In [1]:

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

from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.svm import SVC
from xgboost import XGBRegressor
from sklearn.ensemble import BaggingRegressor

from sklearn.model_selection import cross_val_score, GridSearchCV
from sklearn.metrics import make_scorer, mean_absolute_percentage_error, mean_absolute_error
from sklearn.feature_selection import mutual_info_regression
```

In [2]:

```
rs = 42
models = [LinearRegression(),
          KNeighborsRegressor(),
          DecisionTreeRegressor(random_state=rs),
          RandomForestRegressor(random_state=rs),
          SVC(random_state=rs)]
sl_festivals = [pd.to_datetime(d) for d in ['2021-10-19', '2021-11-04', '2021-12-25', '2022-01-15', '2022-03-01']]
sl_holidays = [pd.to_datetime(d) for d in ['2021-10-20', '2021-11-18', '2021-12-18', '2022-01-17',
                                           '2022-02-04', '2022-02-16']]
Week = {'w1':19, 'w2':20, 'w3':21, 'w4':22}
Phase = {19:'MM2', 20:'End', 21:'Start', 22:'MM1'}
Weight = {19:-1, 20:0, 21:1, 22:0}
```

In [3]:

```
def find_week(date, count_from=pd.to_datetime('2021-10-04')):
    return (pd.to_datetime(date) - count_from).days//7

def find_phase(date):
    day = int(pd.to_datetime(date).day)
    if day <= 7:
        return 'MS'
    elif day <= 15:
        return 'MM1'
    elif day <= 23:
        return 'MM2'
    else:
        return 'ME'

def find_weight(date):
    date = pd.to_datetime(date)
    if date in sl_festivals:
        return 1
    elif date in sl_holidays:
        return -1
    else:
        return 0

def make_mi_scores(X, y):
    discrete_features = X.dtypes == int
    mi_scores = mutual_info_regression(X, y, discrete_features=discrete_features, random_state=rs)
    mi_scores = pd.Series(mi_scores, name="MI Scores", index=X.columns)
    mi_scores = mi_scores.sort_values(ascending=False)
    return mi_scores

def plot_mi_scores(scores):
    plt.figure(dpi=100, figsize=(8, 5))
    scores = scores.sort_values(ascending=True)
    width = np.arange(len(scores))
    ticks = list(scores.index)
    plt.barh(width, scores)
    plt.yticks(width, ticks)
    plt.title("Mutual Information Scores")
    plt.show()

def MAPE_score(y_true, y_pred):
    return (sum(abs(y_pred - y_true))/sum(y_true))*100

def evaluate_for_models(models, X, y):
    results = pd.DataFrame({'Model': [], 'ScoreMean': [], 'Score Standard Deviation': []})
    for model in models:
        score = cross_val_score(model, X, y,
                                scoring=make_scorer(MAPE_score))
        new_result = {'Model': model.__class__.__name__,
                      'ScoreMean': score.mean(), 'Score Standard Deviation': score.std()}
        results = results.append(new_result, ignore_index=True)
    return results.sort_values(by=['ScoreMean', 'Score Standard Deviation'])

def evaluate_val(models, X_train, X_val, y_train, y_val):
    results = pd.DataFrame({'Model': [], 'MAPE_score': []})
    for model in models:
        m = model.fit(X_train, y_train)
        y_pred = m.predict(X_val)
        new_result = {'Model': model.__class__.__name__, 'MAPE_score': MAPE_score(y_val, y_pred)}
        results = results.append(new_result, ignore_index=True)
    return results.sort_values(by=['MAPE_score'])
```

In [4]:
```
train_data_path = '../data-storm-30/train_data.csv'
val_data_path = '../data-storm-30/validation_data.csv'
test_data_path = '../data-storm-30/test_data.csv'
```

In [5]:
```
train_df = pd.read_csv(train_data_path)
val_df = pd.read_csv(val_data_path)
test_df = pd.read_csv(test_data_path)
```

In [6]:
```
train_df.head()
```

Out[6]:

	CategoryCode	ItemCode	DateID	DailySales
0	category_2	117610	11/6/2021	7
1	category_4	836584	11/18/2021	16
2	category_1	370195	1/24/2022	6
3	category_2	172582	10/30/2021	5
4	category_2	1006009	10/30/2021	5

In [7]:
```
val_df.head()
```

Out[7]:

	CategoryCode	ItemCode	Week	WeeklySales
0	category_2	1044502	w1	11
1	category_2	1105009	w1	11
2	category_2	913561	w4	5
3	category_1	1048975	w4	30
4	category_1	17287	w2	60

In [8]:
```
test_df.head()
```

Out[8]:

	CategoryCode	ItemCode	Week	PredictedSales
0	category_1	43738	w4	NaN
1	category_2	1006090	w1	NaN
2	category_2	1076929	w4	NaN
3	category_1	1081321	w3	NaN
4	category_2	216151	w4	NaN

Training Dataset

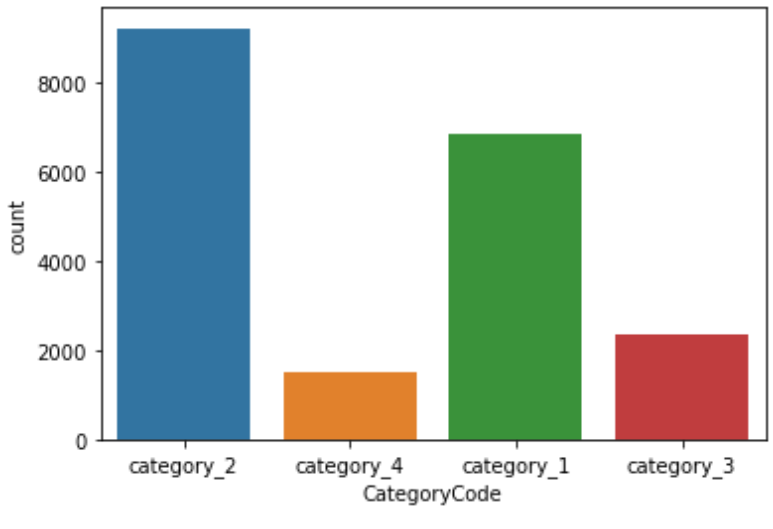
Descriptive Analysis

In [9]:
```
print(train_df.shape)
train_df.info()
```

```
(19921, 4)
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19921 entries, 0 to 19920
Data columns (total 4 columns):
 #   Column        Non-Null Count  Dtype 
---  ------        --------------  ----- 
 0   CategoryCode  19921 non-null  object
 1   ItemCode      19921 non-null  int64 
 2   DateID        19921 non-null  object
 3   DailySales    19921 non-null  int64 
dtypes: int64(2), object(2)
memory usage: 622.7+ KB
```

In [10]:
```
sns.countplot(x=train_df.CategoryCode)
```

Out[10]:
```
<AxesSubplot:xlabel='CategoryCode', ylabel='count'>
```



In [11]:
```
print(train_df.ItemCode.value_counts())
```

```
20824      136
132028     136
245581     136
17296      136
119554     136
           ...
1090114     63
1068883     62
1090303     62
1090294     59
1015621     58
Name: ItemCode, Length: 194, dtype: int64
```

In [12]:
```
print(train_df.DateID.value_counts())
```

```
12/31/2021    168
1/13/2022     167
12/30/2021    165
1/7/2022      165
12/24/2021    161
              ...
10/17/2021    129
10/5/2021     129
10/18/2021    128
10/20/2021    128
2/9/2022      125
Name: DateID, Length: 136, dtype: int64
```

In [13]:
```
train_df.DailySales.describe()
```

Out[13]:
```
count    19921.000000
mean         7.351890
std         14.605342
min          1.000000
25%          2.000000
50%          3.000000
75%          7.000000
max        434.000000
Name: DailySales, dtype: float64
```

Data Cleaning

1. Missing Values Handling

In [14]:
```
train_df.isnull().sum()
```

Out[14]:
```
CategoryCode    0
ItemCode        0
DateID          0
DailySales      0
dtype: int64
```

In [15]:
```
val_df.isnull().sum()
```

Out[15]:
```
CategoryCode    0
ItemCode        0
Week            0
WeeklySales     0
dtype: int64
```

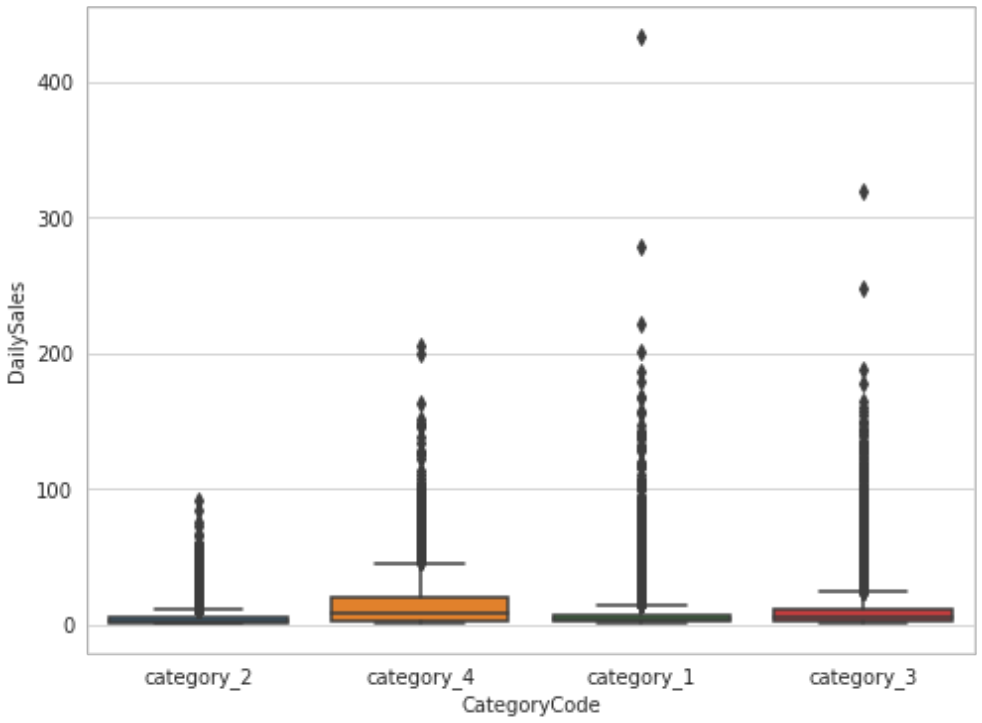
In [16]:
```
test_df.isnull().sum()
```

Out[16]:
```
CategoryCode        0
ItemCode            0
Week                0
PredictedSales    377
dtype: int64
```

2. Outliers Handling

Training Dataset

In [17]:
```
plt.figure(figsize=(8,6))
sns.set_style("whitegrid")
sns.boxplot(x='CategoryCode', y='DailySales', data=train_df)
plt.show()
```



In [18]:

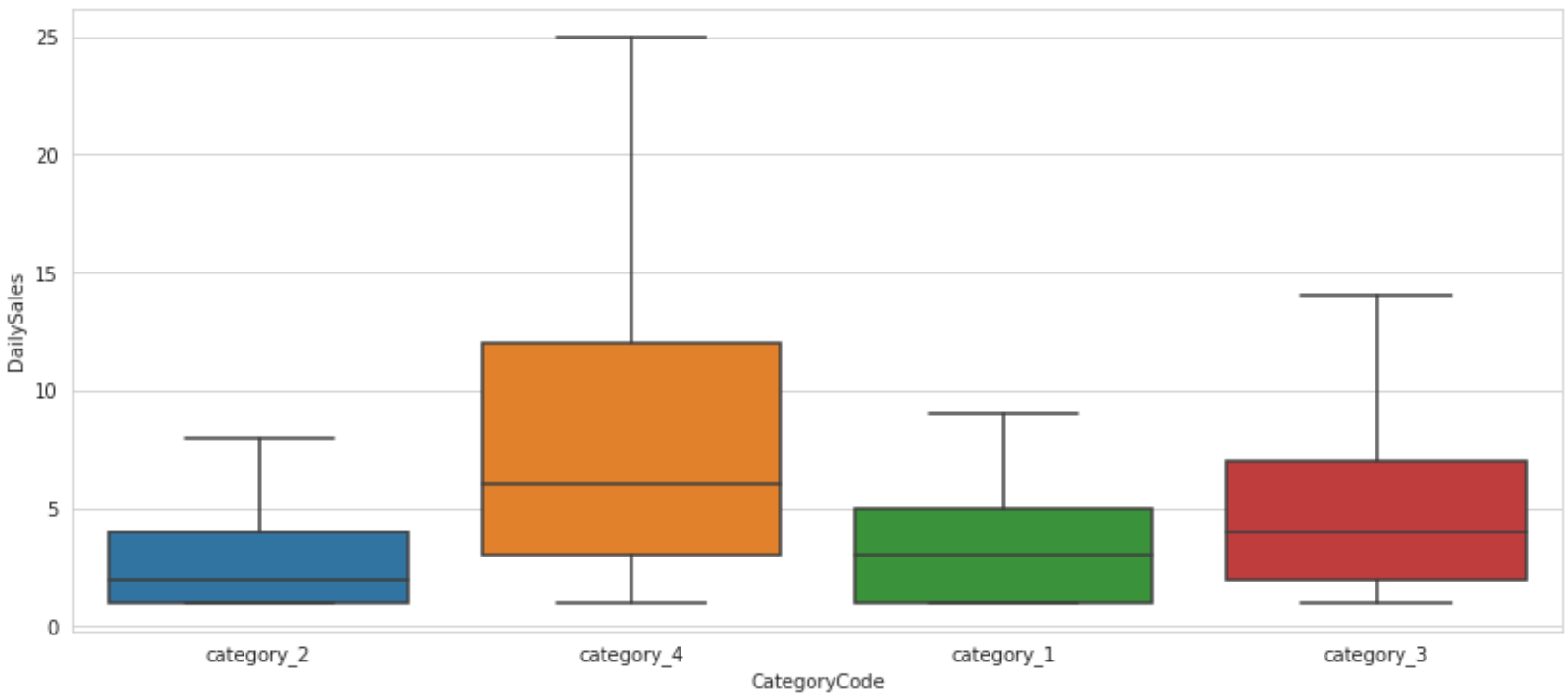
```
has_outliers = True
while has_outliers:
    for i in range(1, 5):
        c = 'category_' + str(i)
        c_train = train_df.loc[train_df.CategoryCode == c]
        c_q25, c_q75 = np.percentile(c_train.DailySales, 25), np.percentile(c_train.DailySales, 75)
        c_iqr = c_q75 - c_q25
        upper = c_q75 + (1.5 * c_iqr)
        c_outliers_index = train_df.loc[(train_df.DailySales > upper) & (train_df.CategoryCode == c)].index
        if len(c_outliers_index) == 0:
            has_outliers = False
        else:
            train_df.drop(c_outliers_index, inplace=True)

train_df.shape
```

Out[18]:

```
(16825, 4)
```

In [19]:

```
plt.figure(figsize=(14,6))
sns.boxplot(x='CategoryCode', y='DailySales', data=train_df)
plt.show()
```

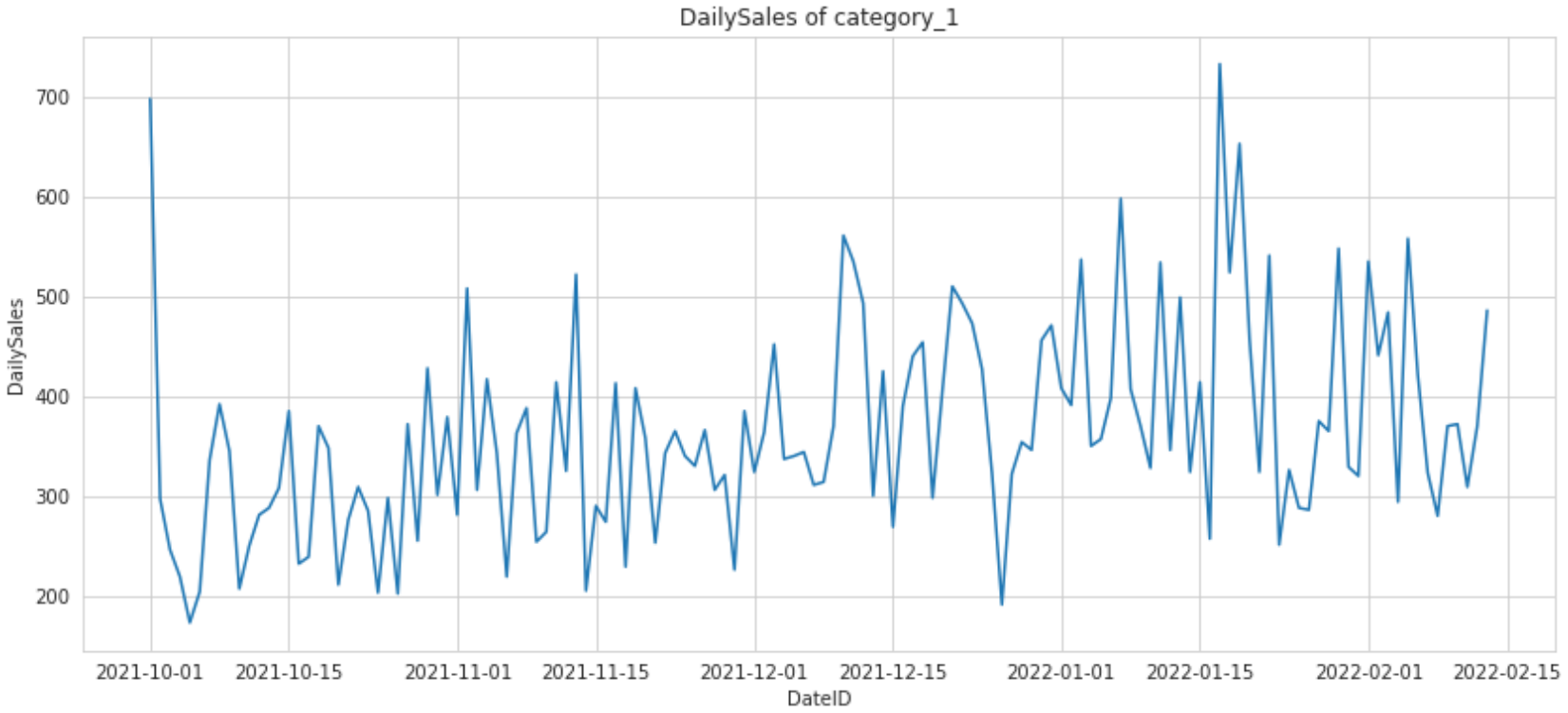


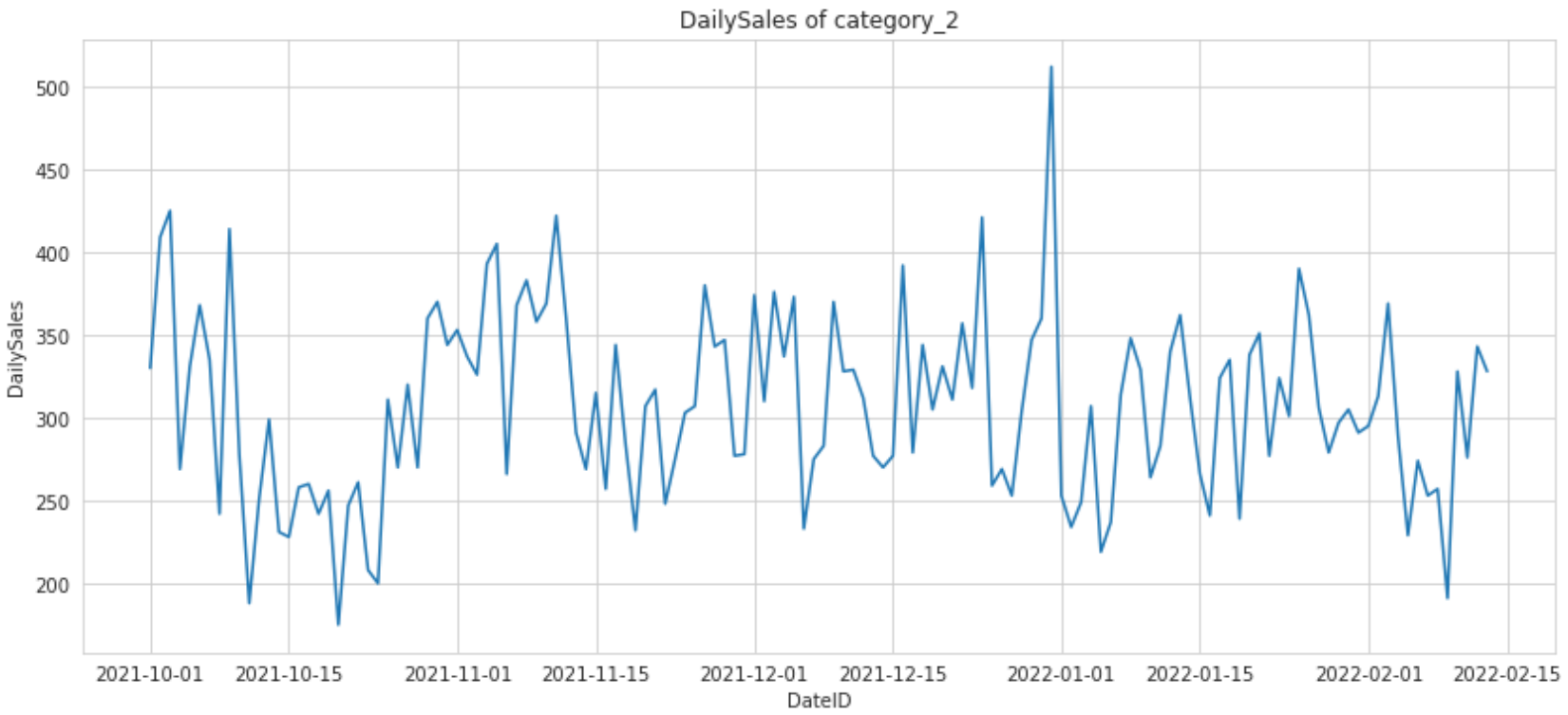
Exploratory Analysis

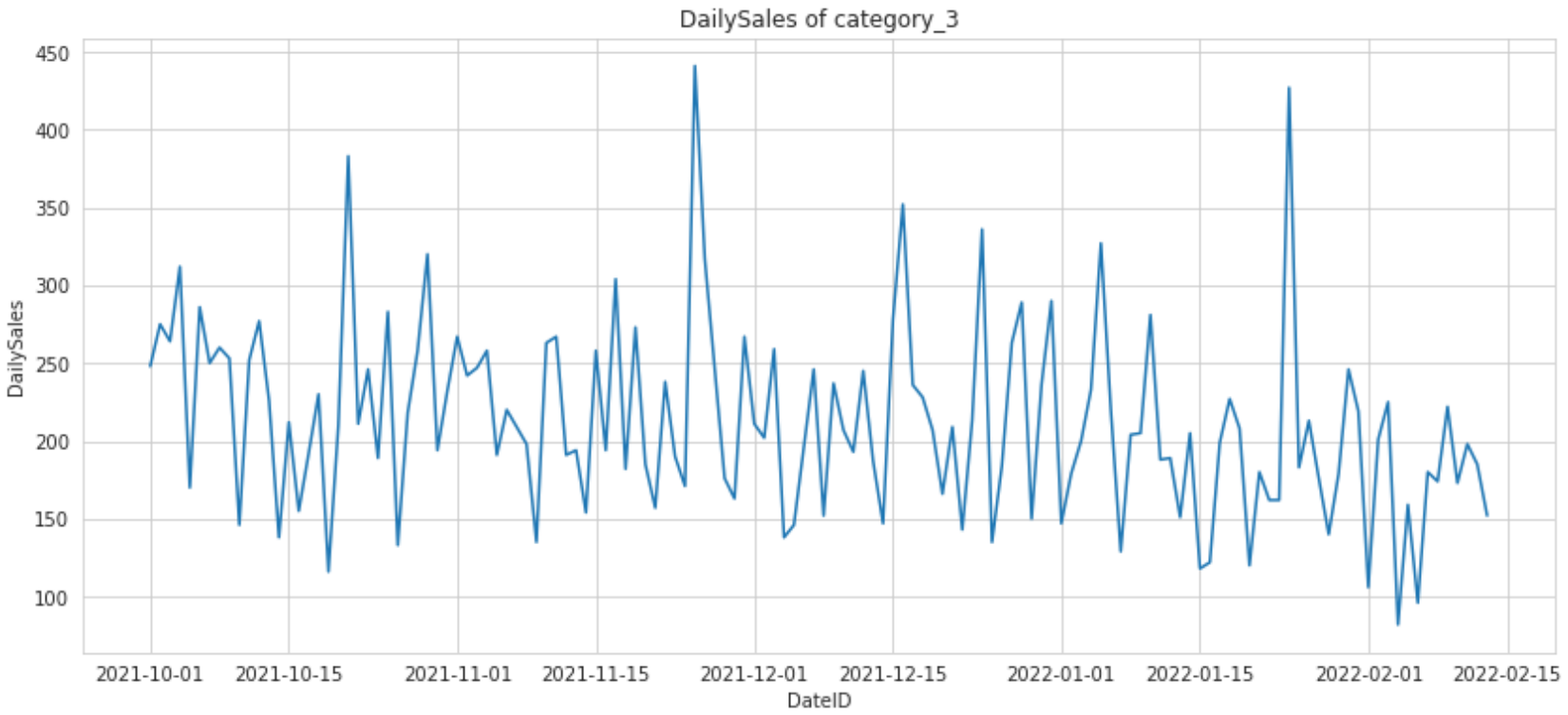
Ploat DailySales for Each Category

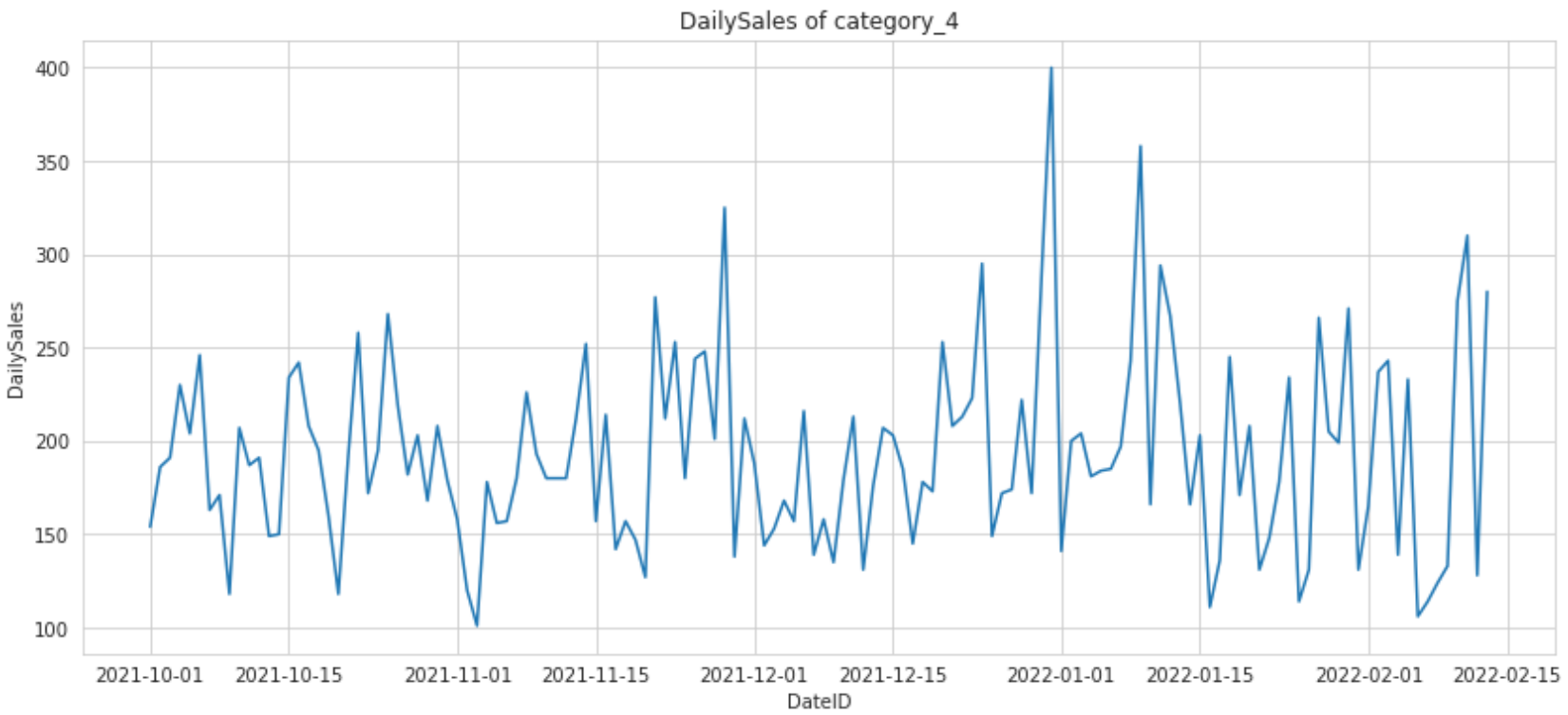
In [20]:

