loc[:,['Store',"Weekly_Sales"]]
```

In [61]:
```
df_target
```

Out[61]:

	Store	Weekly_Sales
Date		
2010-02-05	1	1643690.90
2010-02-12	1	1641957.44
2010-02-19	1	1611968.17
2010-02-26	1	1409727.59
2010-03-05	1	1554806.68
...	...	...
2012-09-28	45	713173.95
2012-10-05	45	733455.07
2012-10-12	45	734464.36
2012-10-19	45	718125.53
2012-10-26	45	760281.43

6435 rows × 2 columns

In [62]:
```
from pmdarima.arima import auto_arima
model = auto_arima(df["Weekly_Sales"], seasonal=True, stepwise=True, trace=True)
```

```
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=173103.554, Time=4.29 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=174457.419, Time=0.24 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=173626.224, Time=0.65 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=173359.721, Time=0.83 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=174455.423, Time=0.16 sec
```

```
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=173301.748, Time=2.83 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=173266.524, Time=3.18 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=172741.309, Time=4.85 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=172905.020, Time=4.69 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,2)(0,0,0)[0] intercept   : AIC=172730.428, Time=12.92 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,1)(0,0,0)[0] intercept   : AIC=172847.176, Time=4.30 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,2)(0,0,0)[0] intercept   : AIC=172588.751, Time=23.11 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,1)(0,0,0)[0] intercept   : AIC=172597.113, Time=6.85 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,3)(0,0,0)[0] intercept   : AIC=172572.018, Time=13.13 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,3)(0,0,0)[0] intercept   : AIC=172609.343, Time=19.04 sec
```

```
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,4)(0,0,0)[0] intercept   : AIC=172568.730, Time=15.32 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,4)(0,0,0)[0] intercept   : AIC=172608.399, Time=12.34 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,5)(0,0,0)[0] intercept   : AIC=172515.273, Time=27.51 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,5)(0,0,0)[0] intercept   : AIC=172515.184, Time=12.83 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,5)(0,0,0)[0] intercept   : AIC=172520.188, Time=11.26 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,4)(0,0,0)[0] intercept   : AIC=172730.332, Time=13.91 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,5)(0,0,0)[0]             : AIC=172513.152, Time=12.63 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,5)(0,0,0)[0]             : AIC=172518.165, Time=9.96 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(4,1,4)(0,0,0)[0]             : AIC=172606.296, Time=10.99 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,5)(0,0,0)[0]             : AIC=172513.236, Time=21.20 sec
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(3,1,4)(0,0,0)[0]             : AIC=172728.335, Time=11.63 sec
```

```
d:\yourenv\Lib\site-packages\sklearn\utils\deprecation.py:151: FutureWarning: 'fo
rce_all_finite' was renamed to 'ensure_all_finite' in 1.6 and will be removed in
1.8.
  warnings.warn(
 ARIMA(5,1,4)(0,0,0)[0]             : AIC=172566.624, Time=14.47 sec