```
data = pd.read_csv(train_data_path, index_col="DateID", parse_dates=True).sort_index().drop(columns=['ItemCode'])
data = pd.DataFrame(data.groupby(['CategoryCode', 'DateID']).DailySales.sum())

def plt_dailySales(c):
    plt.figure(figsize=(14,6))
    plt.title("DailySales of " + c)
    sns.lineplot(data=data.loc[pd.IndexSlice[c,:],:], x='DateID', y='DailySales')
    plt.show()

for i in range(1, 5):
    plt_dailySales('category_' + str(i))
```


DailySales of category_1
DailySales
700
600
500
400
300
200
2021-10-01
2021-10-15
2021-11-01
2021-11-15
2021-12-01
2021-12-15
2022-01-01
2022-01-15
2022-02-01
2022-02-15
DateID

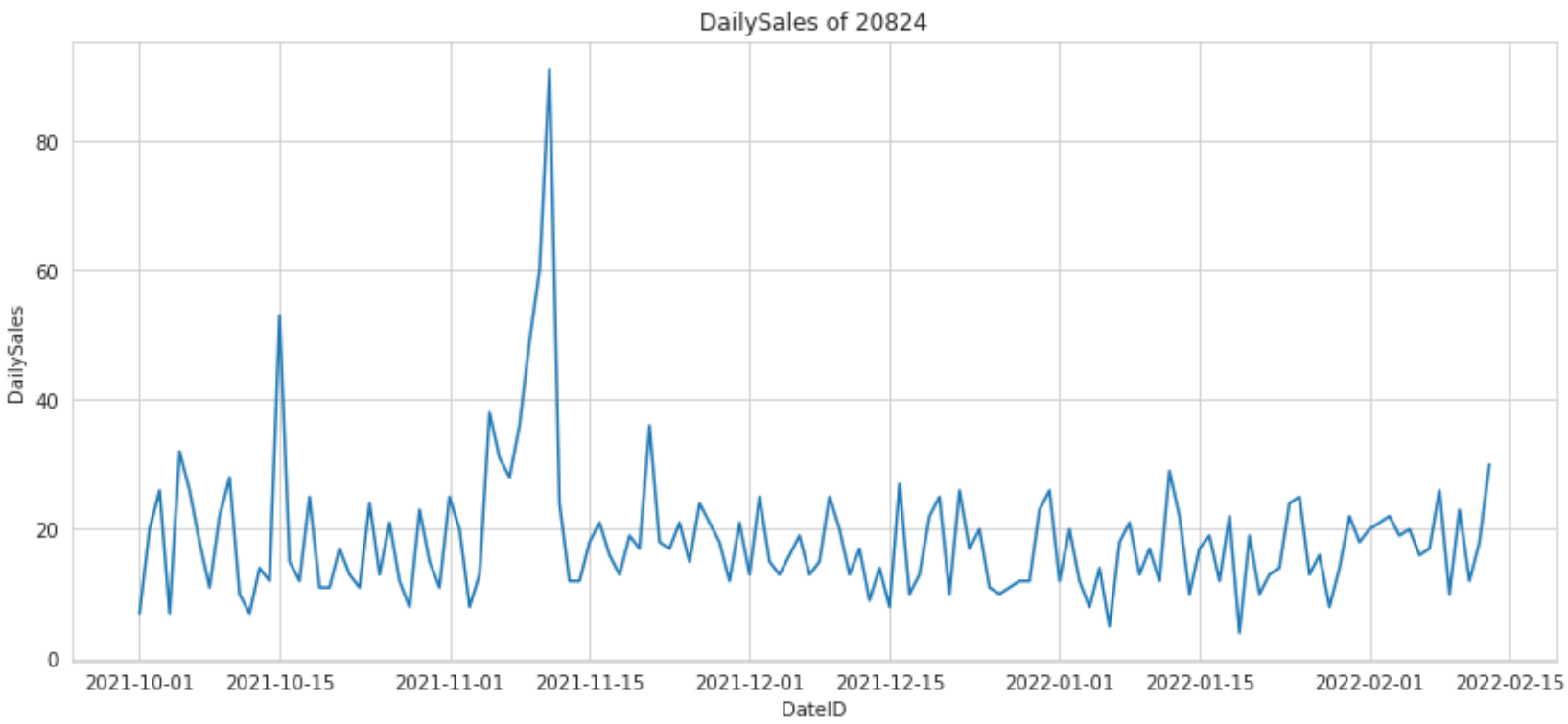

DailySales of category_2
DailySales
500
450
400
350
300
250
200
2021-10-01
2021-10-15
2021-11-01
2021-11-15
2021-12-01
2021-12-15
2022-01-01
2022-01-15
2022-02-01
2022-02-15
DateID


DailySales of category_3
DailySales
450
400
350
300
250
200
150
100
2021-10-01
2021-10-15
2021-11-01
2021-11-15
2021-12-01
2021-12-15
2022-01-01
2022-01-15
2022-02-01
2022-02-15
DateID


DailySales of category_4
DailySales
400
350
300
250
200
150
100
2021-10-01
2021-10-15
2021-11-01
2021-11-15
2021-12-01
2021-12-15
2022-01-01
2022-01-15
2022-02-01
2022-02-15
DateID

Ploat DailySales of An Item

In [21]:
```
data = pd.read_csv(train_data_path, index_col="DateID", parse_dates=True).sort_index()
data = pd.DataFrame(data.groupby(['ItemCode', 'DateID']).DailySales.sum())

def plt_dailySales(ic):
    plt.figure(figsize=(14,6))
    plt.title("DailySales of " + str(ic))
    sns.lineplot(data=data.loc[pd.IndexSlice[ic,:],:], x='DateID', y='DailySales')
    plt.show()

plt_dailySales(20824)
```



In [22]:
```
make_mi_scores(pd.DataFrame(train_df.ItemCode), train_df.DailySales)
```

Out[22]:
```
ItemCode    0.24212
Name: MI Scores, dtype: float64
```

Feature Engineering

1. Feature Creation

1.1. Assign A Week for Dates (0^{th} Week Starts From 04-10-2021)

Add Week

In [23]:
```
def add_week(row):
    row.Week = find_week(row['DateID'])
    return row

train_df['Week'] = np.nan
w_added_train = train_df.apply(add_week, axis='columns')
w_added_train.sort_values('Week')
```

Out[23]:

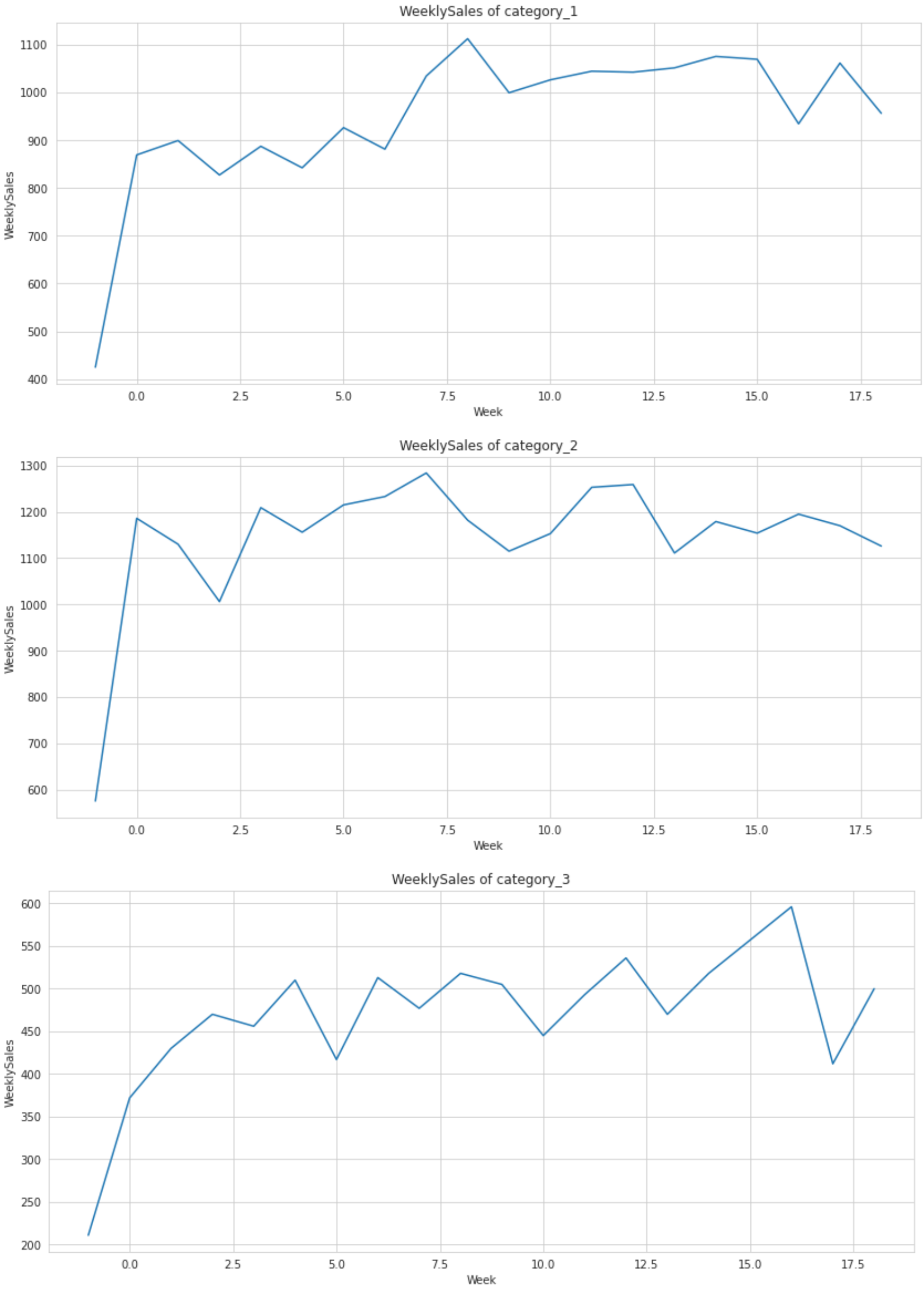
	CategoryCode	ItemCode	DateID	DailySales	Week
17484	category_2	1090249	10/2/2021	3	-1
8640	category_2	138742	10/1/2021	4	-1
17003	category_1	145330	10/2/2021	6	-1
2520	category_3	1090024	10/3/2021	3	-1
8645	category_2	836125	10/1/2021	6	-1
...	...	...	...	...	...
6460	category_2	43630	2/11/2022	8	18
7312	category_2	9925	2/11/2022	1	18
16483	category_2	9925	2/7/2022	1	18
1040	category_2	1092184	2/8/2022	3	18
18618	category_3	1090024	2/7/2022	5	18

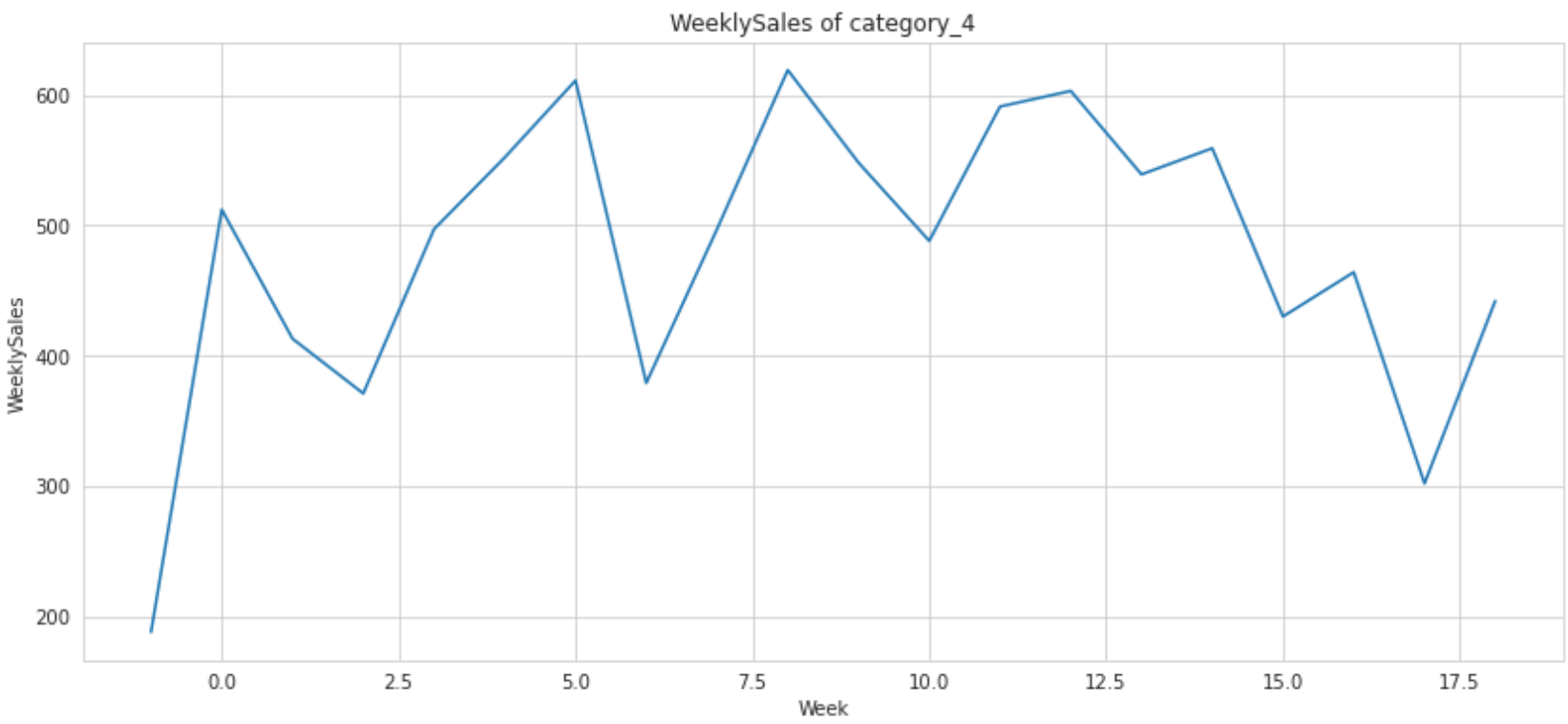
16825 rows × 5 columns

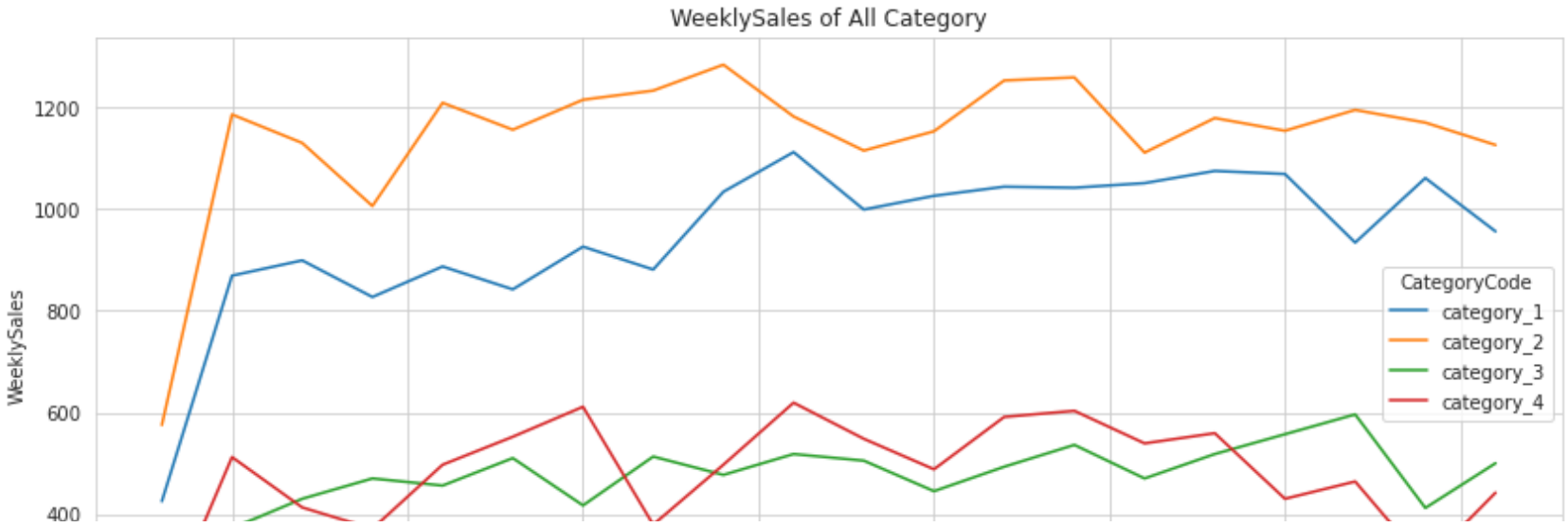
Ploat WeeklySales for Each Category

In [24]:

```
data = w_added_train.copy()
data = pd.DataFrame(data.groupby(['CategoryCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)

def plt_weeklySales(c):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + c)
    sns.lineplot(data=data.loc[pd.IndexSlice[c,:],:].reset_index(), x='Week', y='WeeklySales')
    plt.show()

for i in range(1, 5):
    plt_weeklySales('category_' + str(i))

plt.figure(figsize=(14,6))
plt.title("WeeklySales of All Category")
sns.lineplot(data=data.loc[pd.IndexSlice[:,:],:], x='Week', y='WeeklySales', hue='CategoryCode')
plt.show()
```



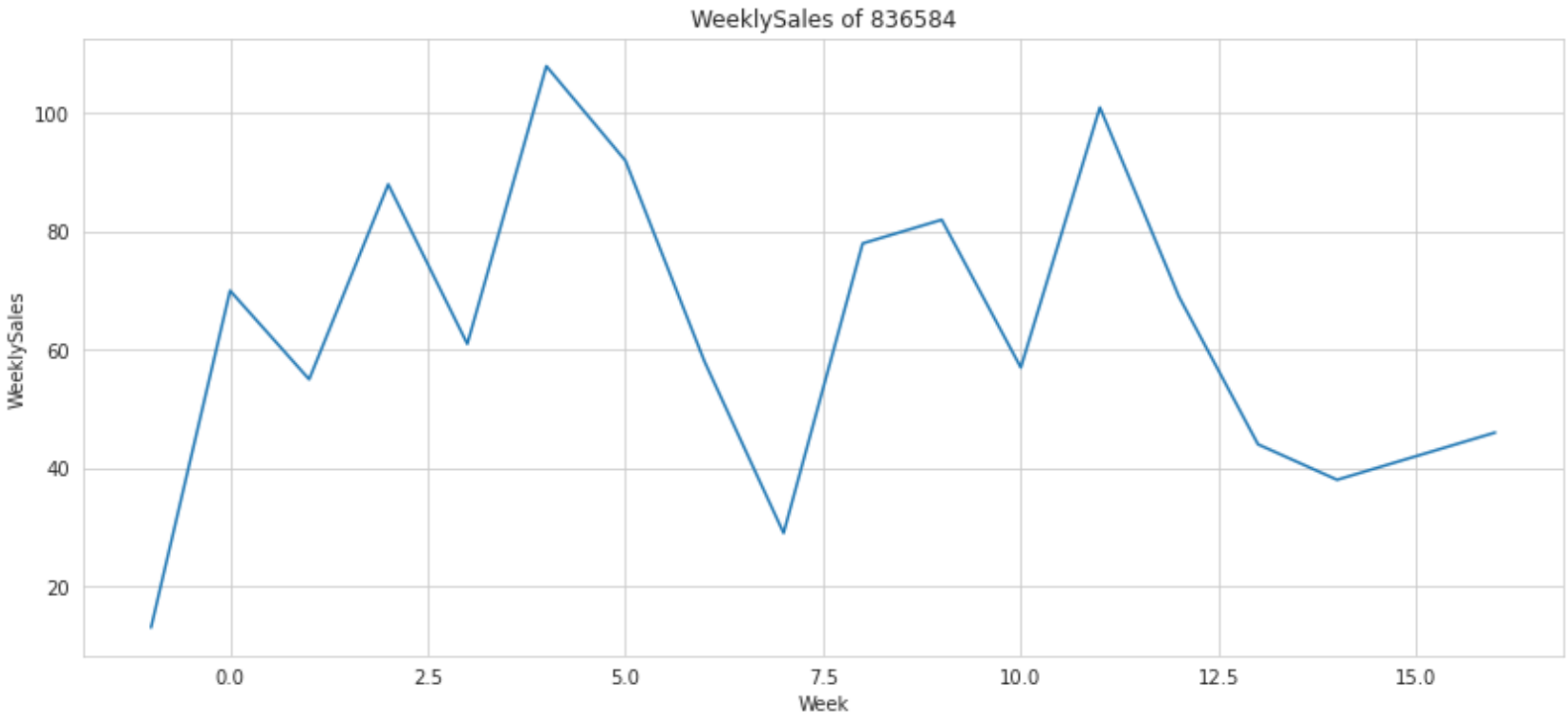




Ploat WeeklySales for A Specific Item in A Specific Category

In [25]:

```
data = w_added_train.copy()
data = pd.DataFrame(data.groupby(['CategoryCode', 'ItemCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)

def plt_weeklySales(c, ic):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + str(ic))
    sns.lineplot(data=data.loc[pd.IndexSlice[c, ic, :], :].reset_index(), x='Week', y='WeeklySales')
    plt.show()

CategoryCode = 'category_4'
ItemCode = 836584
plt_weeklySales(CategoryCode, ItemCode)
```



1.2. Assign A Phase for Dates

- MonthStart (MS)
- MonthMiddle1 (MM1)
- MonthMiddle2 (MM2)
- MonthEnd (ME)

Add Phase

In [26]:
```
n_p = 4
def add_phase(row):
    row.Phase = find_phase(row['DateID'])
    return row

w_added_train['Phase'] = np.nan
pw_added_train = w_added_train.apply(add_phase, axis='columns')
pw_added_train.sort_values('Week')
```

Out[26]:

	CategoryCode	ItemCode	DateID	DailySales	Week	Phase
17484	category_2	1090249	10/2/2021	3	-1	MS
8640	category_2	138742	10/1/2021	4	-1	MS
17003	category_1	145330	10/2/2021	6	-1	MS
2520	category_3	1090024	10/3/2021	3	-1	MS
8645	category_2	836125	10/1/2021	6	-1	MS
...	...	...	...	...	...	...
6460	category_2	43630	2/11/2022	8	18	MM1
7312	category_2	9925	2/11/2022	1	18	MM1
16483	category_2	9925	2/7/2022	1	18	MS
1040	category_2	1092184	2/8/2022	3	18	MM1
18618	category_3	1090024	2/7/2022	5	18	MS

16825 rows × 6 columns

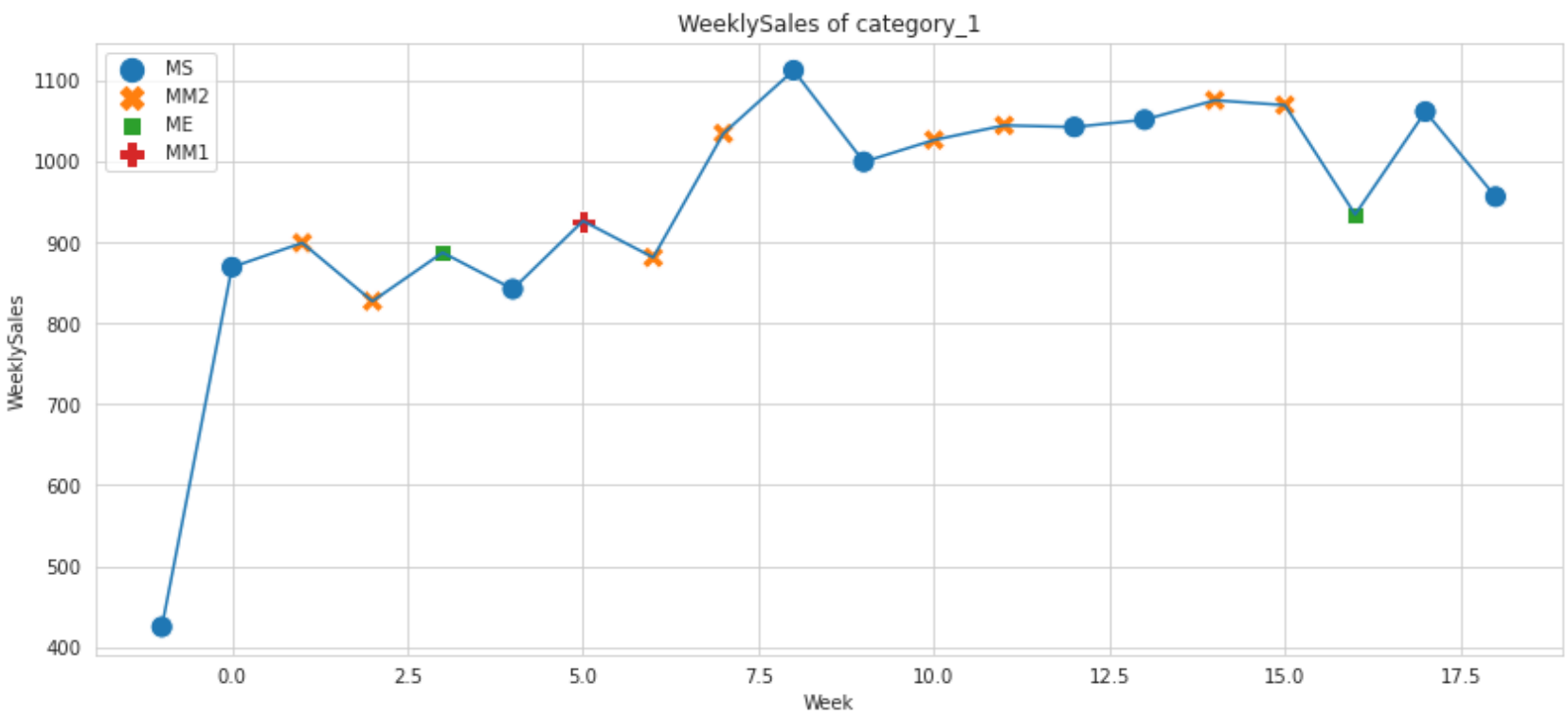
Find The Phase of The n^{th} Week

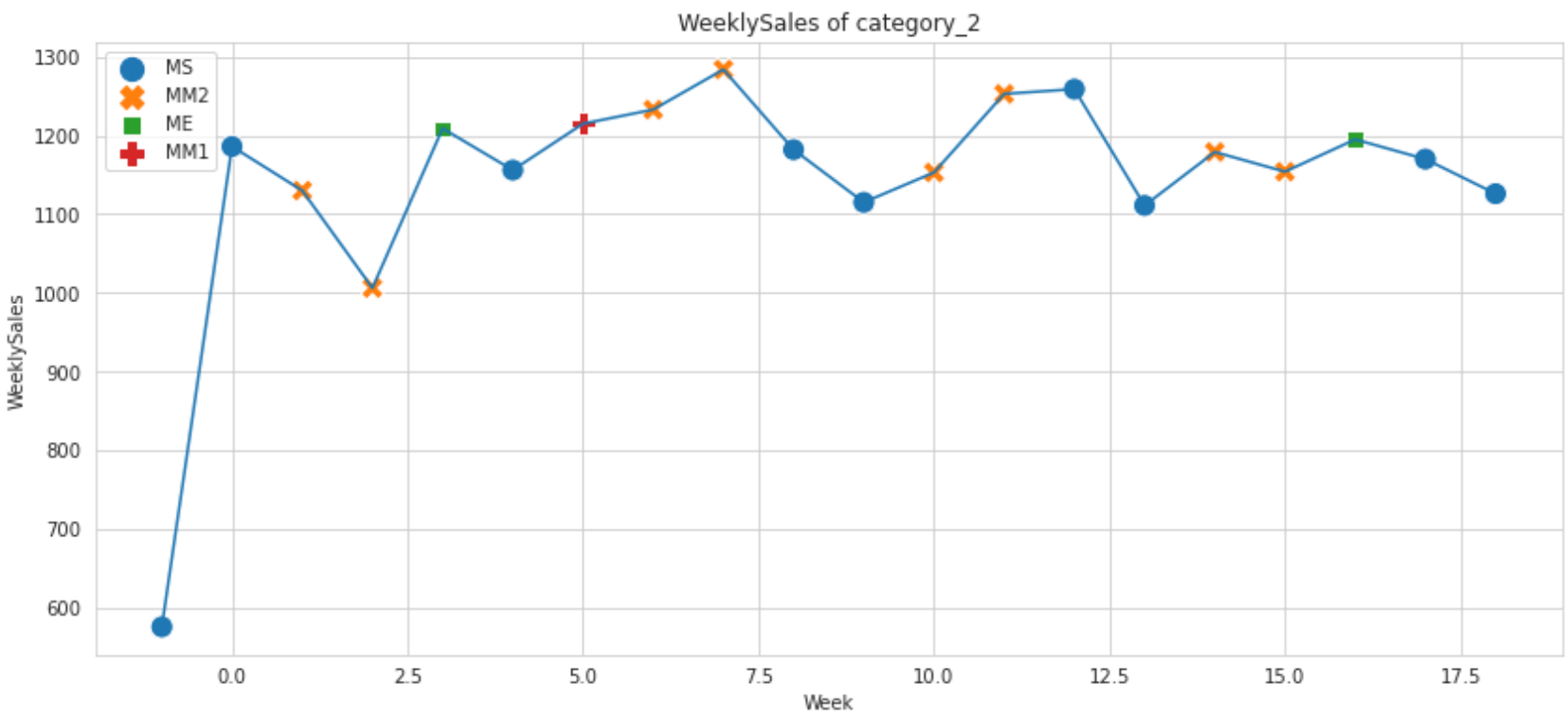
In [27]:
```
def find_phase_of_week(nth_week):
    wk_p = pd.DataFrame(pd.DataFrame(pw_added_train.groupby(['Week', 'DateID']).Phase.max()).reset_index().groupby(['Week']).Phase
    return wk_p.loc[nth_week, 'Phase']