Best model:  ARIMA(4,1,5)(0,0,0)[0]
Total fit time: 275.163 seconds
```

Store 1 Dataset

In [63]:
```
result = adfuller(df_target[df_target['Store']==1]['Weekly_Sales'])
result
```

Out[63]:
```
(-5.102186145192289,
 1.3877788330759307e-05,
 4,
 138,
 {'1%': -3.47864788917503,
  '5%': -2.882721765644168,
  '10%': -2.578065326612056},
 3412.7325502876756)
```

In [64]:
```
p_value=result[1]
p_value
```

Out[64]:
```
1.3877788330759307e-05
```

p value is close to 0 and we can conclude that the data is stationary

In [65]:
```
store1=pd.DataFrame(df_target[df_target['Store']==1]['Weekly_Sales'])
store1=store1.sort_index()
store1
```

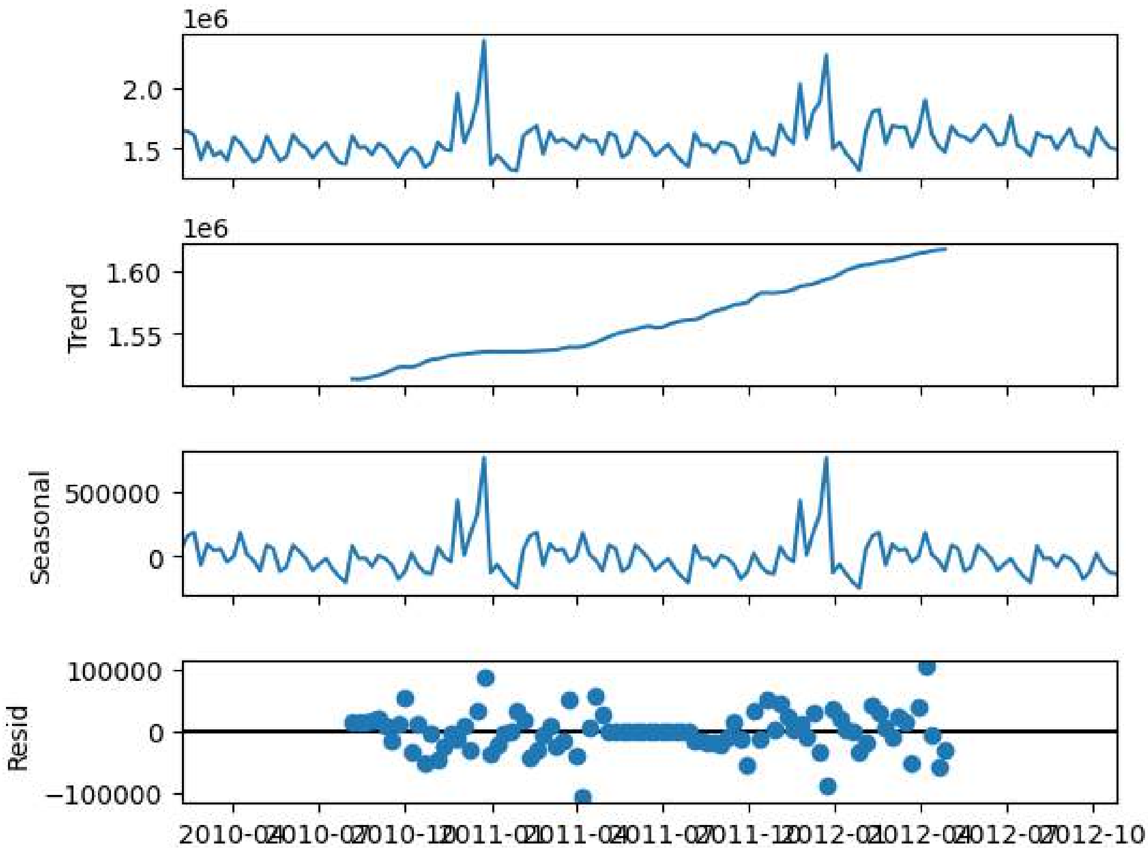
Out[65]:

Date	Weekly_Sales
2010-02-05	1643690.90
2010-02-12	1641957.44
2010-02-19	1611968.17
2010-02-26	1409727.59
2010-03-05	1554806.68
...	...
2012-09-28	1437059.26
2012-10-05	1670785.97
2012-10-12	1573072.81
2012-10-19	1508068.77
2012-10-26	1493659.74

143 rows × 1 columns

Visualizing Seasonality

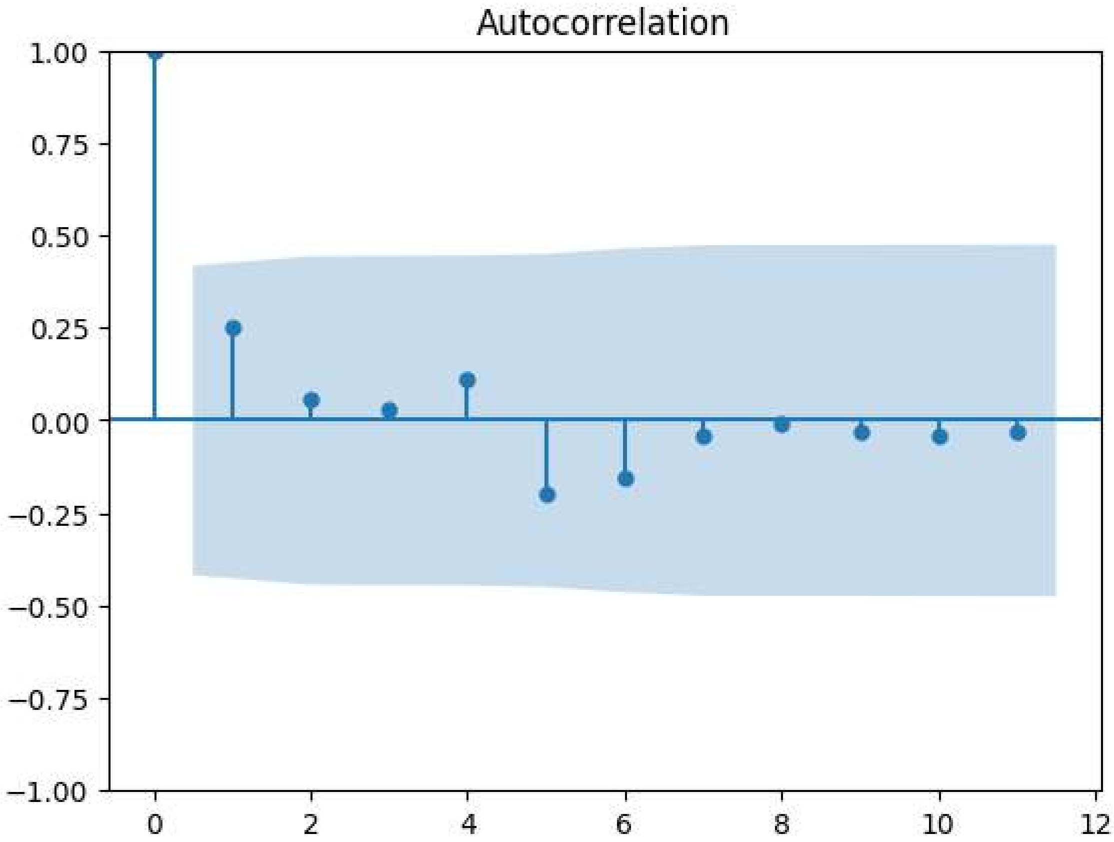
In [66]:
```
decompose = seasonal_decompose(store1)
decompose_plot=decompose.plot()
```

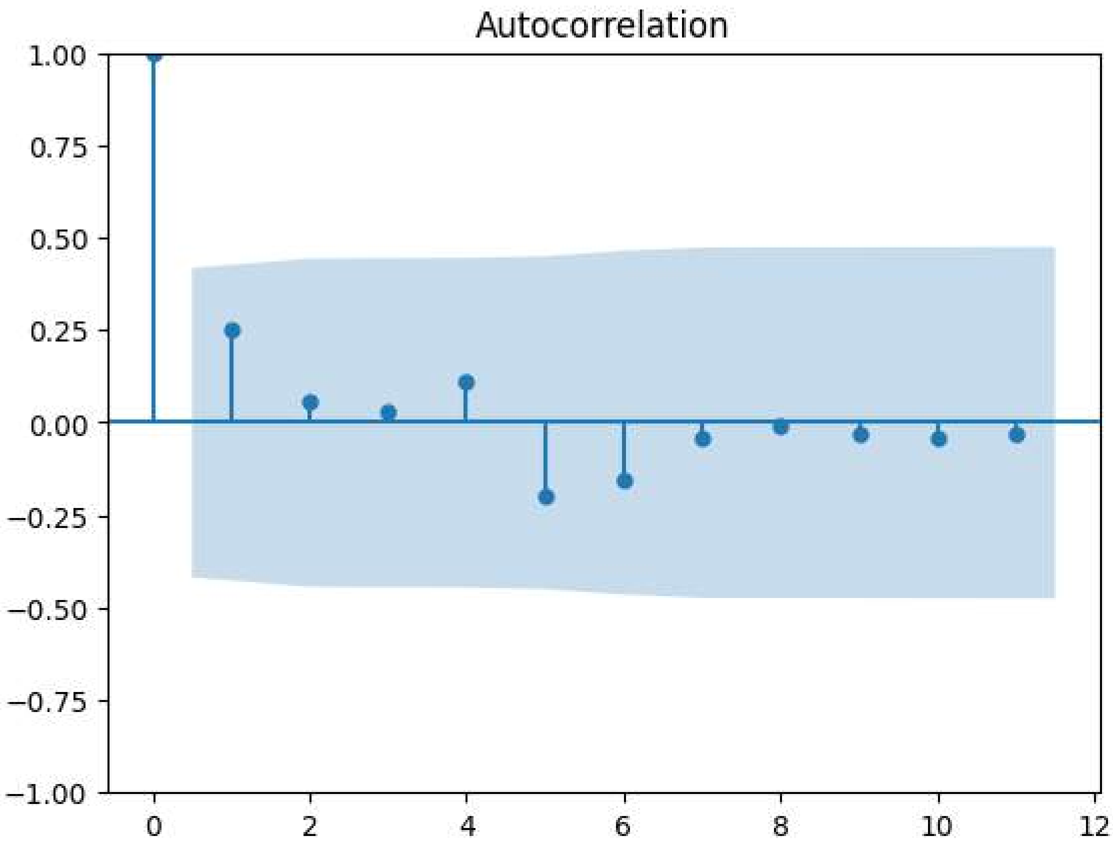


In [67]:
```
acf_plot=acf(store1["Weekly_Sales"])
```

In [68]:
```
plot_acf(acf_plot)
```

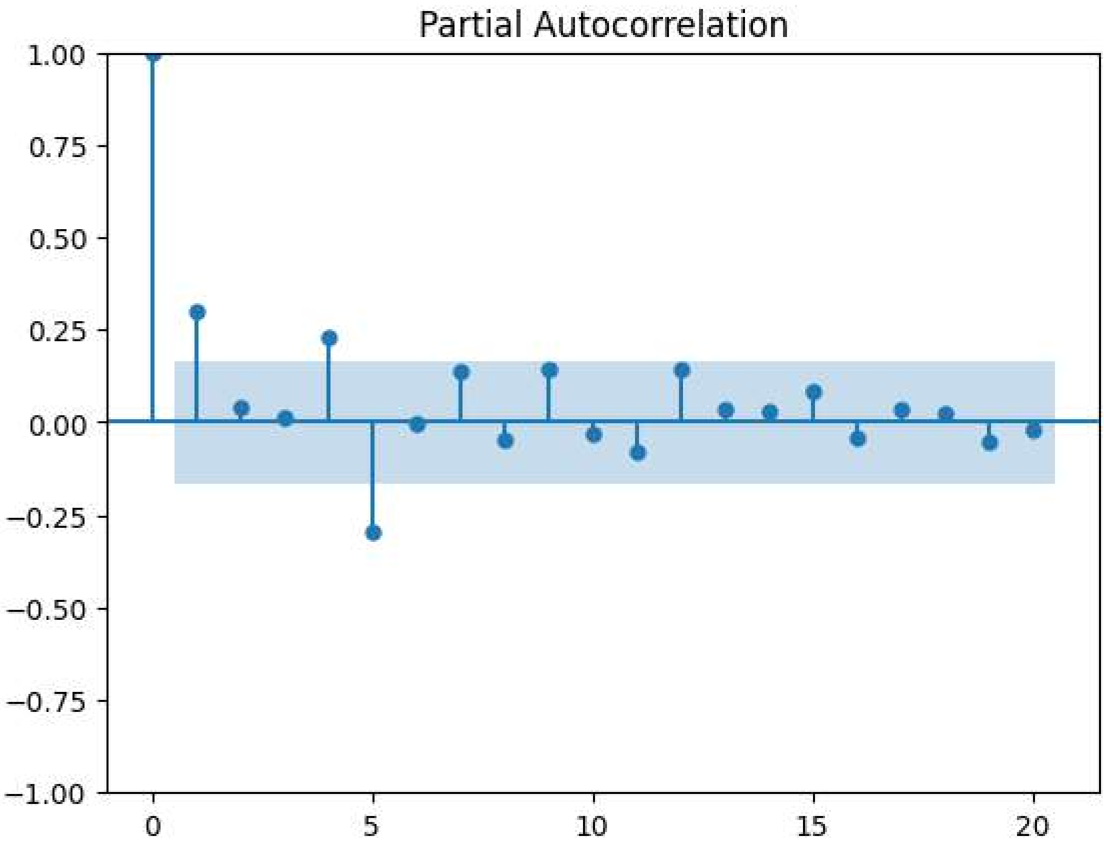
Out[68]:

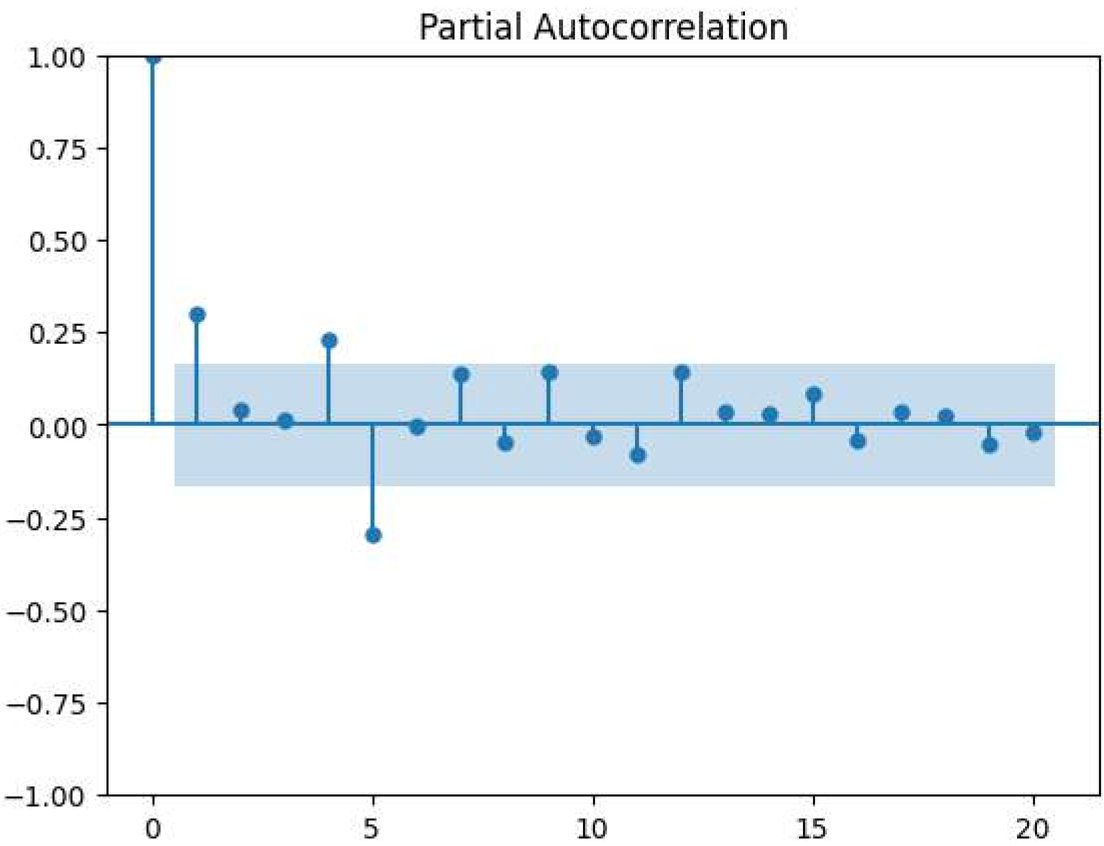




In [69]:
```
plot_pacf(store1["Weekly_Sales"],lags=20)
```

Out[69]:

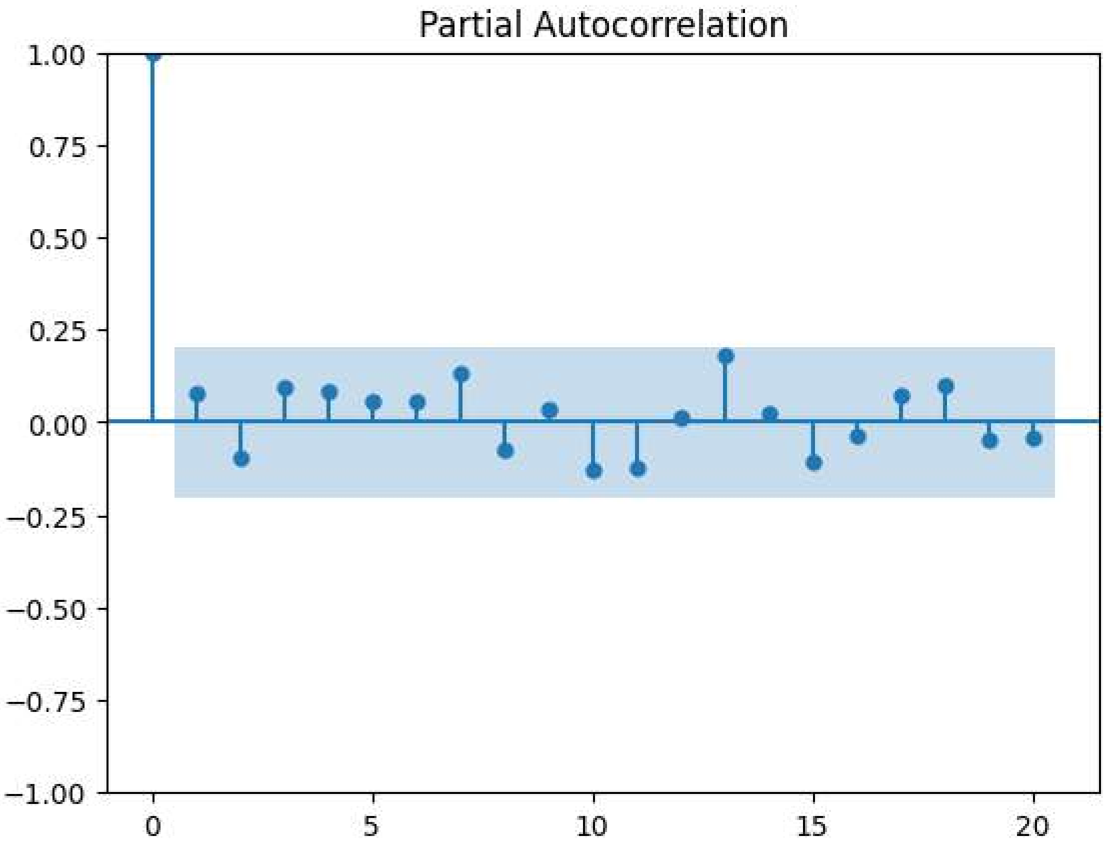




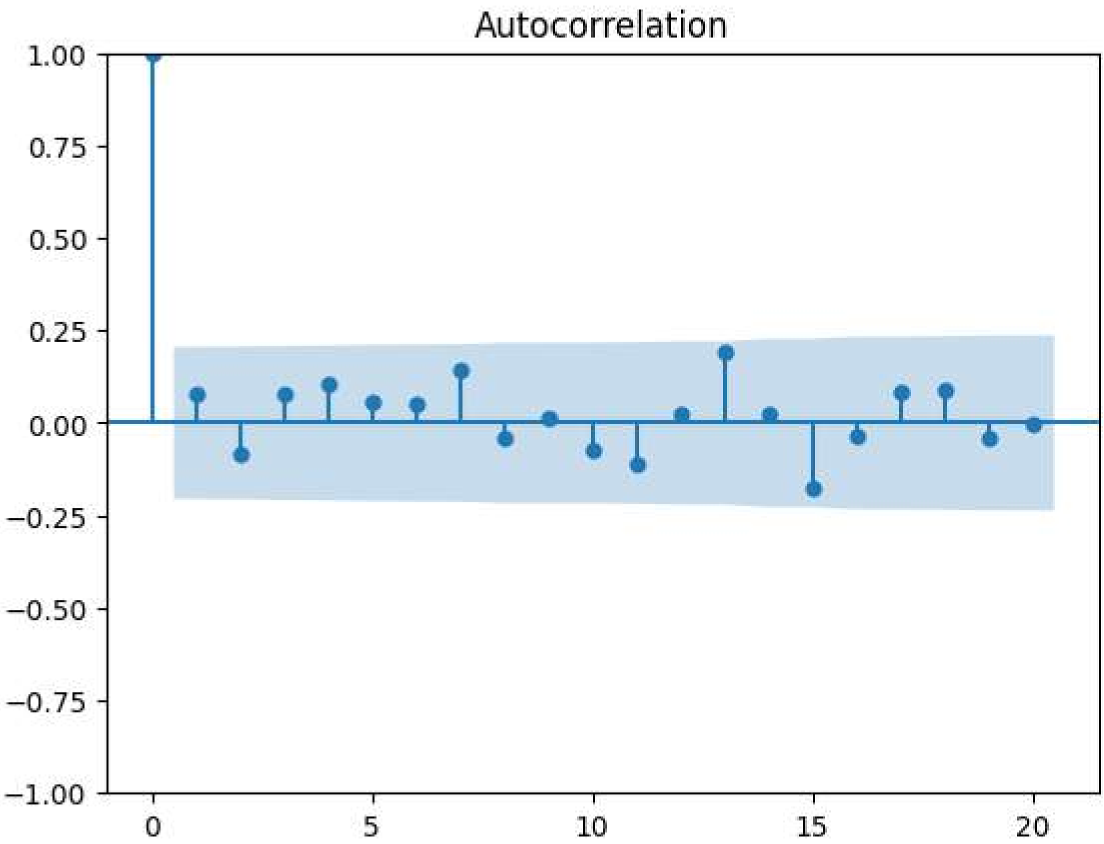
In [70]:
```
store1['lag1']=store1['Weekly_Sales'].diff()
```

In [71]:
```
store1['lag52']=store1['Weekly_Sales'].diff(52)
```

In [72]:
```
pacf_values=plot_pacf(store1['lag52'].dropna(),lags=20)
```



In [73]:
```
acf_values=plot_acf(store1['lag52'].dropna(),lags=20)
```



In [74]:
```
# From the above, pacf(p) ,acf(q) value is 0
pacf_values=sm.tsa.pacf(store1['Weekly_Sales'],nlags=20)
pacf_values
```

Out[74]:
```
array([ 1.        ,  0.30375985,  0.04021628,  0.01219543,  0.23927843,
       -0.30788835, -0.0014493 ,  0.14798536, -0.05206473,  0.1547872 ,
       -0.03652748, -0.08797706,  0.16184013,  0.03250986,  0.03380417,
        0.10062548, -0.04966531,  0.04265725,  0.02866535, -0.0672978 ,
       -0.0144685 ])
```

- p[1]=0.30 value will be newar to zero then p=0

In [75]:
```
train = store1.iloc[:115]['Weekly_Sales']
test = store1.iloc[115:]['Weekly_Sales']
```

In [76]:
```
# Training The Model
model=SARIMAX(train,order=(0,1,0),seasonal_order=(0,1,0,52))
model_fit = model.fit()
model_fit.summary()
```

```
d:\yourenv\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning:
No frequency information was provided, so inferred frequency W-FRI will be used.
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  self._init_dates(dates, freq)
```

Out[76]:

SARIMAX Results

Dep. Variable:	Weekly_Sales	**No. Observations:**	115
Model:	SARIMAX(0, 1, 0)x(0, 1, 0, 52)	**Log Likelihood**	-801.151
Date:	Mon, 27 Jan 2025	**AIC**	1604.302
Time:	02:55:27	**BIC**	1606.429
Sample:	02-05-2010	**HQIC**	1605.137
	- 04-13-2012		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
sigma2	4.169e+09	3.17e+08	13.134	0.000	3.55e+09	4.79e+09

Ljung-Box (L1) (Q):	9.70	**Jarque-Bera (JB):**	2.72
Prob(Q):	0.00	**Prob(JB):**	0.26
Heteroskedasticity (H):	1.79	**Skew:**	0.06
Prob(H) (two-sided):	0.19	**Kurtosis:**	4.02

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Testing The Model

In [77]:
```
pred = model_fit.predict(start= len(train),end=len(train)+len(test)- 1,dynamic=T
```

In [78]:
```
pred
```

Out[78]:
```
2012-04-20    1625962.51
2012-04-27    1516233.39
2012-05-04    1690533.98
2012-05-11    1665918.28
2012-05-18    1489360.97
2012-05-25    1527189.37
2012-06-01    1696221.11
2012-06-08    1650091.02
2012-06-15    1593257.56
2012-06-22    1499972.85
2012-06-29    1549680.79
2012-07-06    1595992.34
2012-07-13    1516262.67
2012-07-20    1458069.52
2012-07-27    1413362.49
2012-08-03    1685526.45
2012-08-10    1586289.79
2012-08-17    1591904.13
2012-08-24    1525836.16
2012-08-31    1611371.92
2012-09-07    1601613.94
2012-09-14    1575402.48
2012-09-21    1441162.97
2012-09-28    1455704.53
2012-10-05    1692132.65
2012-10-12    1554668.63
2012-10-19    1563705.48
2012-10-26    1506391.79
Freq: W-FRI, Name: predicted_mean, dtype: float64
```

In [79]:
```
plt.figure(figsize=(20,10))
plt.plot(test,label="Original")
plt.plot(pred,label="Prediction")
plt.legend()
```

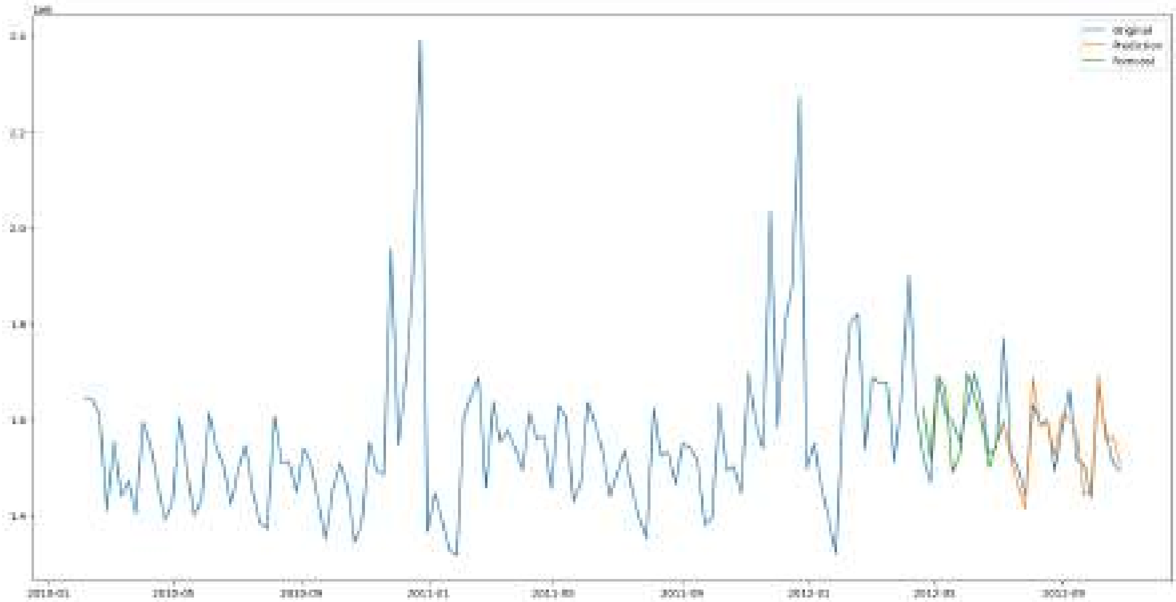
Out[79]: <matplotlib.legend.Legend at 0x2474ea664b0>

Forecasting for Next 12 Weeks

In [80]:
```
forecast=model_fit.forecast(steps=12)
```

In [81]:
```
plt.figure(figsize=(20,10))
plt.plot(store1['Weekly_Sales'],label="Original")
plt.plot(pred,label="Prediction")
plt.plot(forecast,label="Forecast")
plt.legend()
```

Out[81]: <matplotlib.legend.Legend at 0x247049c9fd0>



In [82]:
```
comparison = pd.DataFrame({'Actual': test, 'Predicted': pred})
comparison.dropna(inplace=True)
```

In [83]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error

mae = mean_absolute_error(comparison['Actual'], comparison['Predicted'])
mse = mean_squared_error(comparison['Actual'], comparison['Predicted'])
rmse = np.sqrt(mse)
print(f'Mean Absolute Error (MAE): {mae}')
print(f'Mean Squared Error (MSE): {mse}')
print(f'Root Mean Squared Error (RMSE): {rmse}')
```

```
Mean Absolute Error (MAE): 43867.10071428573
Mean Squared Error (MSE): 3251568436.6039357
Root Mean Squared Error (RMSE): 57022.525694710646
```

In [84]:
```
for i in range(1,46):
    new_data=pd.DataFrame(df[df["Store"]==i]["Weekly_Sales"])
    lag52=pd.DataFrame(new_data["Weekly_Sales"].diff(52))
    acf_values,confidence_intervals=sm.tsa.acf(lag52.dropna(),nlags=20,alpha=0.0
    pacf_values=sm.tsa.pacf(lag52.dropna(),nlags=20)
    significant_acf = []
    significant_pacf = []
    for lag,acf,confident in zip(range(len(acf_values)),acf_values,confidence_in
        if(abs(acf)>confident[1]):
            significant_acf.append(acf)
        else:
            break
    for lag,pacf,confident in zip(range(len(pacf_values)),pacf_values,confidence
        if(abs(acf)>confident[1]):
            significant_pacf.append(acf)
```

```
            else:
                break
        p=len(significant_acf)
        q=len(significant_pacf)
        train=new_data[:round(len(new_data)*0.7)]
        model=SARIMAX(train,order=(p,1,q),seasonal_order=(p,1,q,52))
        model_fit=model.fit()
        pred=model_fit.predict(start=len(train),end=len(new_data)-1,dynamic=True)
        forecast=model_fit.forecast(steps=12)
        plt.figure(figsize=(20,10))
        plt.plot(new_data['Weekly_Sales'],label='Given_sales')
        plt.plot(pred,label='Prediction')
        plt.plot(forecast,label="12 weeks forecast")
        plt.legend()
        plt.title(f'store {i}')
        plt.show()
```

```
d:\yourenv\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning:
No frequency information was provided, so inferred frequency W-FRI will be used.
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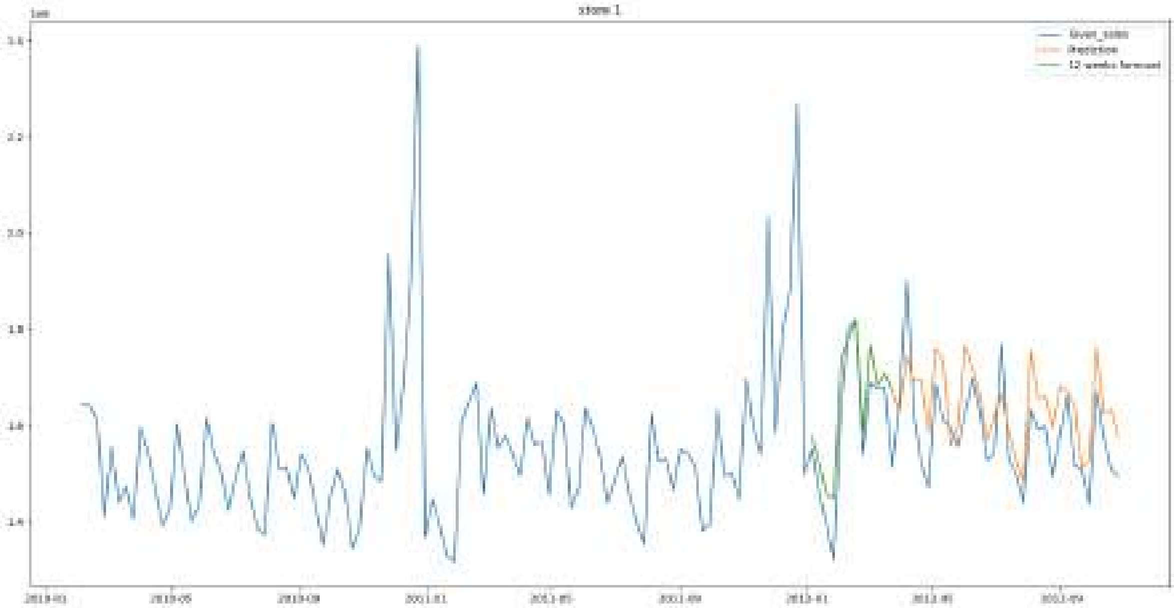


```
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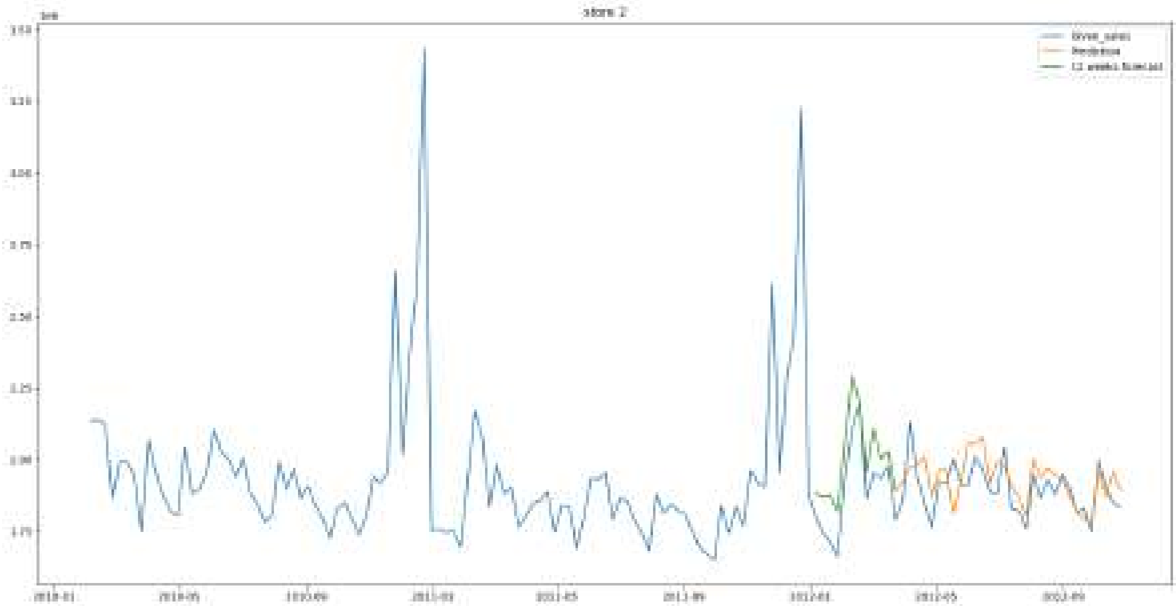


```
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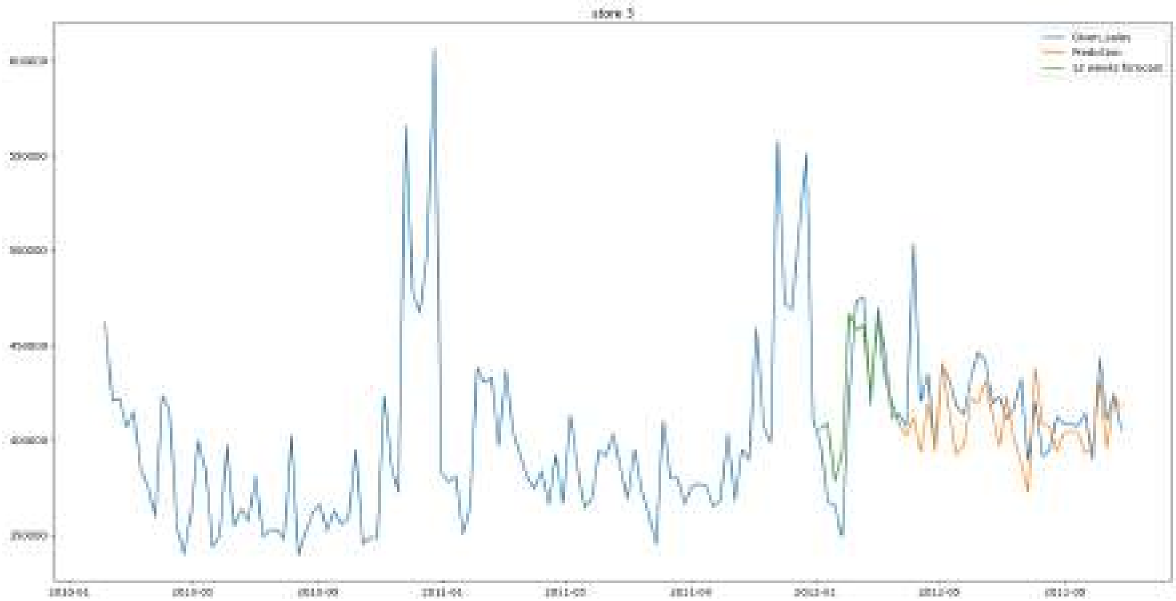


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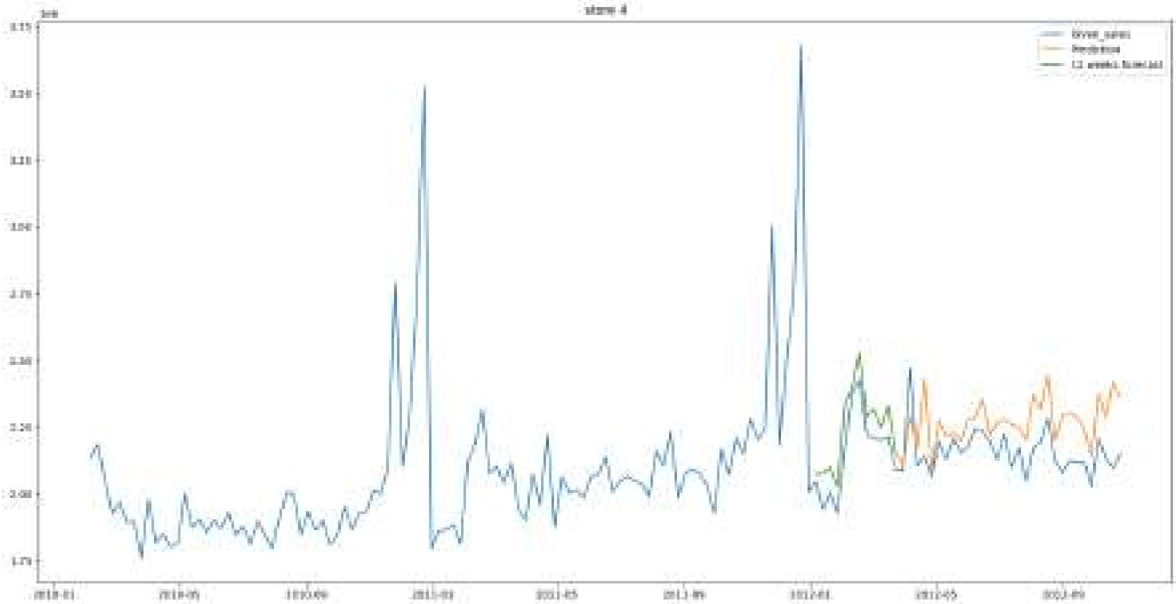