find_phase_of_week(1)
```

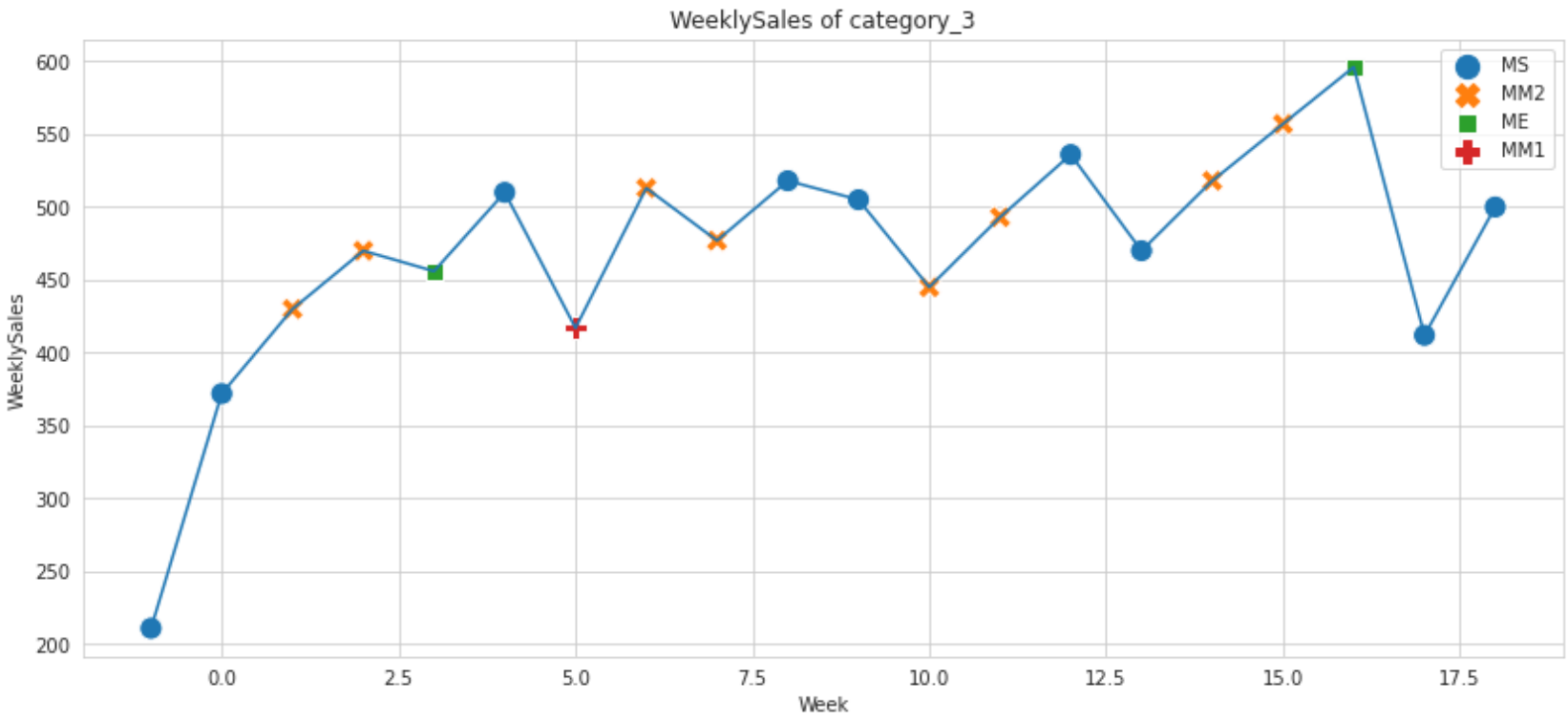
Out[27]: 'MM2'

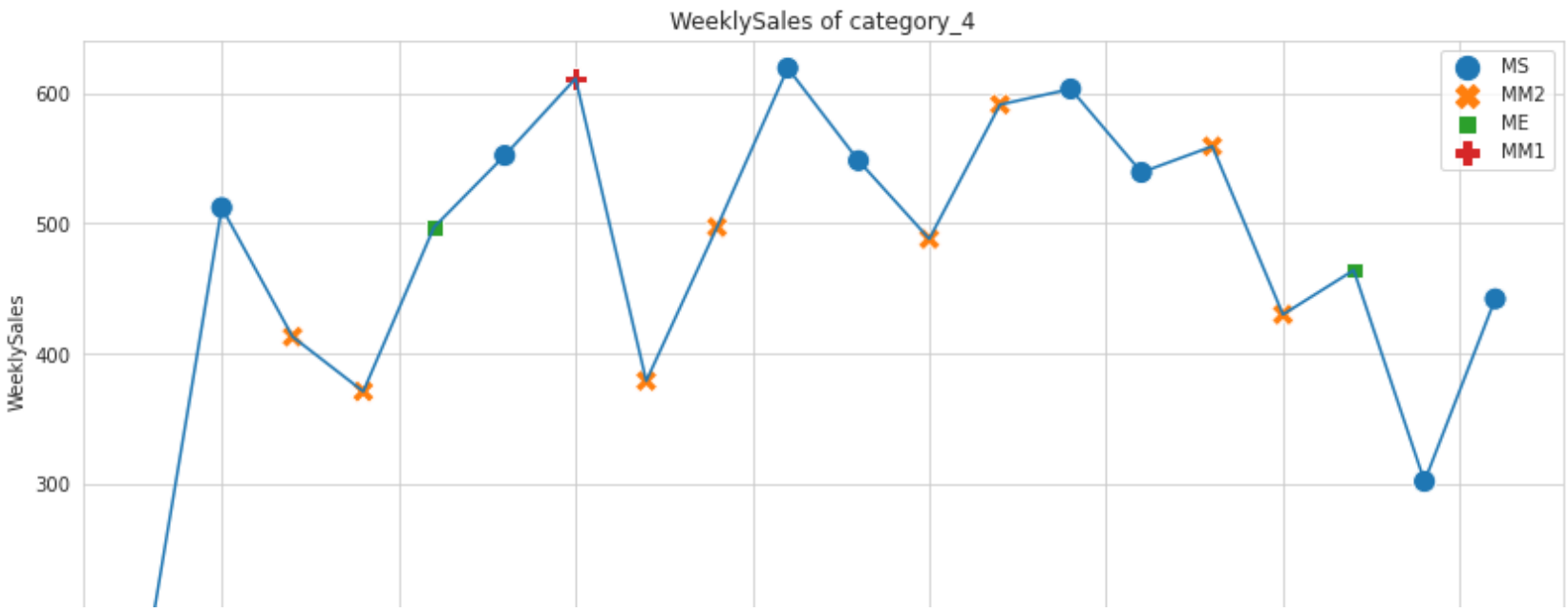
Ploat WeeklySales for Each Category Including Phases

In [28]:
```
def phase_of_week(row):
    row.Phase = find_phase_of_week(row.name[1])
    return row

data = pw_added_train.copy()
data = pd.DataFrame(data.groupby(['CategoryCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)
data['Phase'] = np.nan
data = data.apply(phase_of_week, axis='columns')

def plt_weeklySales_with_phase(c):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + c)
    sns.scatterplot(data=data.loc[pd.IndexSlice[c,:, :],:].reset_index(), x="Week", y="WeeklySales",
                    hue="Phase", style="Phase", size="Phase", sizes=[150]*n_p)
    sns.lineplot(data=data.loc[pd.IndexSlice[c,:, :],:].reset_index(), x='Week', y='WeeklySales')
    plt.show()

for i in range(1, 5):
    plt_weeklySales_with_phase('category_' + str(i))
```





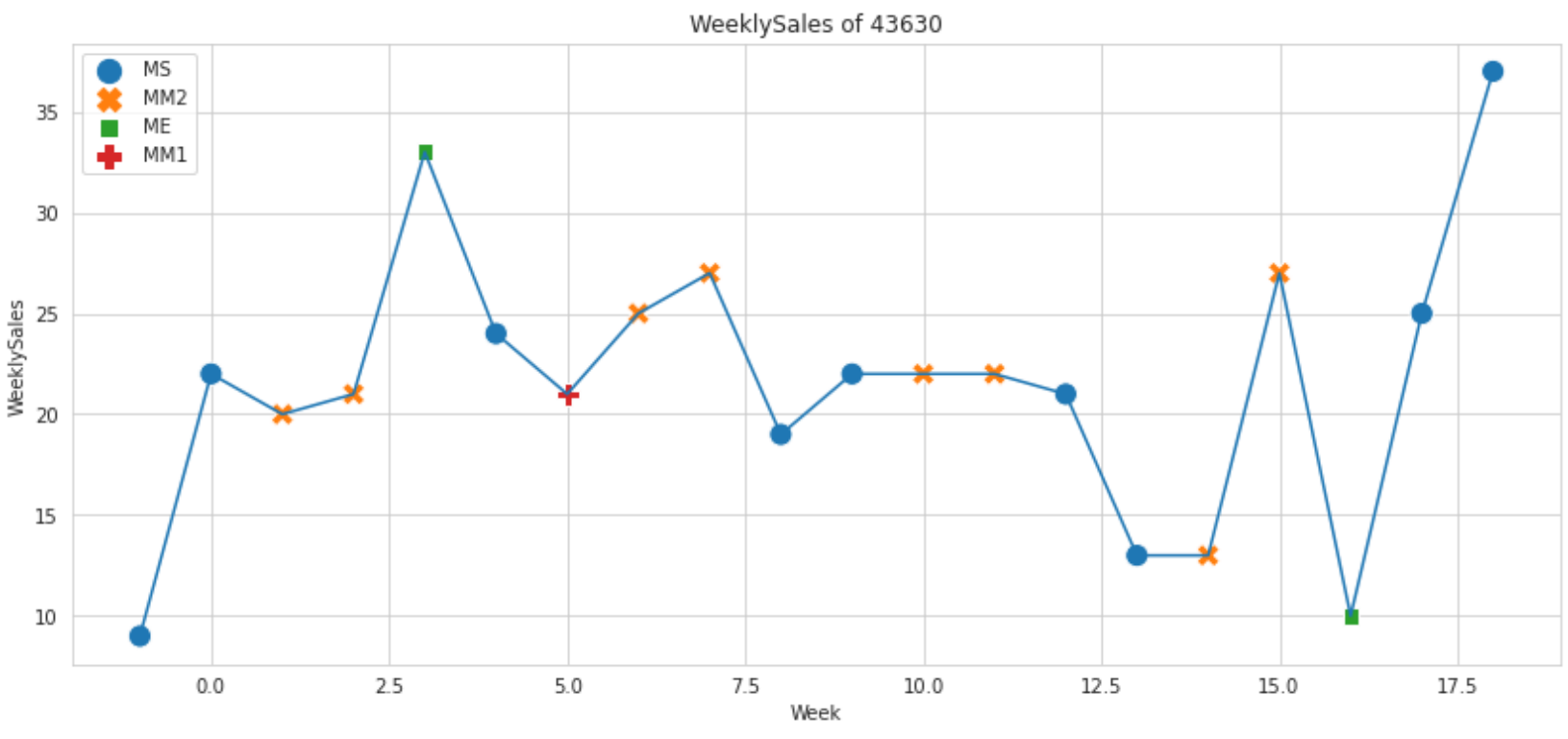




Ploat WeeklySales for A Specific Item in A Specific Category Including Phases

In [29]:

```
def phase_of_week(row):
    row.Phase = find_phase_of_week(row.name[1])
    return row

ItemCode = 43630
data = pw_added_train.copy()
data = pd.DataFrame(data.groupby(['ItemCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)
data['Phase'] = np.nan
data = data.loc[[ItemCode]]
data = data.apply(phase_of_week, axis='columns')

def plt_weeklySales_with_phase(ic):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + str(ic))
    sns.scatterplot(data=data.loc[pd.IndexSlice[ic, :], :].reset_index(), x="Week", y="WeeklySales",
                    hue="Phase", style="Phase", size="Phase", sizes=[150]*n_p)
    sns.lineplot(data=data.loc[pd.IndexSlice[ic, :], :].reset_index(), x='Week', y='WeeklySales')
    plt.show()

plt_weeklySales_with_phase(ItemCode)
```



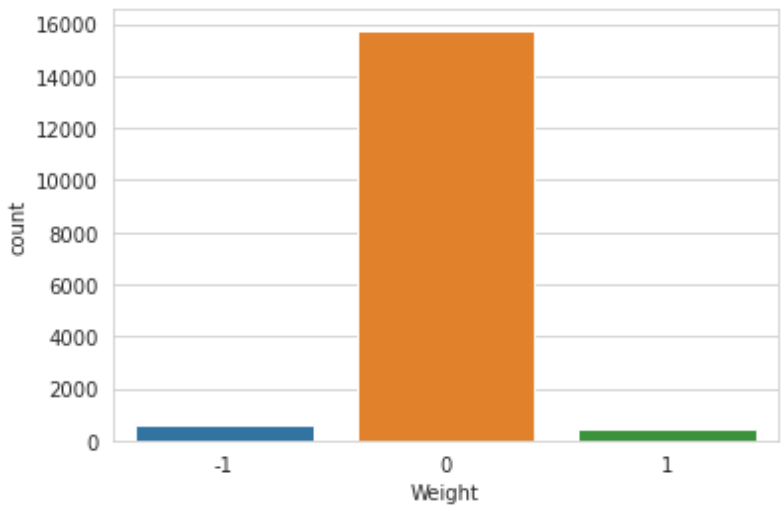
1.3. Assign A Weight for Dates

- -1 for holidays
- 0 for normal days
- 1 for festivals

Add Weight

In [30]:
```
def add_weight(row):
    row.Weight = find_weight(row['DateID'])
    return row

pw_added_train['Weight'] = np.nan
wpw_added_train = pw_added_train.apply(add_weight, axis='columns')
sns.countplot(x=wpw_added_train.Weight)
```

Out[30]:
```
<AxesSubplot:xlabel='Weight', ylabel='count'>
```



Find The Weight of The nth Week

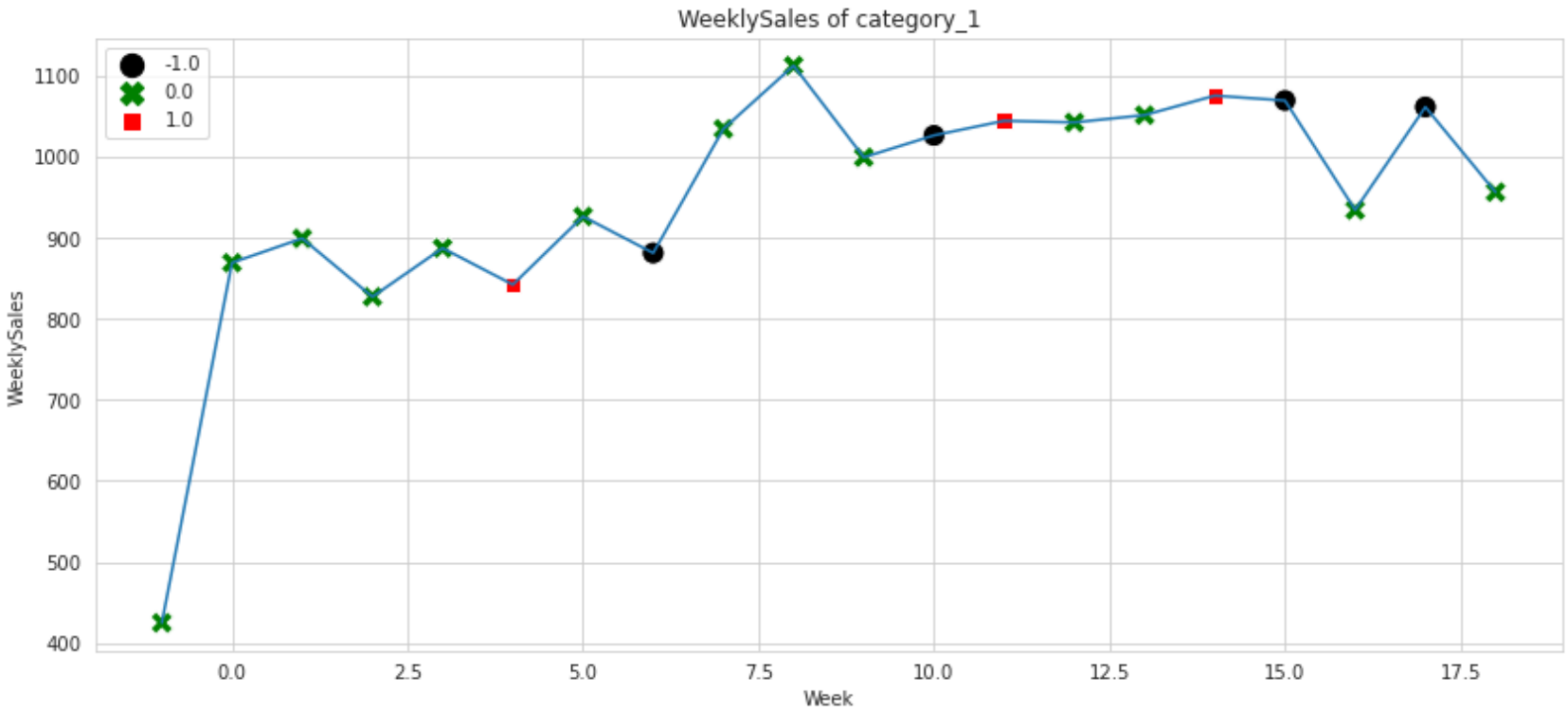
In [31]:
```
def find_weight_of_week(nth_week):
    wk_wgt = pd.DataFrame(pd.DataFrame(wpw_added_train.groupby(['Week', 'DateID']).Weight.max()).reset_index().groupby(['Week']).W
    return wk_wgt.loc[nth_week, 'Weight']