```
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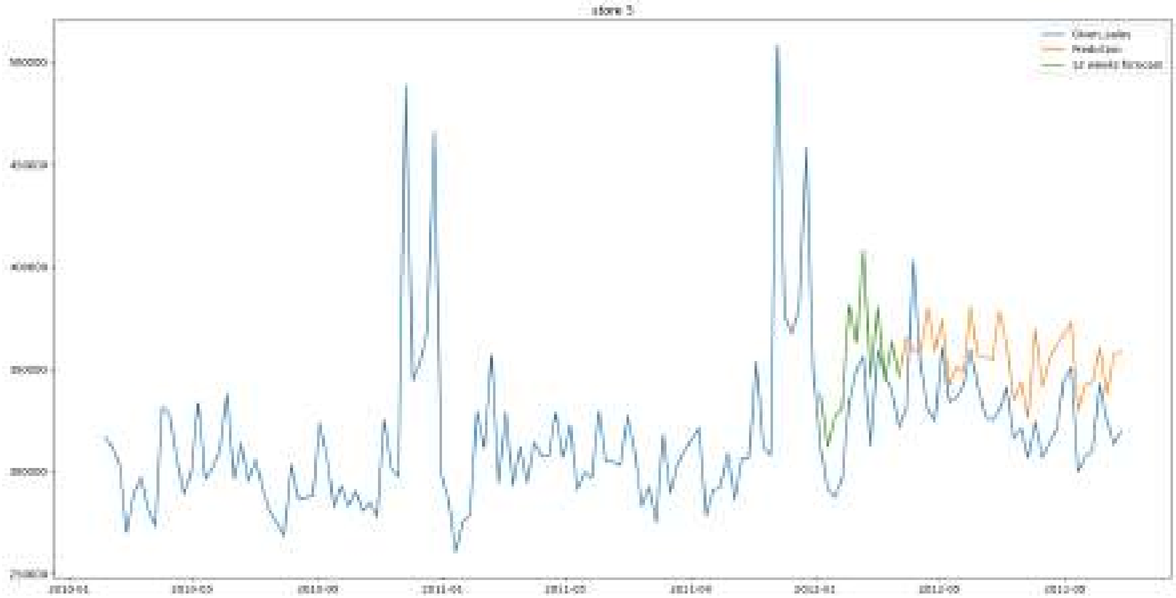


```
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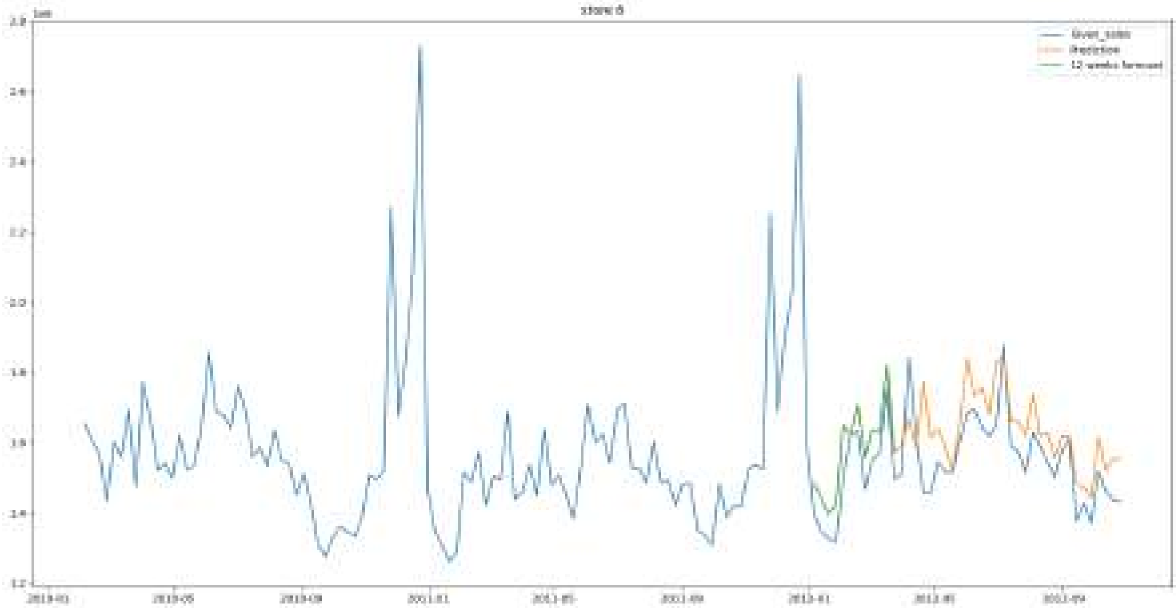

```
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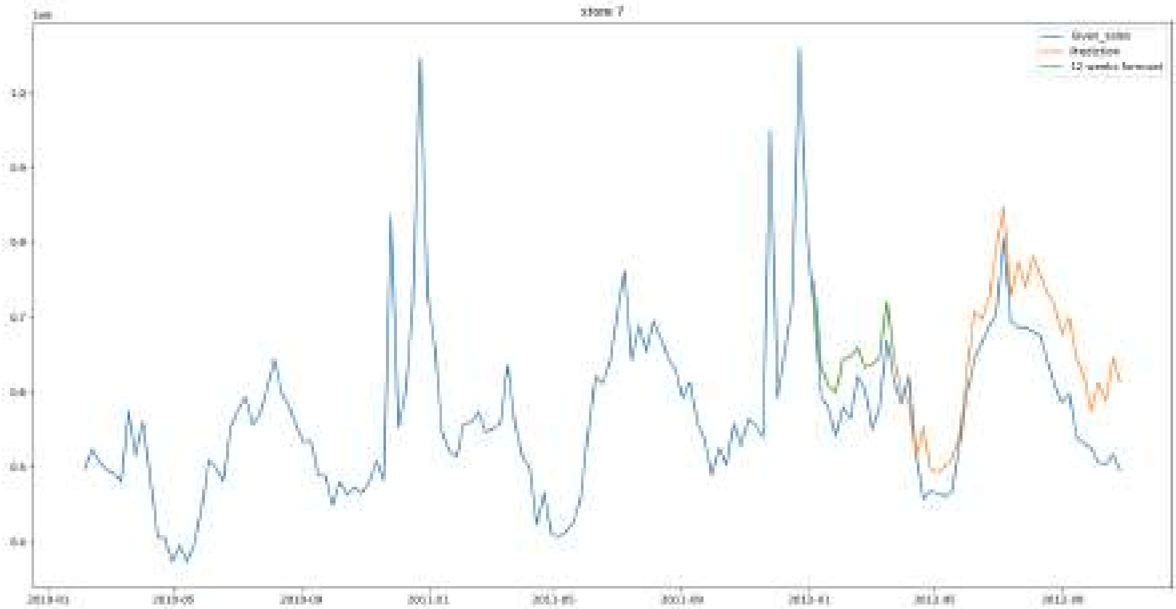

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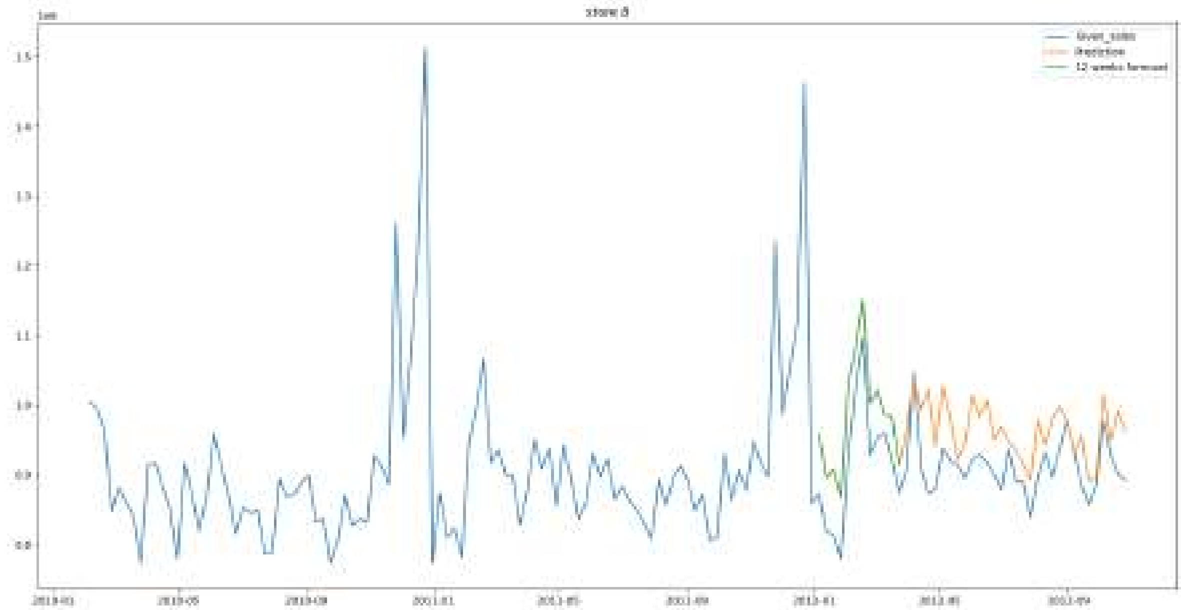


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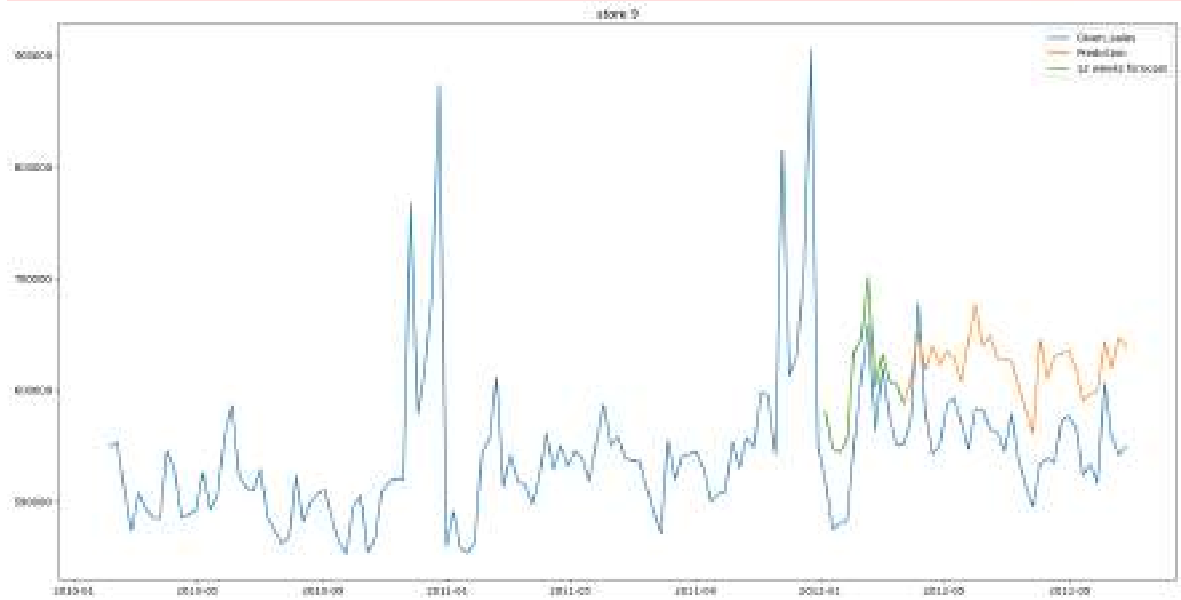


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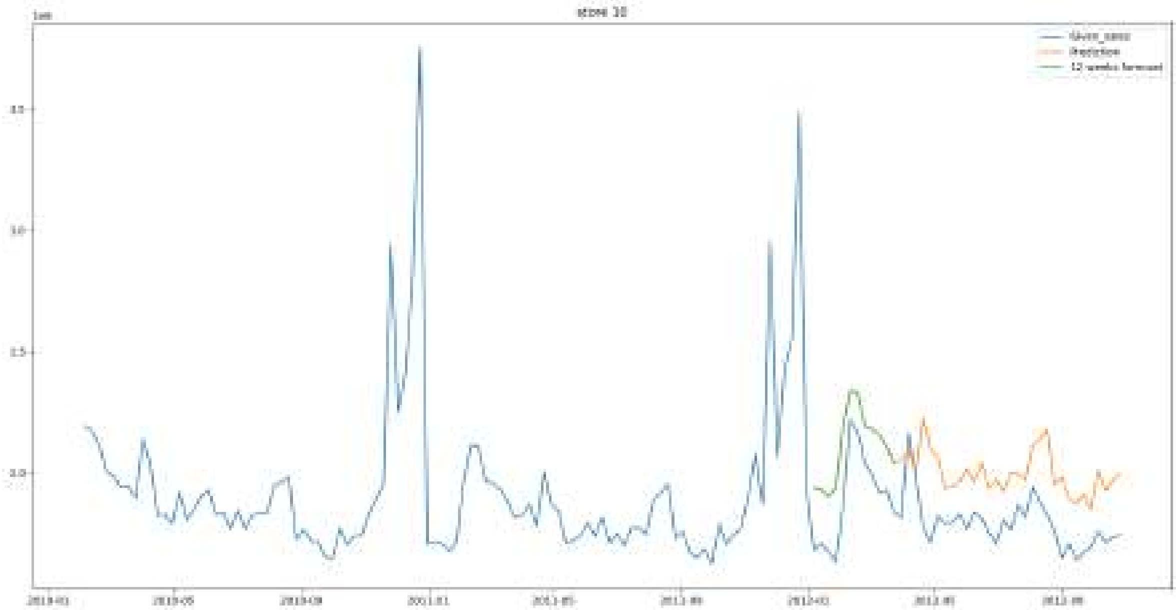