find_weight_of_week(15)
```

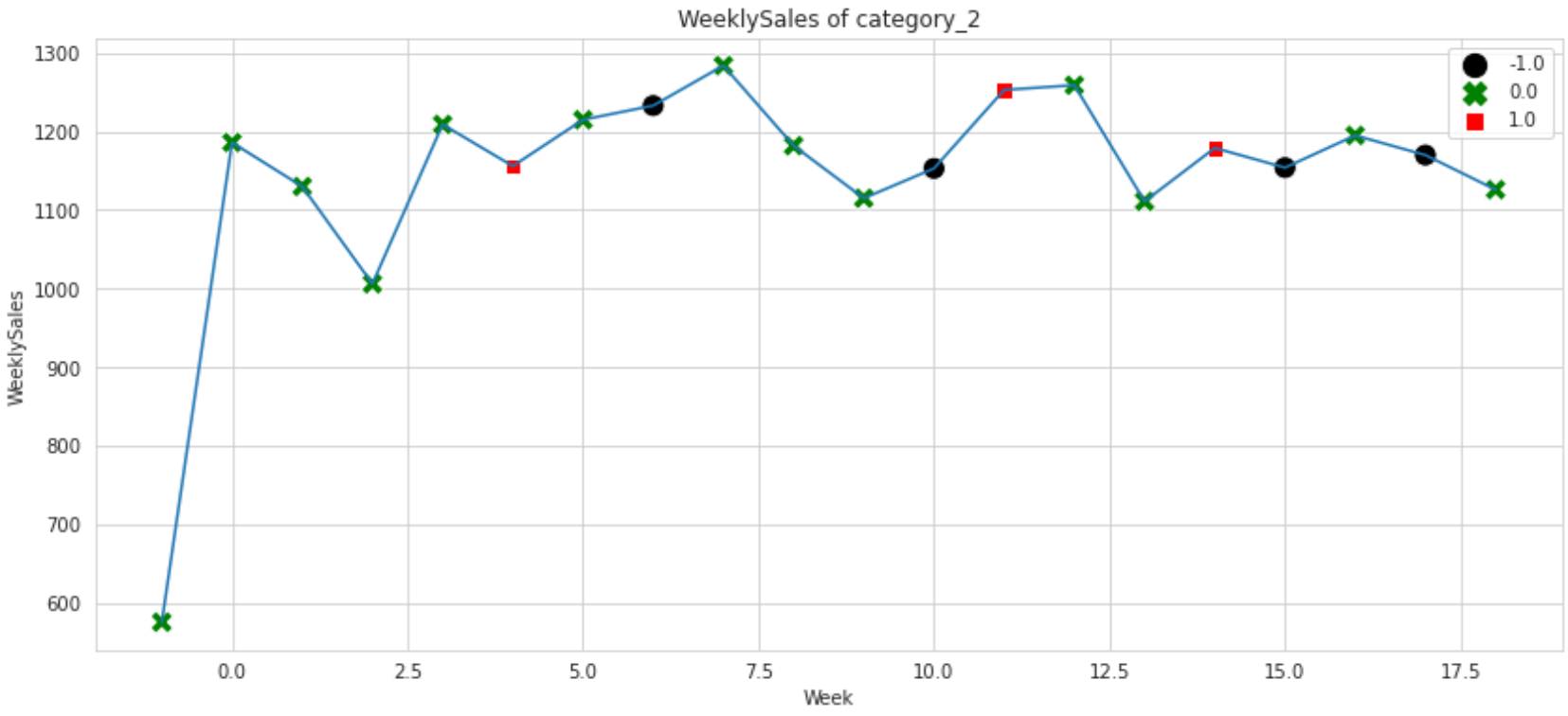
Out[31]:
```
-1
```

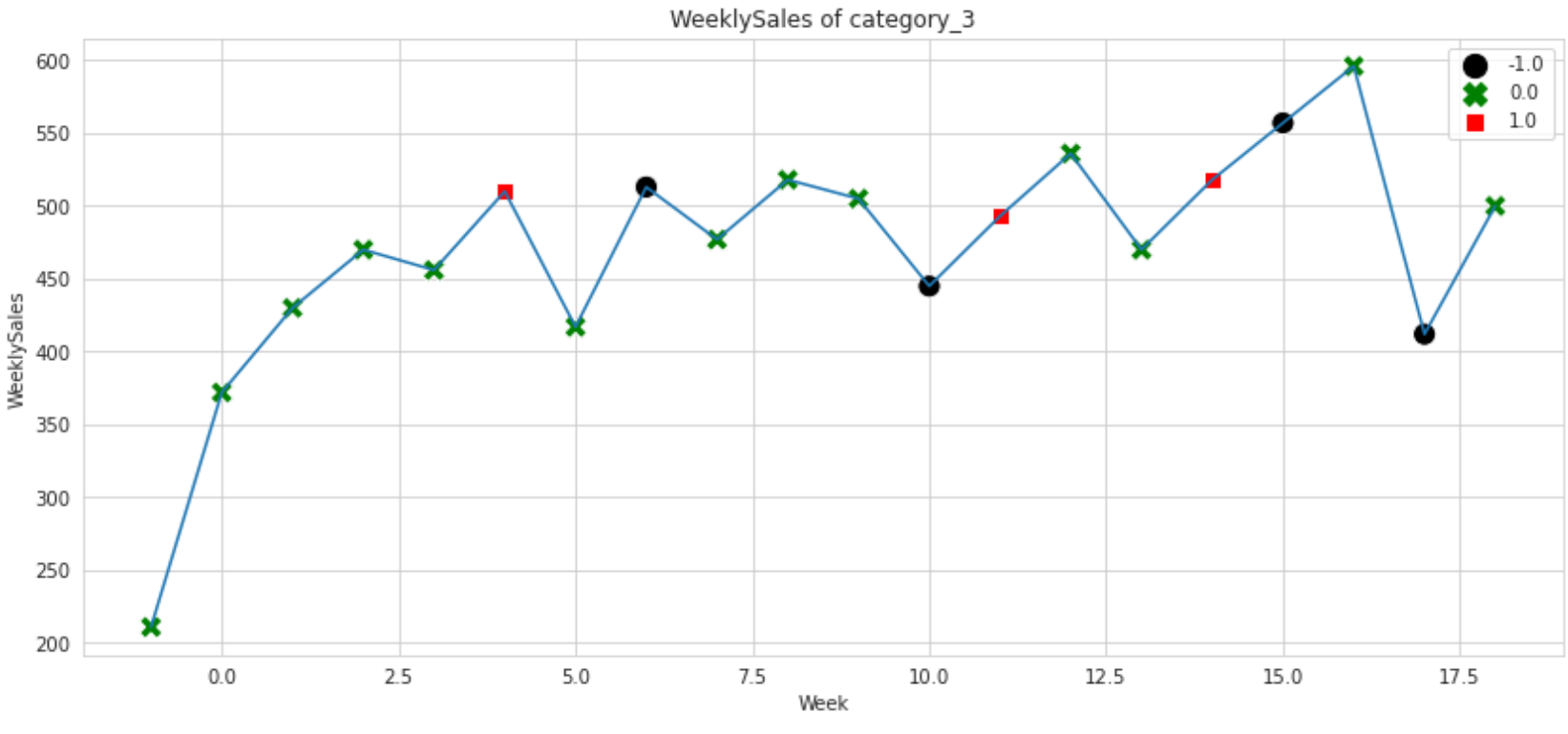
Ploat WeeklySales for Each Category Including Weights

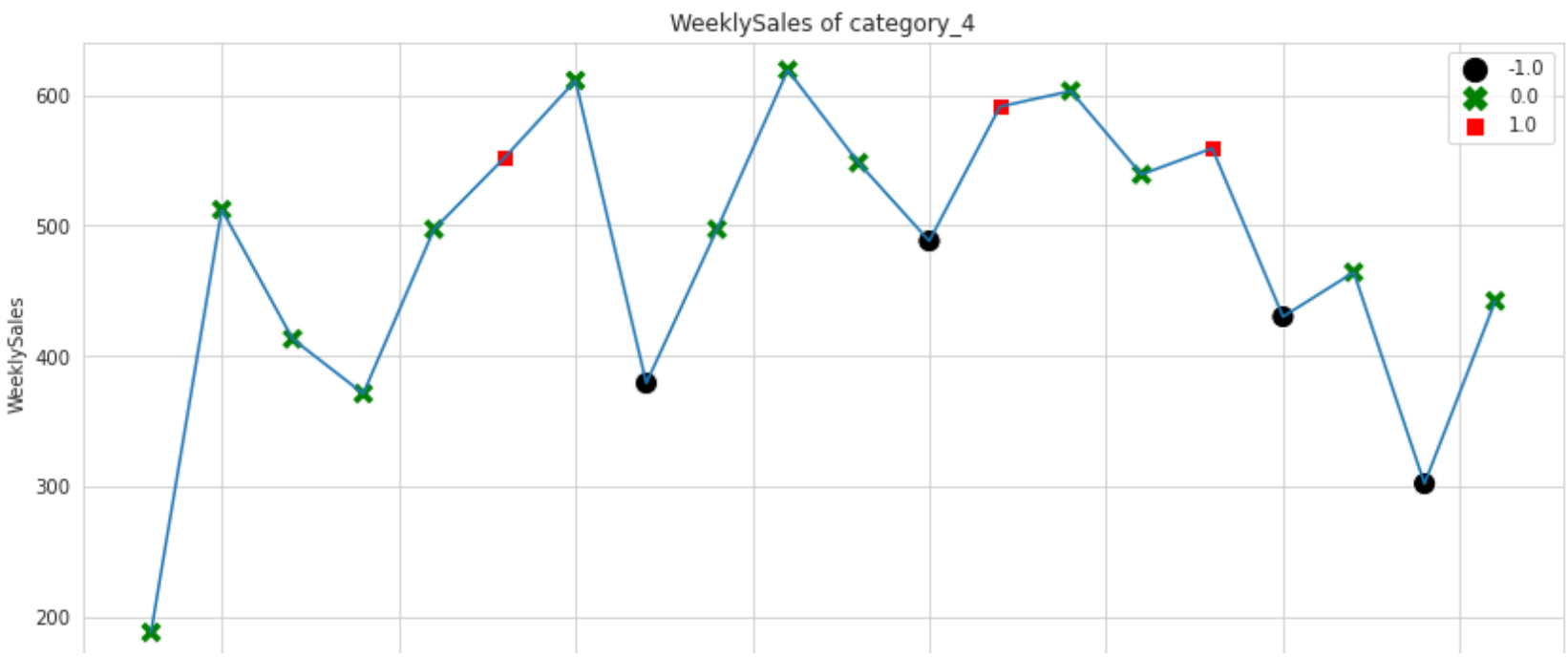
In [32]:

```
def weight_of_week(row):
    row.Weight = find_weight_of_week(row.name[1])
    return row

data = wpw_added_train.copy()
data = pd.DataFrame(data.groupby(['CategoryCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)
data['Weight'] = np.nan
data = data.apply(weight_of_week, axis='columns')

def plt_weeklySales_with_weight(c):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + c)
    sns.scatterplot(data=data.loc[pd.IndexSlice[c,:, :],:].reset_index(), x="Week", y="WeeklySales",
                    hue="Weight", style="Weight", size="Weight", sizes=(150, 150),
                    palette={-1: 'black', 0: 'g', 1: 'r'})
    sns.lineplot(data=data.loc[pd.IndexSlice[c,:, :],:].reset_index(), x='Week', y='WeeklySales')
    plt.show()

for i in range(1, 5):
    plt_weeklySales_with_weight('category_' + str(i))
```



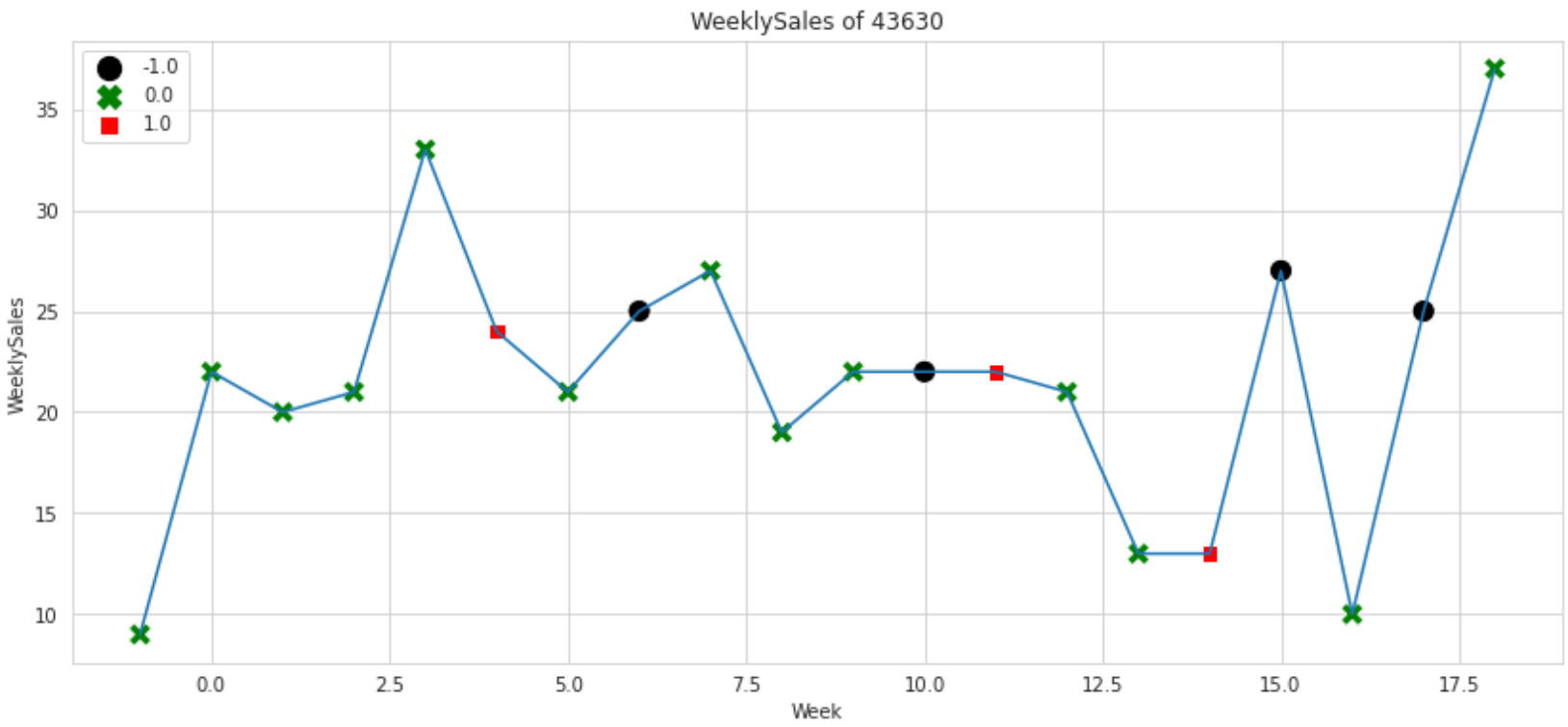






Ploat WeeklySales for A Specific Item in A Specific Category Including Weights

In [33]:
```
def weight_of_week(row):
    row.Weight = find_weight_of_week(row.name[1])
    return row