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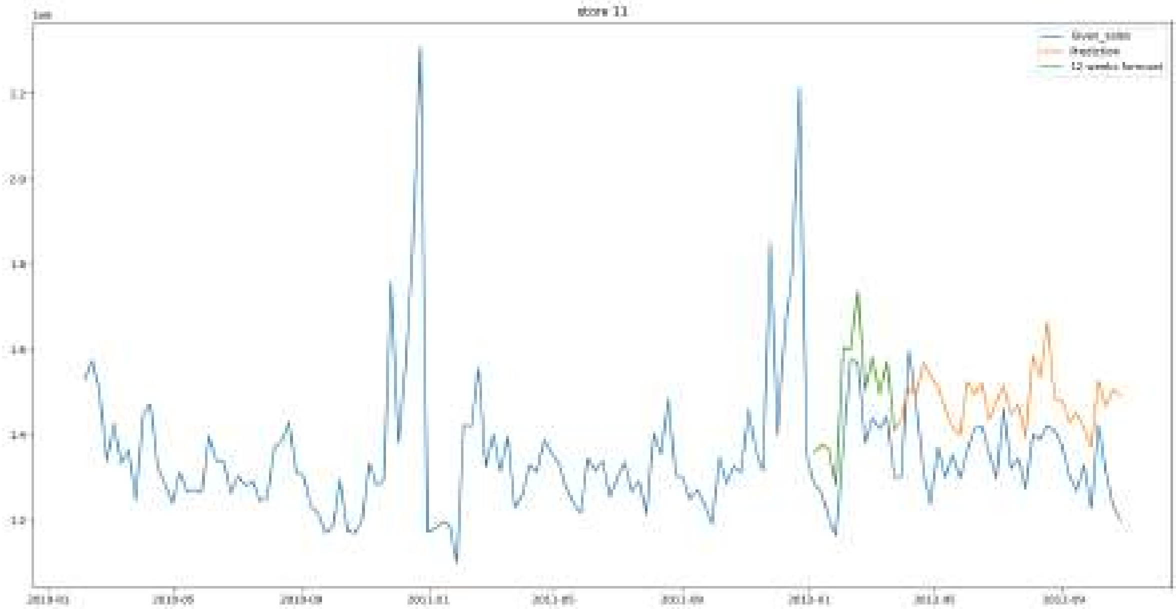


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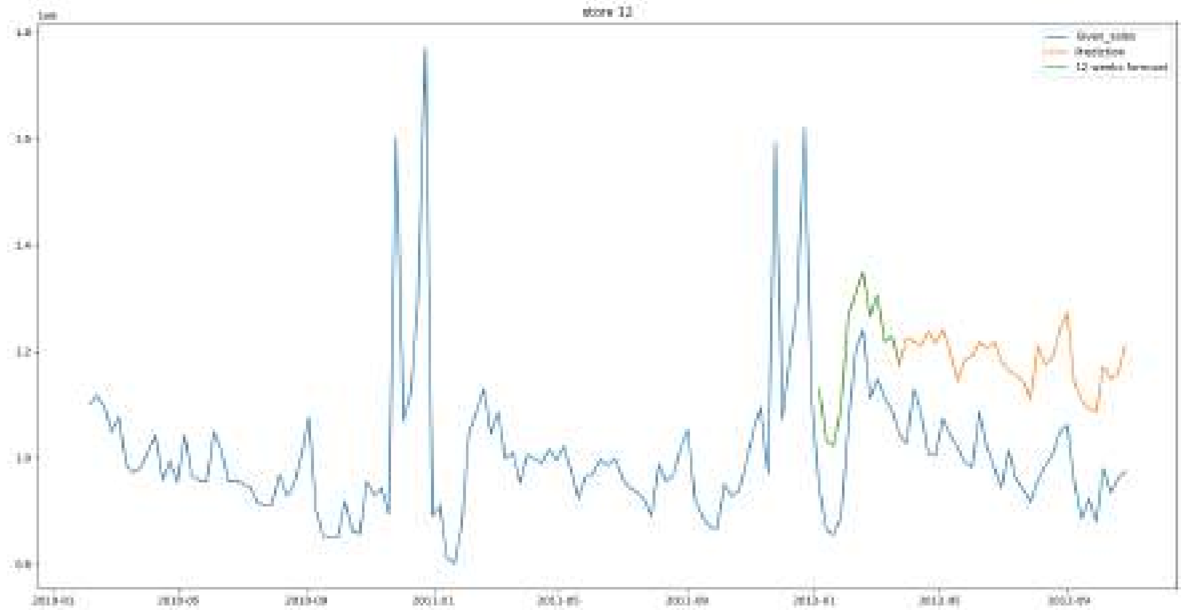


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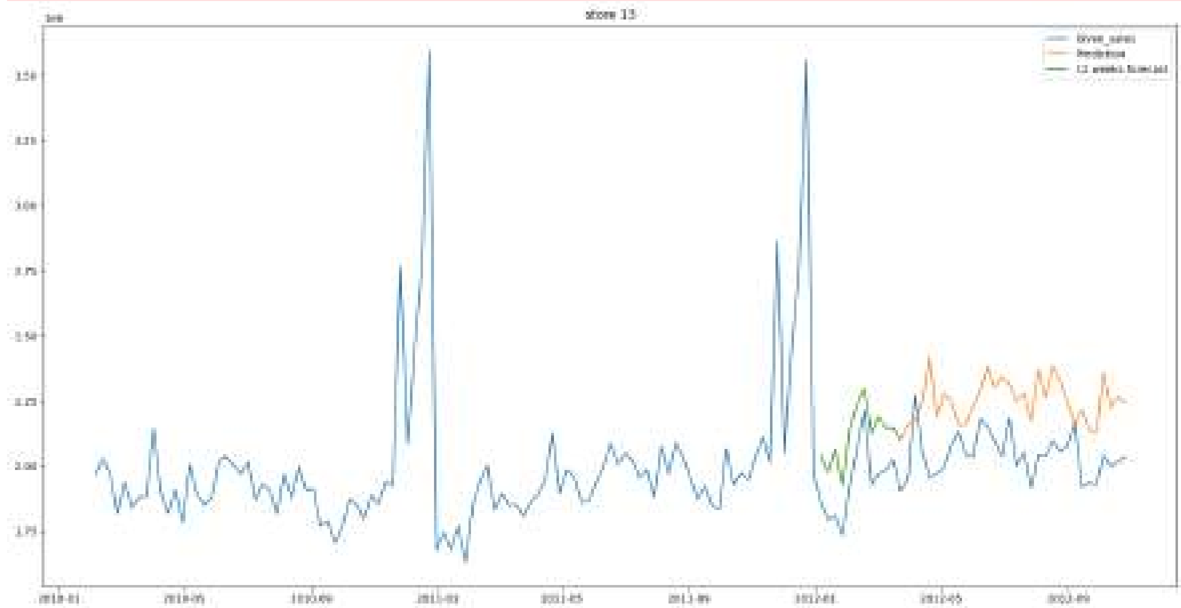


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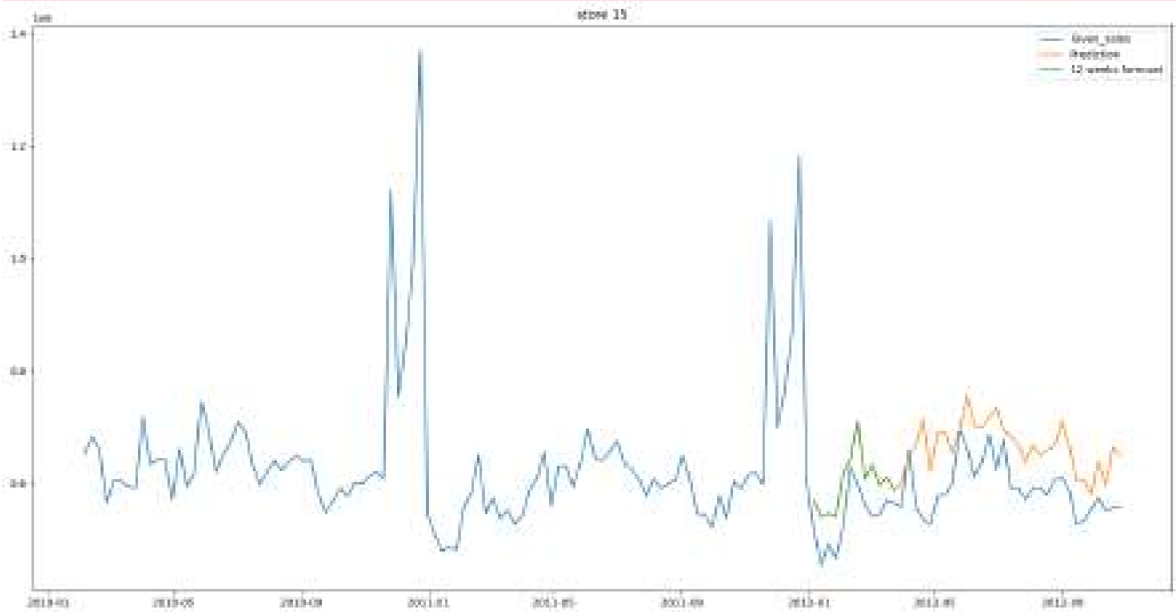


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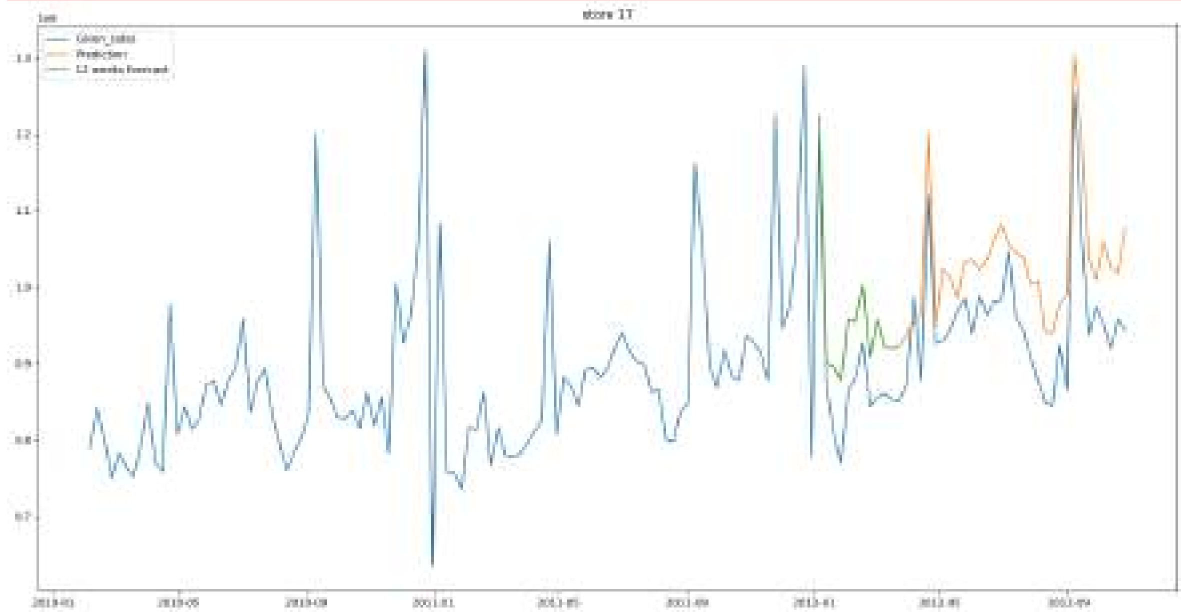

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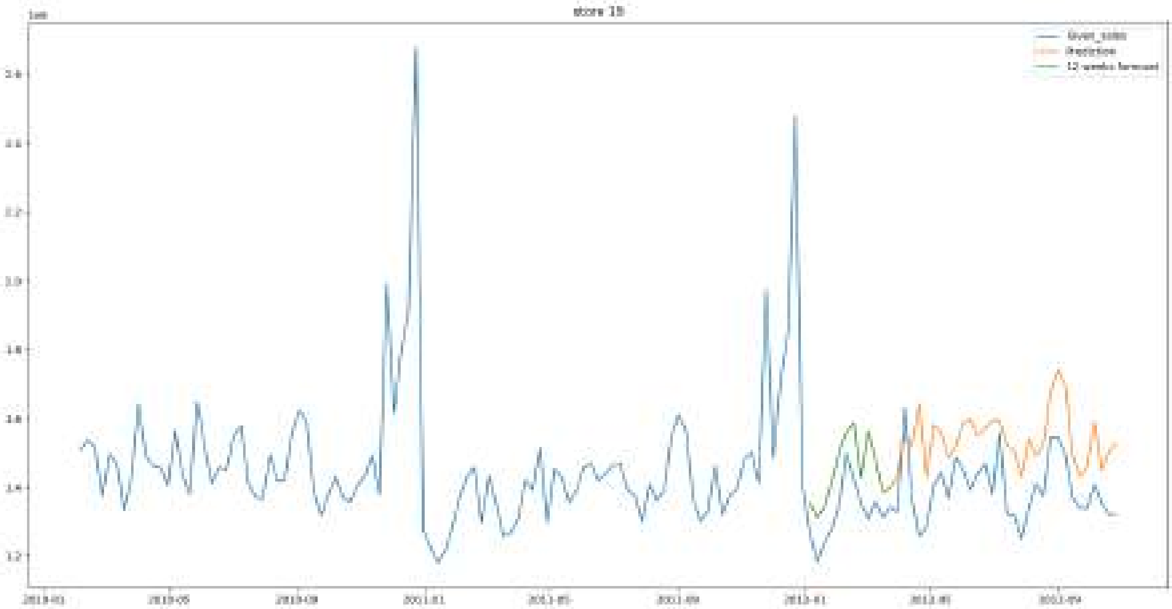

```
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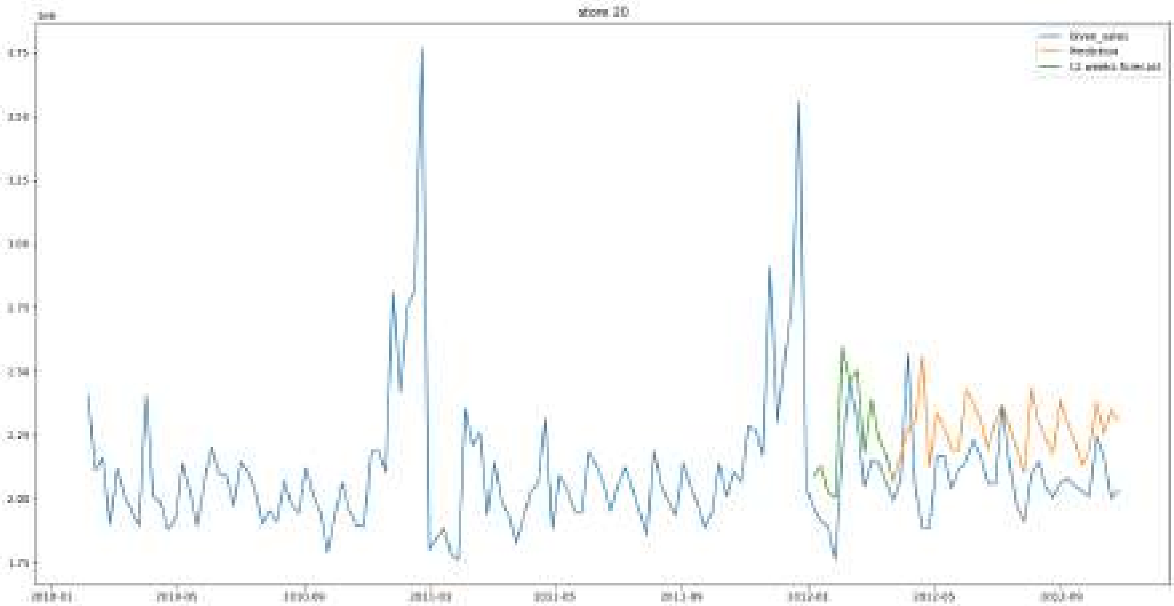


```
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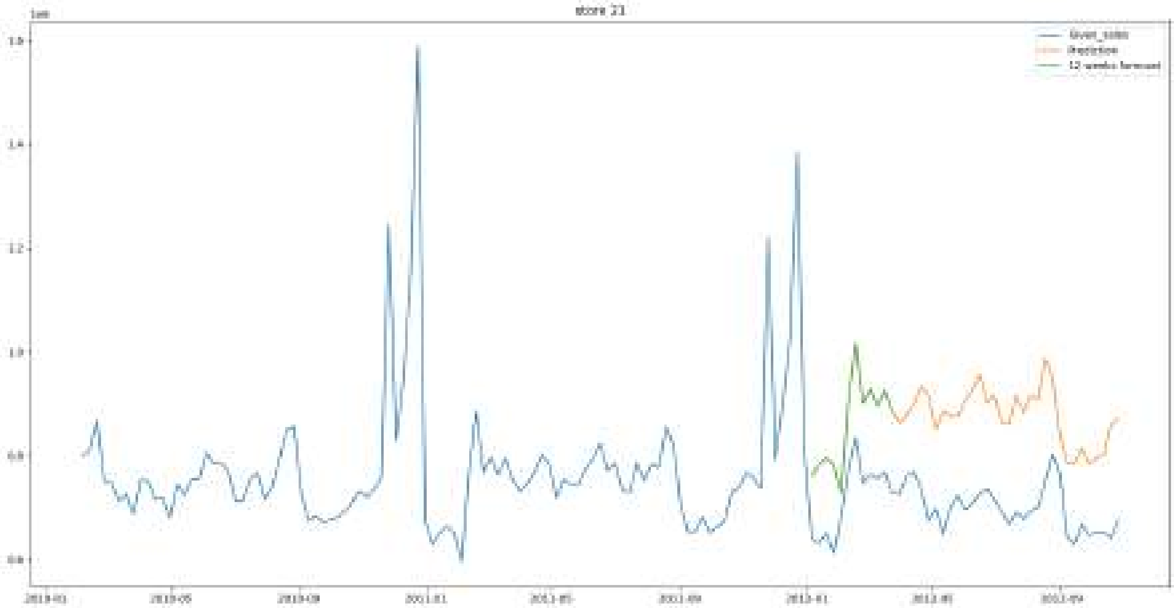


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```
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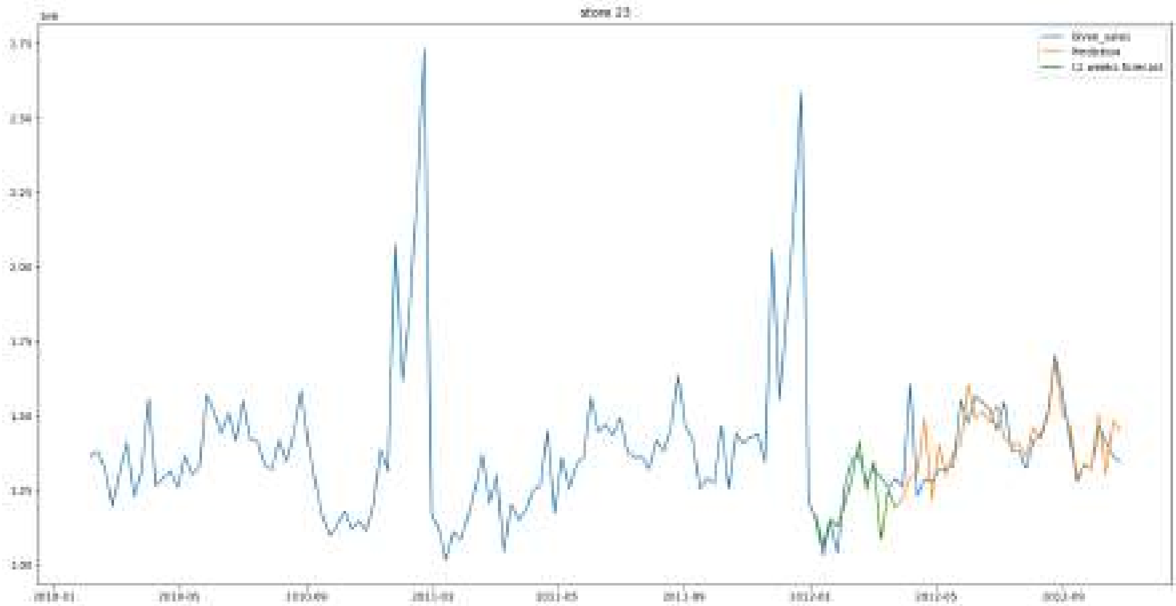


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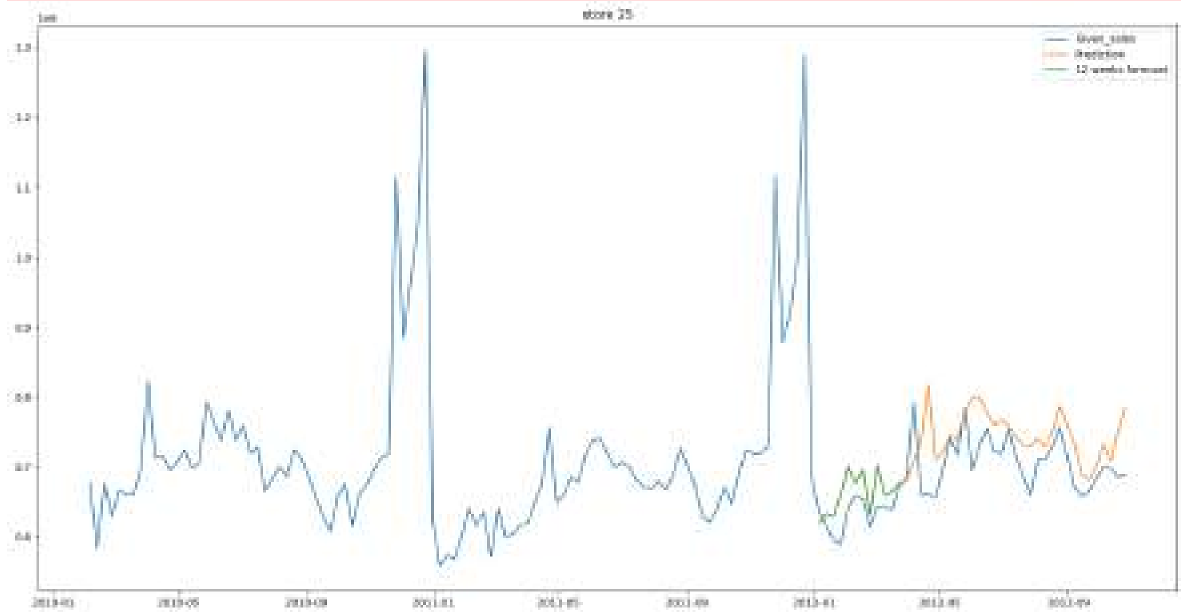


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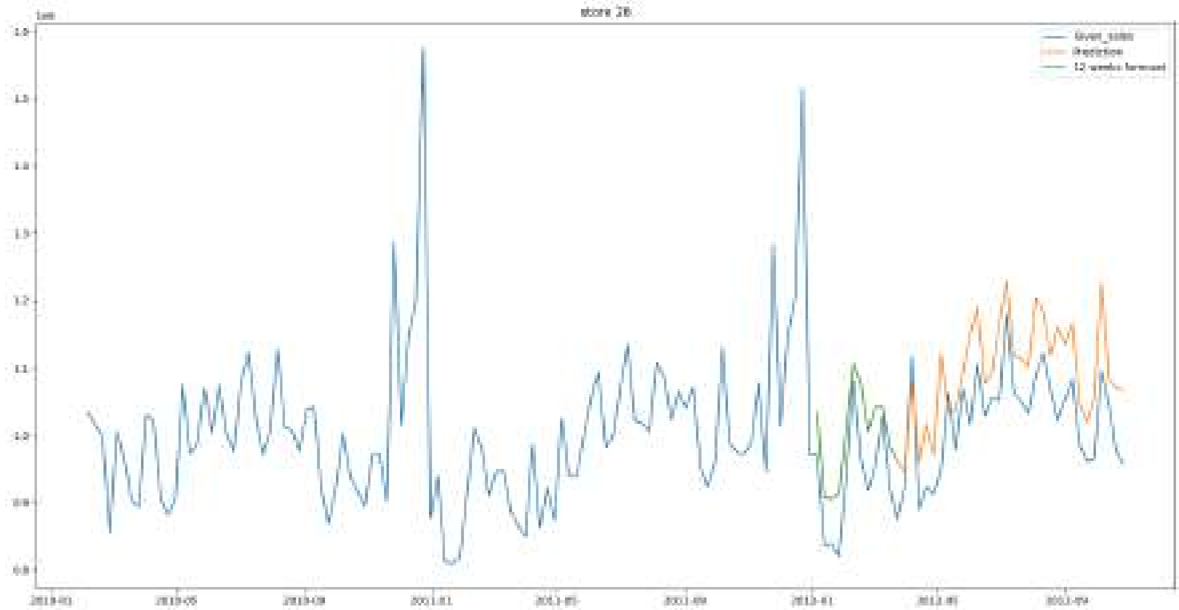

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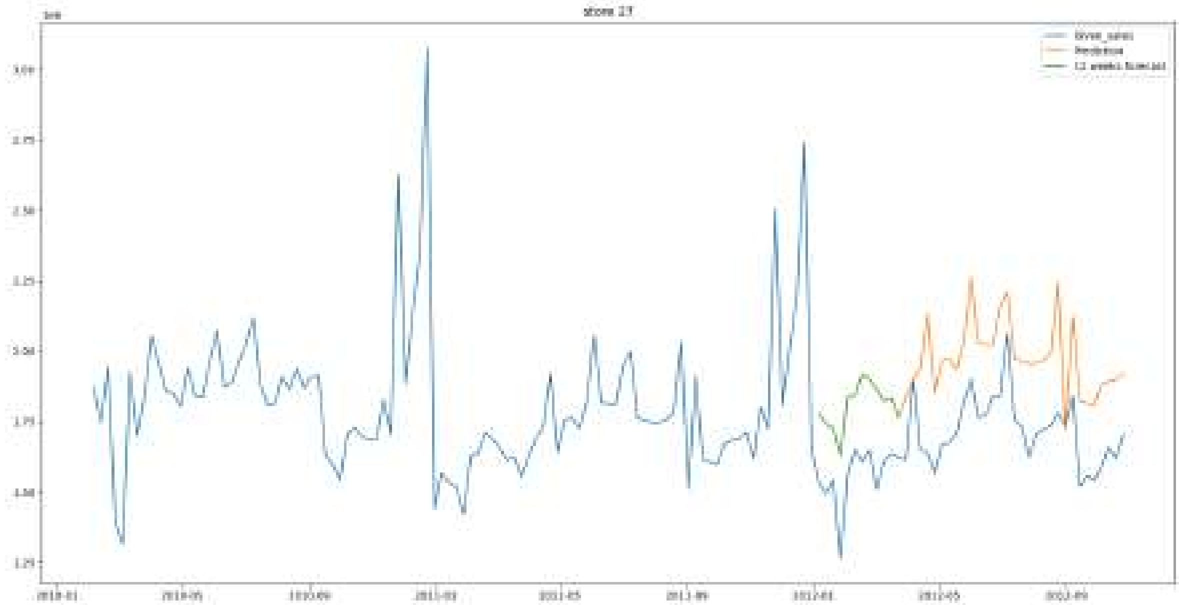