ItemCode = 43630
data = wpw_added_train.copy()
data = pd.DataFrame(data.groupby(['ItemCode', 'Week']).DailySales.sum())
data.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)
data['Weight'] = np.nan
data = data.loc[[ItemCode]]
data = data.apply(weight_of_week, axis='columns')

def plt_weeklySales_with_weight(ic):
    plt.figure(figsize=(14,6))
    plt.title("WeeklySales of " + str(ic))
    sns.scatterplot(data=data.loc[pd.IndexSlice[ic,:, :],:].reset_index(), x="Week", y="WeeklySales",
                    hue="Weight", style="Weight", size="Weight", sizes=(150, 150),
                    palette={-1: 'black', 0: 'g', 1: 'r'})
    sns.lineplot(data=data.loc[pd.IndexSlice[ic,:, :],:].reset_index(), x='Week', y='WeeklySales')
    plt.show()

plt_weeklySales_with_weight(ItemCode)
```



Create The Final Test Dataset

In [34]:
```
groupby_ciw_ftrain = pd.DataFrame(wpw_added_train.groupby(['CategoryCode', 'ItemCode', 'Week']).DailySales.sum())
groupby_ciw_ftrain.rename(columns={'DailySales': 'WeeklySales'}, inplace=True)
```

Add Phase

In [35]:
```
def add_phase(row):
    row.Phase = find_phase_of_week(row.Week)
    return row

groupby_ciw_ftrain = groupby_ciw_ftrain.reset_index()
groupby_ciw_ftrain['Phase'] = np.nan
pw_added_ftrain = groupby_ciw_ftrain.apply(add_phase, axis='columns')
pw_added_ftrain
```

Out[35]:

	CategoryCode	ItemCode	Week	WeeklySales	Phase
0	category_1	3418	-1	11	MS
1	category_1	3418	0	16	MS
2	category_1	3418	1	26	MM2

	CategoryCode	ItemCode	Week	WeeklySales	Phase
3	category_1	3418	2	15	MM2
4	category_1	3418	3	21	ME
...	...	...	...	...	...
3655	category_4	1082743	13	24	MS
3656	category_4	1082743	14	9	MM2
3657	category_4	1082743	15	75	MM2
3658	category_4	1082743	16	26	ME
3659	category_4	1082743	18	48	MS

Add Weight

In [36]:
```
def add_weight(row):
    row.Weight = find_weight_of_week(row.Week)
    return row

pw_added_ftrain['Weight'] = np.nan
wpw_added_ftrain = pw_added_ftrain.apply(add_weight, axis='columns')
wpw_added_ftrain
```

Out[36]:

	CategoryCode	ItemCode	Week	WeeklySales	Phase	Weight
0	category_1	3418	-1	11	MS	0
1	category_1	3418	0	16	MS	0
2	category_1	3418	1	26	MM2	0
3	category_1	3418	2	15	MM2	0
4	category_1	3418	3	21	ME	0
...	...	...	...	...	...	...
3655	category_4	1082743	13	24	MS	0
3656	category_4	1082743	14	9	MM2	1
3657	category_4	1082743	15	75	MM2	-1
3658	category_4	1082743	16	26	ME	0
3659	category_4	1082743	18	48	MS	0

3660 rows × 6 columns

2. Feature Encoding

In [37]:
```
wpw_added_ftrain = wpw_added_ftrain.loc[wpw_added_ftrain.Week != -1]
encoder = ce.OneHotEncoder(cols=['CategoryCode','ItemCode', 'Phase'], return_df=True, use_cat_names=True)
enocoded_train = encoder.fit_transform(wpw_added_ftrain)
enocoded_train.info()
```

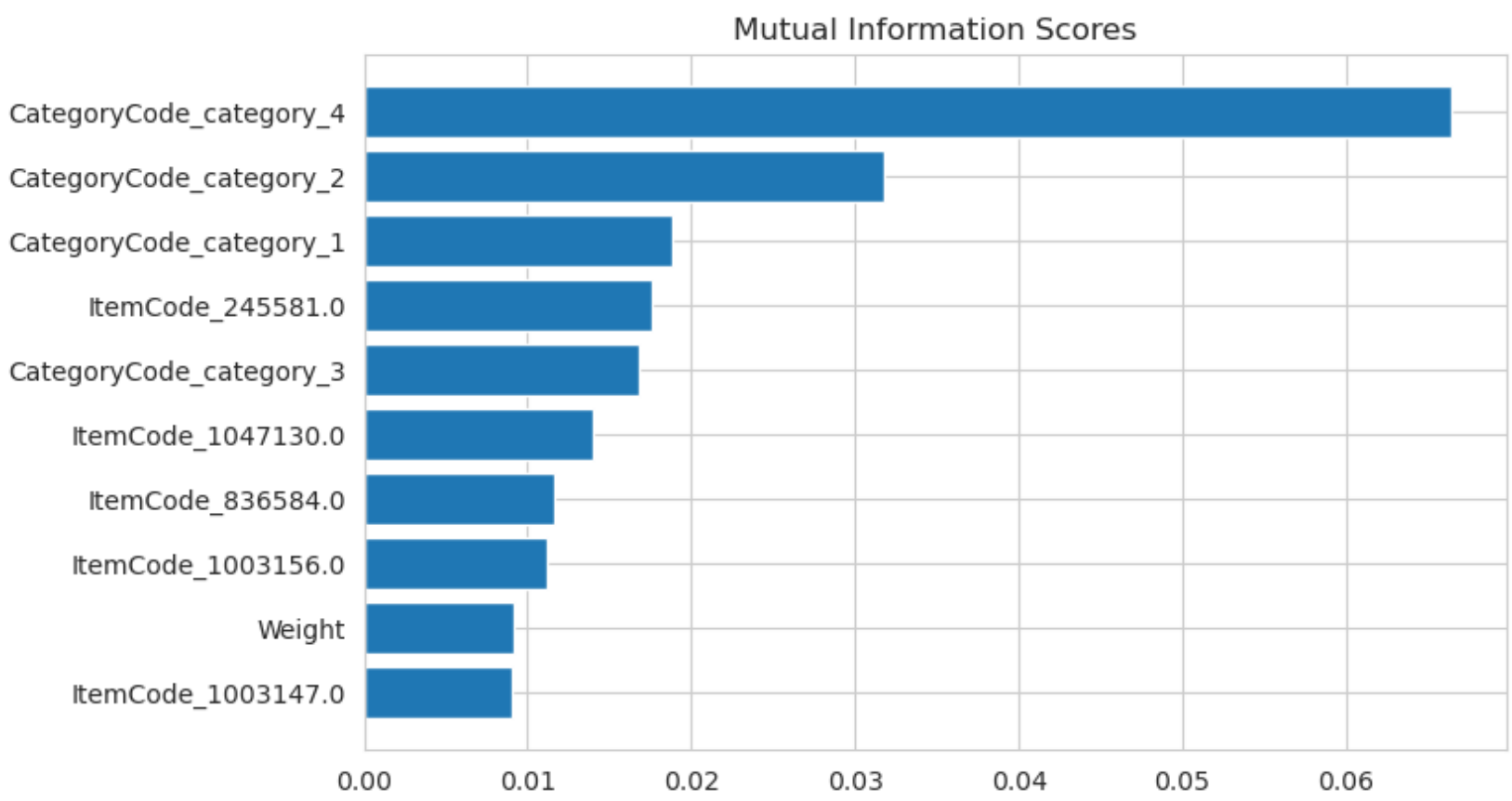
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3491 entries, 1 to 3659
Columns: 204 entries, CategoryCode_category_1 to Weight
dtypes: int64(204)
memory usage: 5.5 MB
```

```
/home/kajanan/ProgramFiles/anaconda3/lib/python3.9/site-packages/category_encoders/utils.py:21: FutureWarning: is_categorical is d
eprecated and will be removed in a future version.  Use is_categorical_dtype instead
  elif pd.api.types.is_categorical(cols):
```

In [38]:
```
X = enocoded_train.drop(columns=['WeeklySales'])
y = enocoded_train.WeeklySales
```

3. Feature Selection Based on Feature Importance(Using Mutual Infomation)

In [39]:
```
mi_score = make_mi_scores(X, y)
plot_mi_scores(mi_score.head(10))
```



In [40]:
```
droppable_features = mi_score.loc[mi_score < 0.0001]
```

In [41]:
```
X = X.drop(columns=droppable_features.index)
```

Evaluate The Models on Training Dataset Using Cross-Validation for Model Selection

- 5-Fold Cross-Validation
- Scoring Method - MAPE

In [42]:
```
evaluate_for_models(models, X, y)
```

```
/home/kajanan/ProgramFiles/anaconda3/lib/python3.9/site-packages/sklearn/model_selection/_split.py:666: UserWarning: The least pop
ulated class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(("The least populated class in y has only %d"
```

Out[42]:

	Model	ScoreMean	Score Standard Deviation
3	RandomForestRegressor	5.445308e+01	7.130853e+00
2	DecisionTreeRegressor	5.510833e+01	7.239937e+00
1	KNeighborsRegressor	5.574691e+01	1.861969e+00
4	SVC	5.856447e+01	8.343438e+00
0	LinearRegression	2.151169e+14	5.264901e+13

In [43]:
```
best_model = RandomForestRegressor(random_state=rs)
parameters = {'n_estimators': np.arange(1, 100, 20), 'max_depth': np.arange(1, 100, 20)}
grdSCV = GridSearchCV(best_model, parameters, scoring=make_scorer(MAPE_score))
grdSCV.fit(X, y)
```

Out[43]:
```
GridSearchCV(estimator=RandomForestRegressor(random_state=42),
             param_grid={'max_depth': array([ 1, 21, 41, 61, 81]),
                         'n_estimators': array([ 1, 21, 41, 61, 81])},
             scoring=make_scorer(MAPE_score))
```

In [44]:
```
grdSCV_result = pd.DataFrame(grdSCV.cv_results_)
grdSCV_result[['param_n_estimators', 'param_max_depth', 'mean_test_score',
               'std_test_score']].sort_values(by=['mean_test_score', 'std_test_score']).head(2)
```

Out[44]:

	param_n_estimators	param_max_depth	mean_test_score	std_test_score
5	1	21	50.646327	7.182567
12	41	41	50.871124	7.322822

In [45]:
```
for e, d in [(1, 21), (1, 41)]:
    print(e, d)
    model_blr = BaggingRegressor(base_estimator=RandomForestRegressor(random_state=rs, n_estimators=e, max_depth=d), random_state=
    parameters = {'n_estimators': np.arange(1, 100, 20)}
    grdSCV = GridSearchCV(model_blr, parameters, scoring=make_scorer(MAPE_score))
    grdSCV.fit(X, y)
    grdSCV_result = pd.DataFrame(grdSCV.cv_results_)
    print(grdSCV_result[['param_n_estimators', 'mean_test_score',
                         'std_test_score']].sort_values(by=['mean_test_score', 'std_test_score']).head(2))
```

```
1 21
  param_n_estimators  mean_test_score  std_test_score
1                 21        50.880203        6.914308
3                 61        50.949356        6.926332
1 41
```

	param_n_estimators	mean_test_score	std_test_score
2	41	50.620240	7.367974

In [46]:
```
best_models = [RandomForestRegressor(random_state=rs, n_estimators=1, max_depth=21),
               BaggingRegressor(base_estimator=RandomForestRegressor(random_state=rs, n_estimators=1, max_depth=41),
                                random_state=rs, n_estimators=41)]
```

In [47]:
```
X_train = X
y_train = y
```

Validation Dataset

In [48]:
```
def add_week(row):
    row.Week = Week[row['Week']]
    return row

w_added_val = val_df.apply(add_week, axis='columns')
w_added_val
```

Out[48]:

	CategoryCode	ItemCode	Week	WeeklySales
0	category_2	1044502	19	11
1	category_2	1105009	19	11
2	category_2	913561	22	5
3	category_1	1048975	22	30
4	category_1	17287	20	60
...	...	...	...	...
365	category_2	124954	20	43
366	category_2	40759	19	48
367	category_1	1090303	19	19
368	category_2	1090276	21	6
369	category_1	3418	22	69

370 rows × 4 columns

In [49]:
```
def add_phase(row):
    row.Phase = Phase[row['Week']]
    return row

w_added_val['Phase'] = np.nan
pw_added_val = w_added_val.apply(add_phase, axis='columns')
pw_added_val
```

Out[49]:

	CategoryCode	ItemCode	Week	WeeklySales	Phase
0	category_2	1044502	19	11	MM2
1	category_2	1105009	19	11	MM2
2	category_2	913561	22	5	MM1
3	category_1	1048975	22	30	MM1
4	category_1	17287	20	60	End
...	...	...	...	...	...
365	category_2	124954	20	43	End
366	category_2	40759	19	48	MM2
367	category_1	1090303	19	19	MM2
368	category_2	1090276	21	6	Start
369	category_1	3418	22	69	MM1

370 rows × 5 columns

In [50]:
```
def add_weight(row):
    row.Weight = Weight[row['Week']]
    return row

pw_added_val['Weight'] = np.nan
wpw_added_val = pw_added_val.apply(add_weight, axis='columns')
wpw_added_val
```

Out[50]:

	CategoryCode	ItemCode	Week	WeeklySales	Phase	Weight
0	category_2	1044502	19	11	MM2	-1
1	category_2	1105009	19	11	MM2	-1
2	category_2	913561	22	5	MM1	0
3	category_1	1048975	22	30	MM1	0
4	category_1	17287	20	60	End	0