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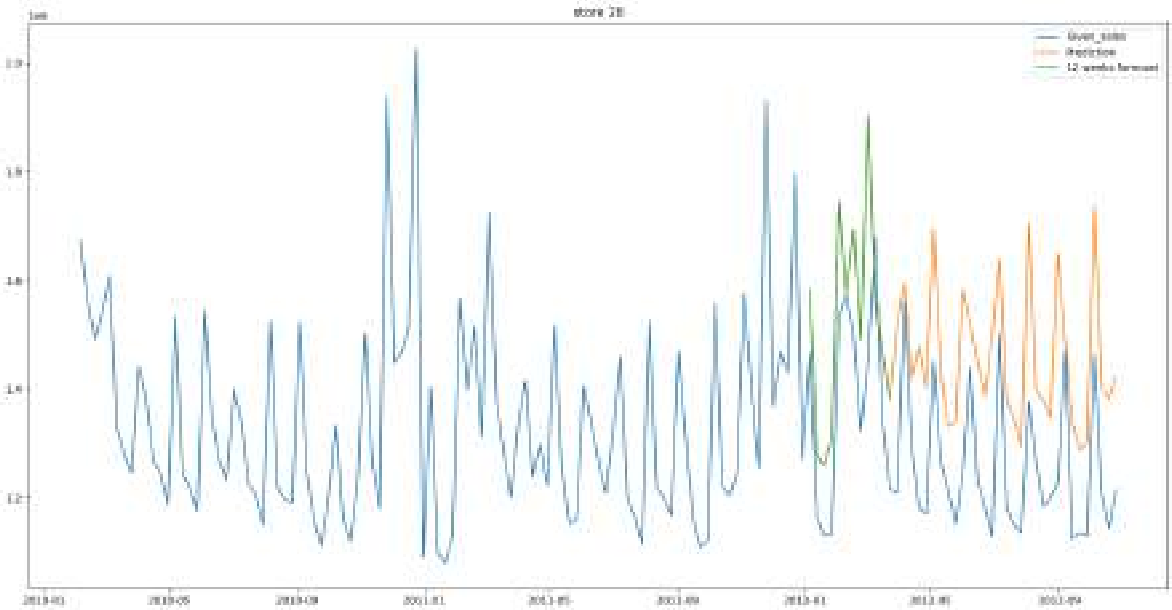

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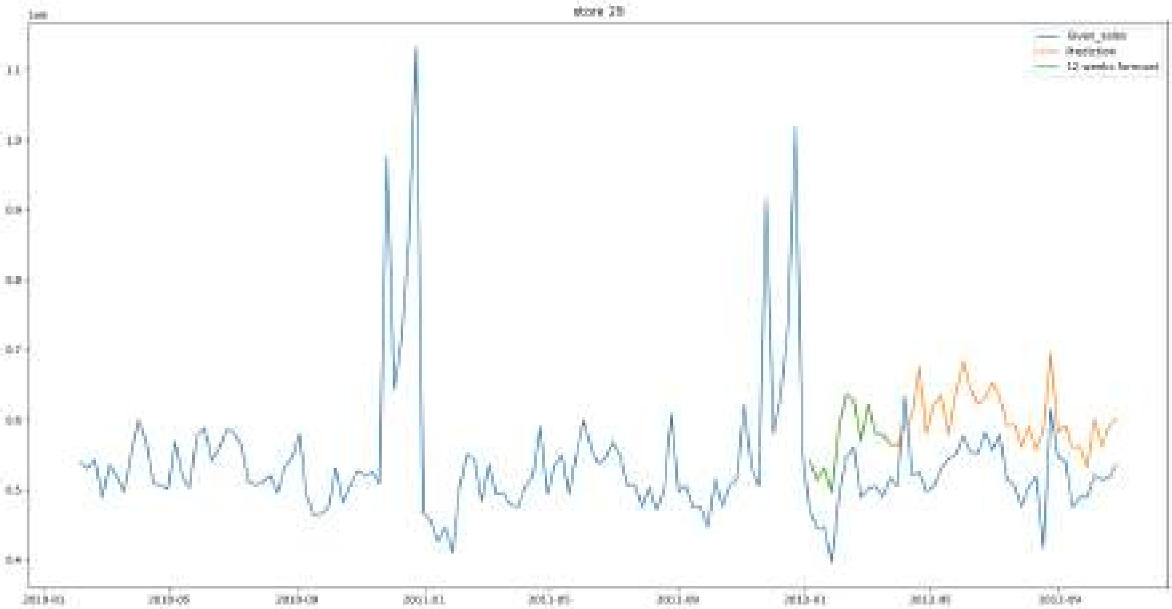

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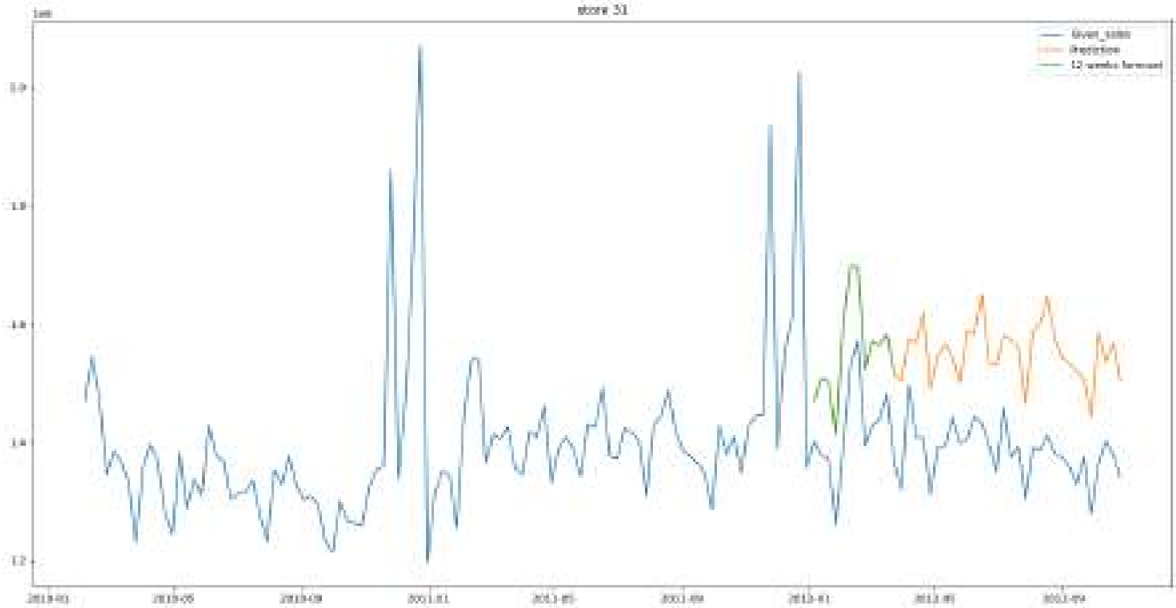

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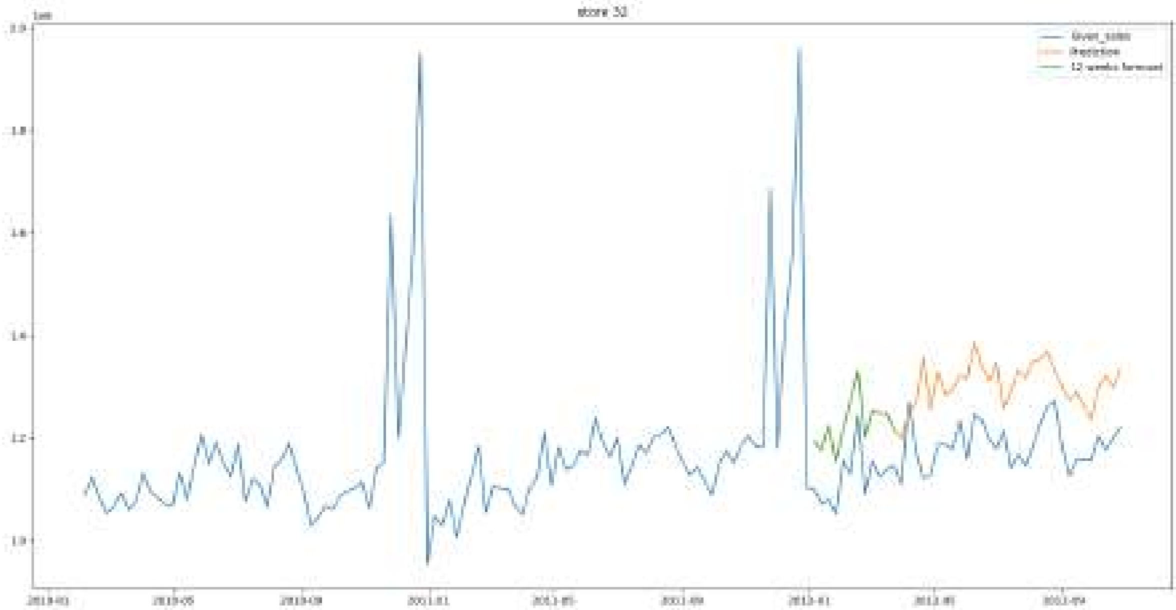


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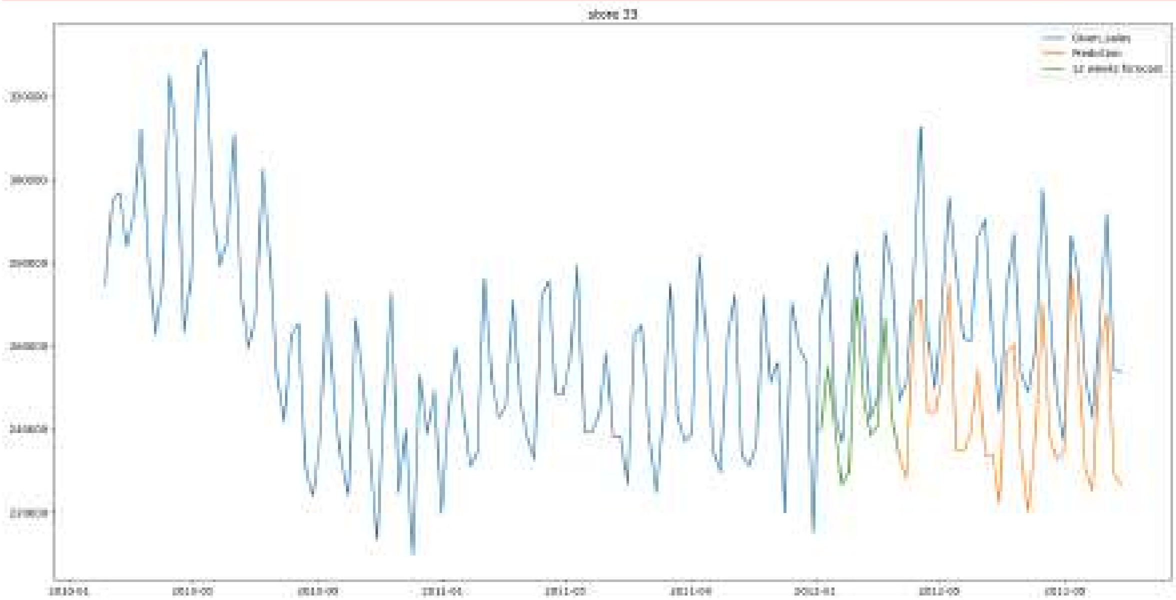


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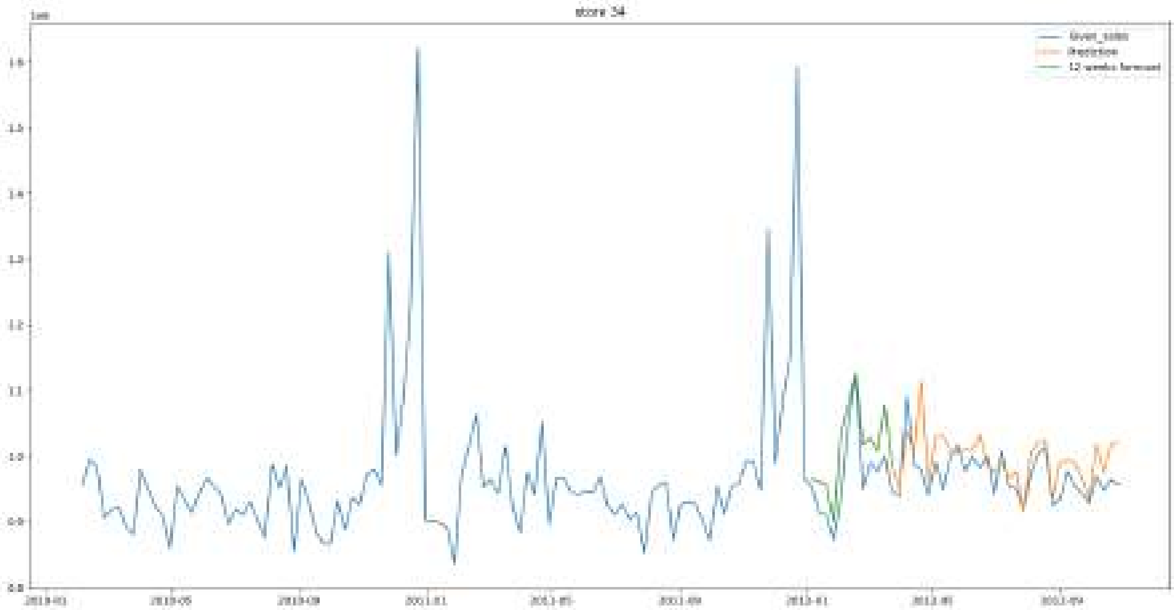


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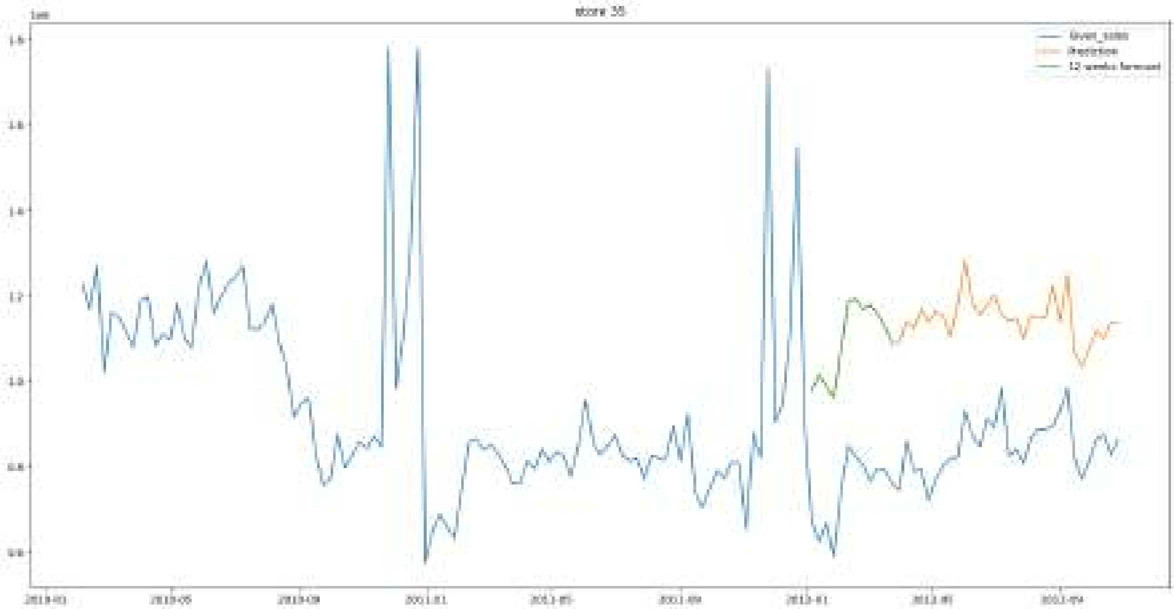