	CategoryCode	ItemCode	Week	WeeklySales	Phase	Weight
...	...	...	...	...	...	...
365	category_2	124954	20	43	End	0
366	category_2	40759	19	48	MM2	-1
367	category_1	1090303	19	19	MM2	-1
368	category_2	1090276	21	6	Start	1
369	category_1	3418	22	69	MM1	0

In [51]:
```
enocoded_val = encoder.transform(wpw_added_val)
enocoded_val
```

Out[51]:

	CategoryCode_category_1	CategoryCode_category_2	CategoryCode_category_3	CategoryCode_category_4	ItemCode_3418.0	ItemCode_3427.0	ItemCode_17287.0
0	0	1	0	0	0	0	0
1	0	1	0	0	0	0	0
2	0	1	0	0	0	0	0
3	1	0	0	0	0	0	0
4	1	0	0	0	0	0	1
...	...	...	...	...	...	...	...
365	0	1	0	0	0	0	0
366	0	1	0	0	0	0	0
367	1	0	0	0	0	0	0
368	0	1	0	0	0	0	0
369	1	0	0	0	1	0	0

370 rows × 204 columns

In [52]:
```
X_val = enocoded_val.drop(columns=['WeeklySales'])
X_val = X_val.drop(columns=droppable_features.index)
y_val = enocoded_val.WeeklySales
```

In [53]:
```
evaluate_val(best_models, X_train, X_val, y_train, y_val)
```

Out[53]:

	Model	MAPE_score
1	BaggingRegressor	68.370056
0	RandomForestRegressor	69.256885

Test + Validation Dataset

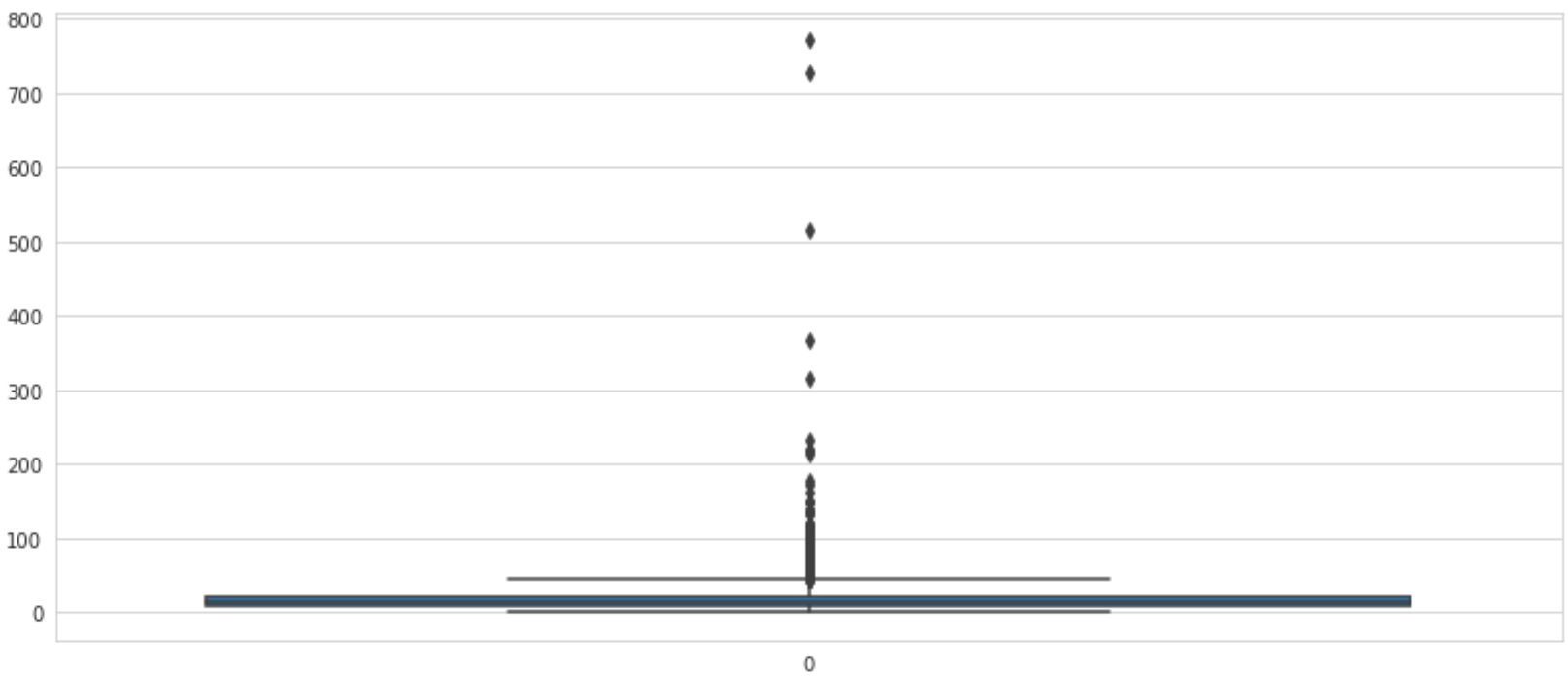
In [54]:
```
X = pd.concat([X_train, X_val])
X = X.reset_index(drop=True)
```

In [55]:
```
y = pd.concat([y_train, y_val])
y = y.reset_index(drop=True)
```

In [56]:
```
y.describe()
```

Out[56]:
```
count    3861.000000
mean       19.498316
std        26.716644
min         1.000000
25%         9.000000
50%        14.000000
75%        23.000000
max       771.000000
Name: WeeklySales, dtype: float64
```

In [57]:
```
plt.figure(figsize=(14,6))
sns.boxplot(data=y)
plt.show()
```



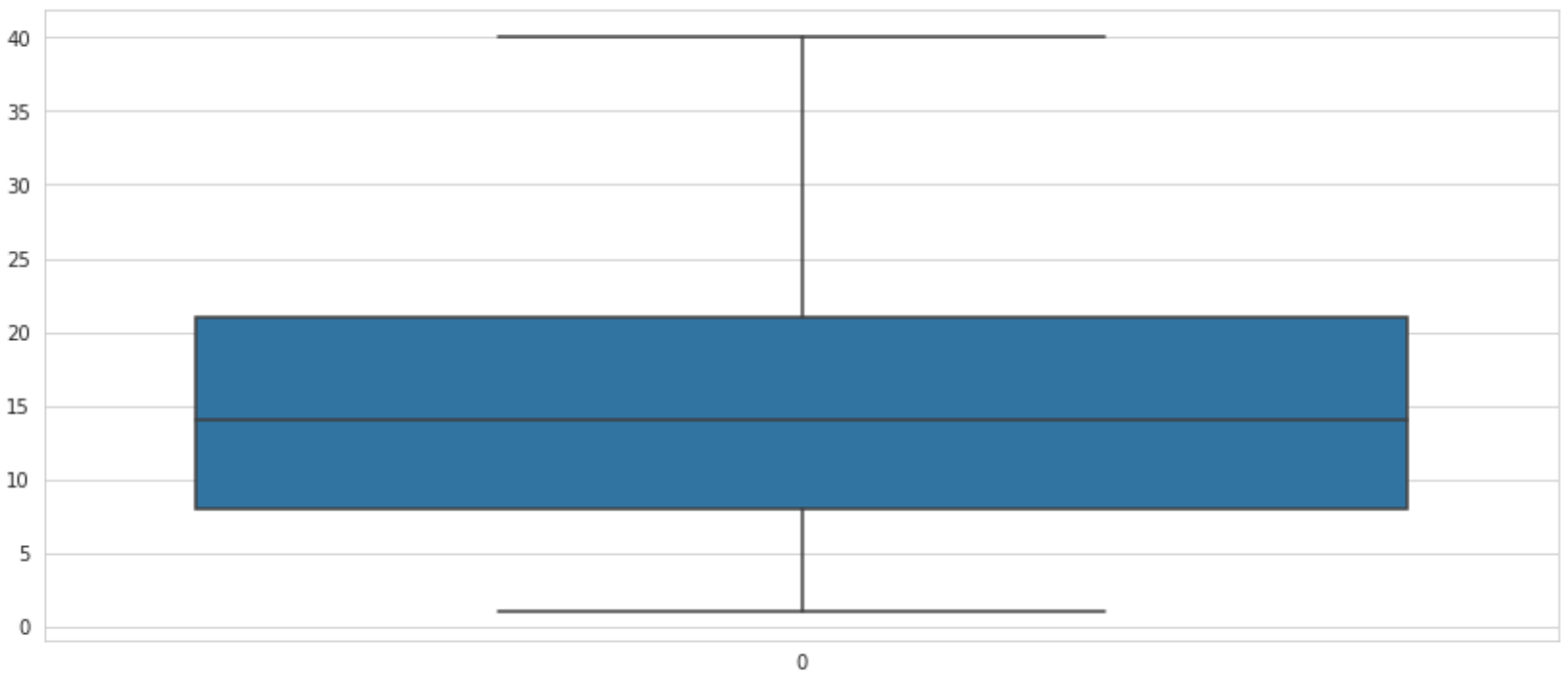
In [58]:

```
has_outliers = True
while has_outliers:
    y_q25, y_q75 = np.percentile(y, 25), np.percentile(y,75)
    y_iqr = y_q75 - y_q25
    upper = y_q75 + (1.5 * y_iqr)
    y_outliers_index = y.loc[y > upper].index
    if len(y_outliers_index) == 0:
        has_outliers = False
    else:
        y.drop(y_outliers_index, inplace=True)
        X.drop(y_outliers_index, inplace=True)

print(X.shape)
print(y.shape)
```

```
(3597, 182)
(3597,)
```

In [59]:

```
plt.figure(figsize=(14,6))
sns.boxplot(data=y)
plt.show()
```



In [60]:

```
evaluate_for_models(best_models, X, y)
```

Out[60]:

	Model	ScoreMean	Score Standard Deviation
1	BaggingRegressor	47.113977	6.014527
0	RandomForestRegressor	51.084091	4.221496

In [61]:

```
final_model = best_models[1]
final_model
```

Out[61]:

```
BaggingRegressor(base_estimator=RandomForestRegressor(max_depth=41,
                                                      n_estimators=1,
                                                      random_state=42),
                 n_estimators=41, random_state=42)
```

Test Dataset

In [62]:

```
def add_week(row):
    row.Week = Week[row['Week']]
    return row

w_added_test = test_df.apply(add_week, axis='columns')
w_added_test
```

Out[62]:

	CategoryCode	ItemCode	Week	PredictedSales
0	category_1	43738	22	NaN
1	category_2	1006090	19	NaN
2	category_2	1076929	22	NaN
3	category_1	1081321	21	NaN
4	category_2	216151	22	NaN
...	...	...	...	...
372	category_2	1101571	19	NaN
373	category_2	1090258	22	NaN
374	category_2	906595	19	NaN
375	category_2	32245	19	NaN
376	category_2	1006090	20	NaN

377 rows × 4 columns

In [63]:

```
def add_phase(row):
    row.Phase = Phase[row['Week']]
    return row

w_added_test['Phase'] = np.nan
pw_added_test = w_added_test.apply(add_phase, axis='columns')
pw_added_test
```

Out[63]:

	CategoryCode	ItemCode	Week	PredictedSales	Phase
0	category_1	43738	22	NaN	MM1
1	category_2	1006090	19	NaN	MM2
2	category_2	1076929	22	NaN	MM1
3	category_1	1081321	21	NaN	Start
4	category_2	216151	22	NaN	MM1
...	...	...	...	...	...
372	category_2	1101571	19	NaN	MM2
373	category_2	1090258	22	NaN	MM1
374	category_2	906595	19	NaN	MM2
375	category_2	32245	19	NaN	MM2
376	category_2	1006090	20	NaN	End

377 rows × 5 columns

In [64]:

```
def add_weight(row):
    row.Weight = Weight[row['Week']]
    return row

pw_added_test['Weight'] = np.nan
wpw_added_test = pw_added_test.apply(add_weight, axis='columns')
wpw_added_test
```

Out[64]:

	CategoryCode	ItemCode	Week	PredictedSales	Phase	Weight
0	category_1	43738	22	NaN	MM1	0
1	category_2	1006090	19	NaN	MM2	-1
2	category_2	1076929	22	NaN	MM1	0
3	category_1	1081321	21	NaN	Start	1
4	category_2	216151	22	NaN	MM1	0
...	...	...	...	...	...	...
372	category_2	1101571	19	NaN	MM2	-1
373	category_2	1090258	22	NaN	MM1	0
374	category_2	906595	19	NaN	MM2	-1
375	category_2	32245	19	NaN	MM2	-1
376	category_2	1006090	20	NaN	End	0

377 rows × 6 columns

In [65]:

```
enocoded_test = encoder.transform(wpw_added_test)
enocoded_test
```

Out[65]:

	CategoryCode_category_1	CategoryCode_category_2	CategoryCode_category_3	CategoryCode_category_4	ItemCode_3418.0	ItemCode_3427.0	ItemCode_17287.0
0	1	0	0	0	0	0	0
1	0	1	0	0	0	0	0
2	0	1	0	0	0	0	0

	CategoryCode_category_1	CategoryCode_category_2	CategoryCode_category_3	CategoryCode_category_4	ItemCode_3418.0	ItemCode_3427.0	ItemCode_17287.0
3	1	0	0	0	0	0	0
4	0	1	0	0	0	0	0
...	...	...	...	...	...	...	...
372	0	1	0	0	0	0	0
373	0	1	0	0	0	0	0
374	0	1	0	0	0	0	0
375	0	1	0	0	0	0	0
376	0	1	0	0	0	0	0

In [66]:
```
X_test = enocoded_test.drop(columns=['PredictedSales'])
X_test = X_test.drop(columns=droppable_features.index)
y_test = enocoded_test.PredictedSales
```

In [67]:
```
final_model.fit(X, y)
```

Out[67]:
```
BaggingRegressor(base_estimator=RandomForestRegressor(max_depth=41,
                                                      n_estimators=1,
                                                      random_state=42),
                 n_estimators=41, random_state=42)
```

In [68]:
```
test_df['PredictedSales'] = final_model.predict(X_test)
test_df
```

Out[68]:

	CategoryCode	ItemCode	Week	PredictedSales
0	category_1	43738	w4	14.561007
1	category_2	1006090	w1	14.626945
2	category_2	1076929	w4	5.271992
3	category_1	1081321	w3	16.107699
4	category_2	216151	w4	14.296376
...	...	...	...	...
372	category_2	1101571	w1	5.674101
373	category_2	1090258	w4	9.823577
374	category_2	906595	w1	12.736801
375	category_2	32245	w1	17.433219
376	category_2	1006090	w2	13.390105

377 rows × 4 columns

In [69]:
```
test_df['ID'] = test_df[['CategoryCode', 'ItemCode', 'Week']].apply(lambda row: '_'.join(row.values.astype(str)), axis=1)
test_df = test_df.rename(columns={'PredictedSales': 'WeeklySales'})
df = test_df.drop(columns=['CategoryCode', 'ItemCode', 'Week'])
ID = df.pop('ID')
df.insert(0, 'ID', ID)
df.to_csv('test-predicted.csv', index=False)
```