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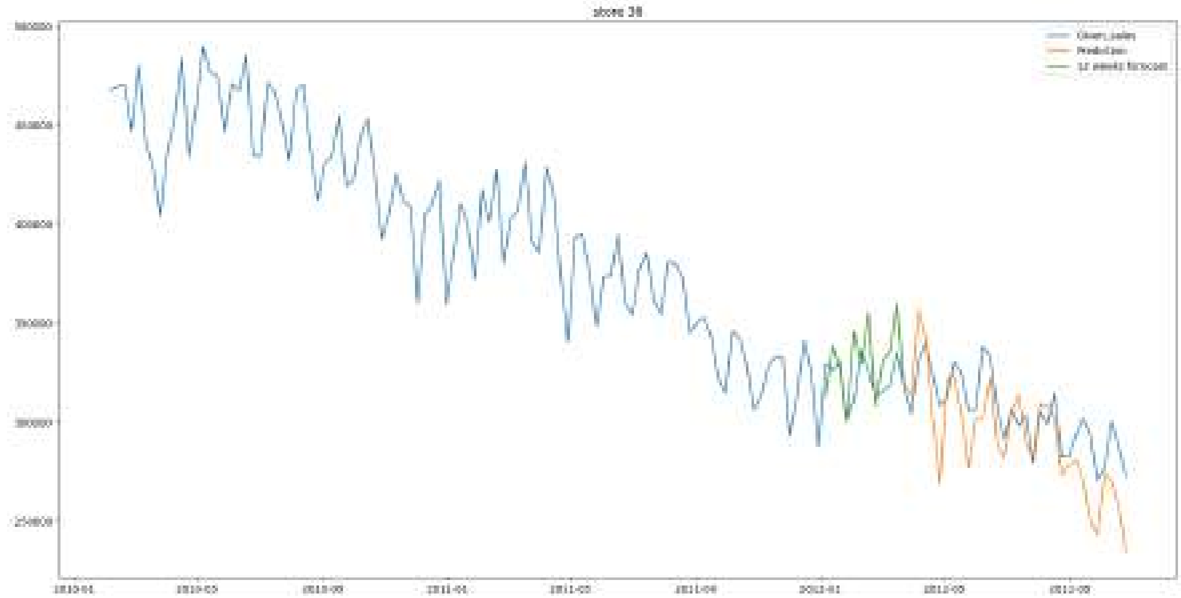

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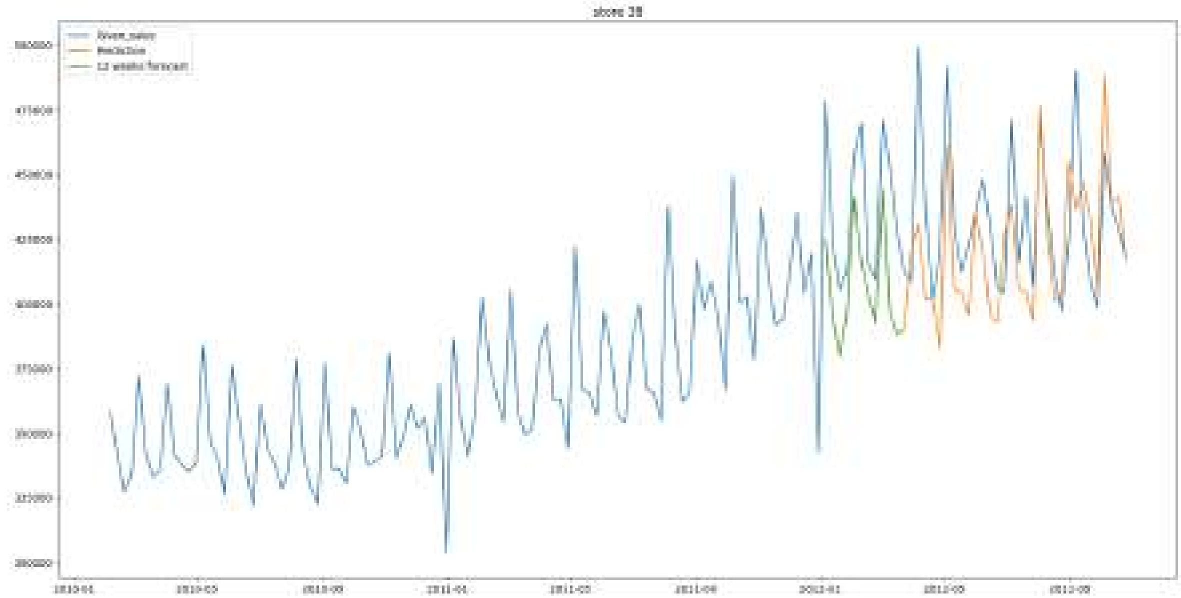

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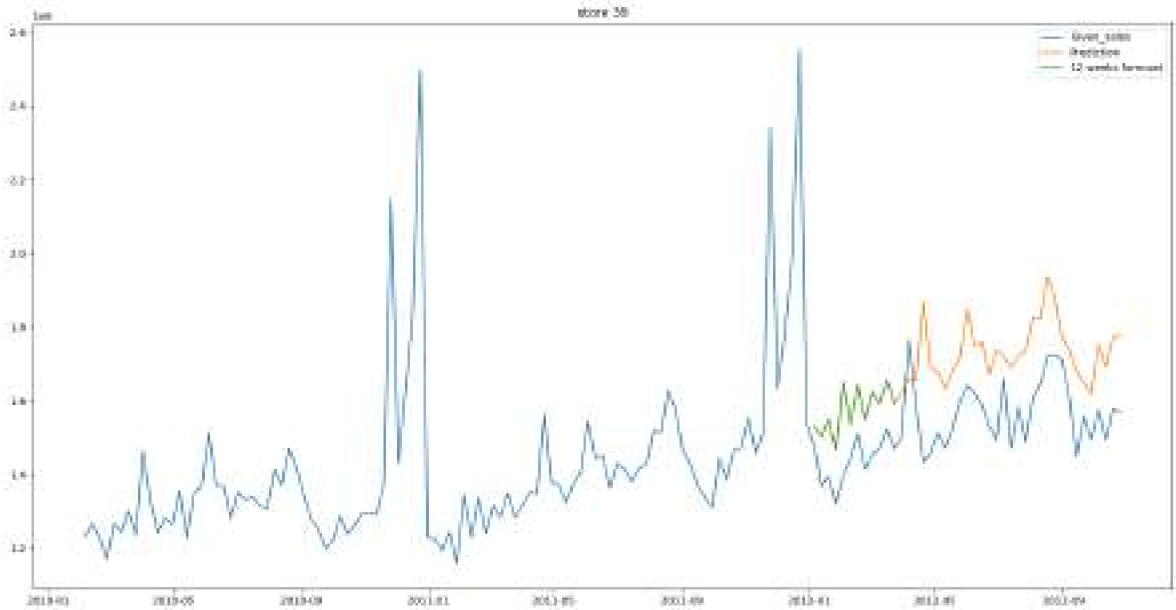

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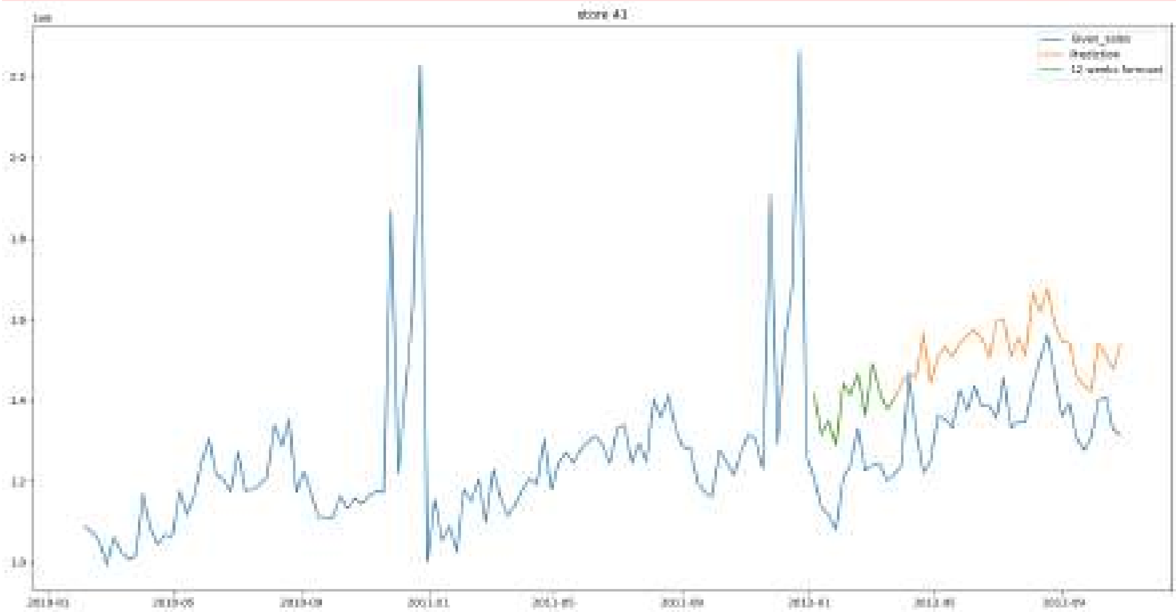


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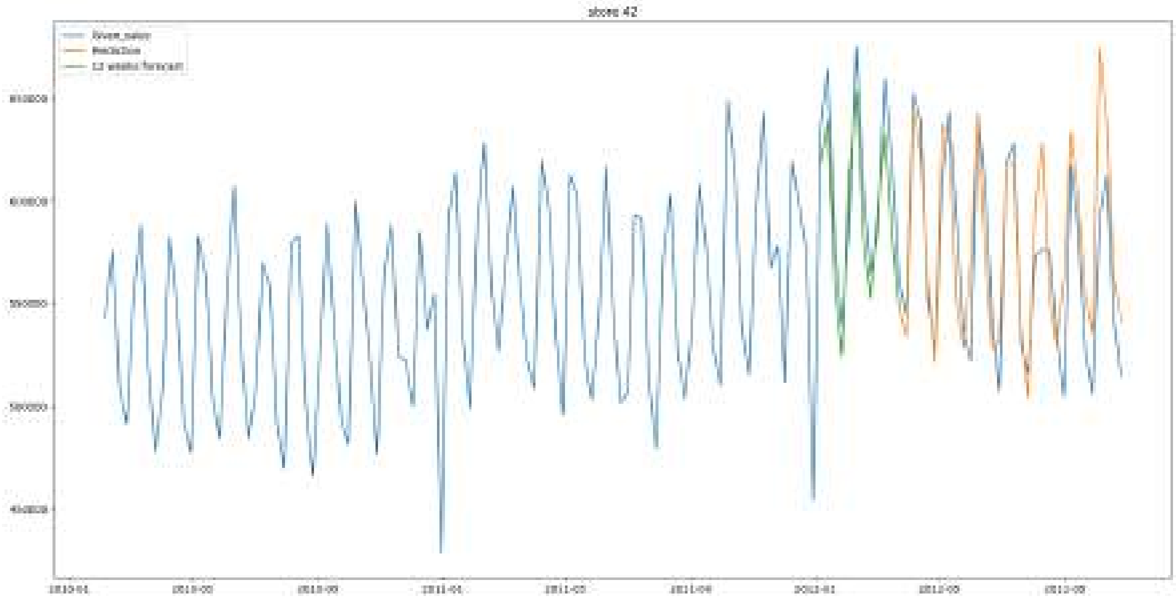


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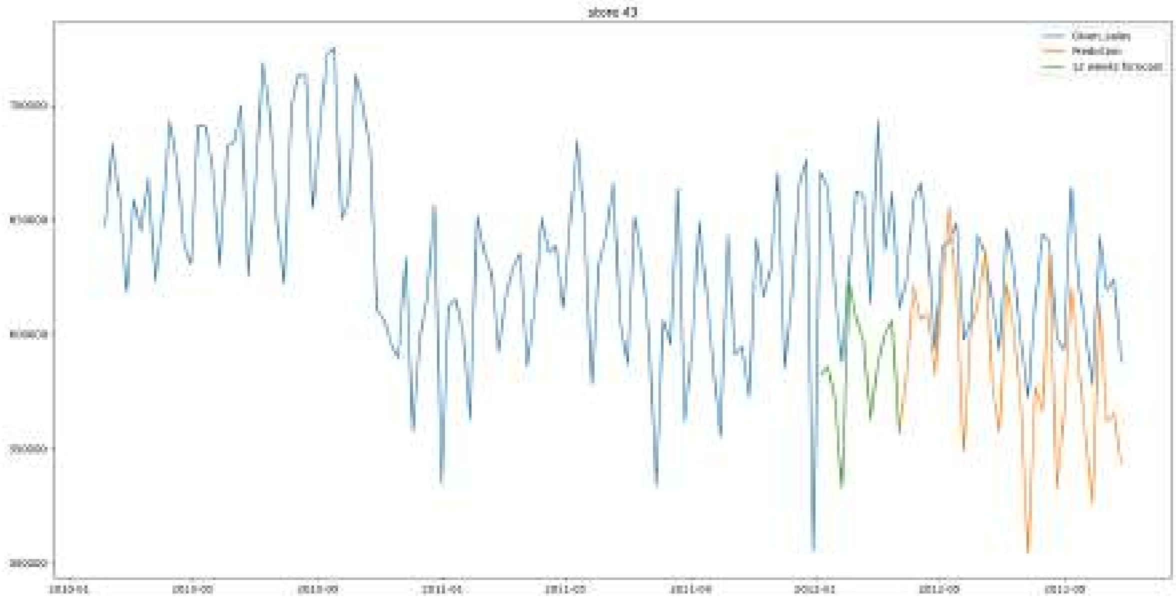


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