

Phase-Four Project Submission

- Student Name: Wes Swager
- Student Pace: Full Time
- Instructor Name: Claude Fried
- Scheduled Project Review Date/Time
 - Technical - 1: Tuesday, May 18, 2021, 4:00pm CST
 - None-Technical: Thursday, May 20, 2021, 2:45pm CST
 - Technical - 2: Friday, May 21, 2021, 9:30am CST

Overview

Analyze monthly median housing sales values data for Lake County, IL and Kenosha and Racine Counties, WI, between 1997 and 2017 and forecast real estate prices using time series modeling.

Business Problem

The Chiwaukee Group are a startup real estate development firm looking to capitalize on growth and business development in the geographic area between Chicago, Illinois and Milwaukee, Wisconsin, through investment in new residential projects.

The Chiwaukee Group are specifically looking to target the counties located between Cook County, IL (Chicago) and Milwaukee County, WI:

- Lake County, IL
- Kenosha County, WI
- Racine County, WI

The Chiwaukee Group have requested a recommendation of the top-five zipcodes within which to invest.

Background

Business Development

The area has experienced significant recent business development:

- Amazon - 2015 - New Distribution Center
- Uline - 2010 - New Headquarters, 2018 - New Distribution Center
- Foxxconn - 2020 - New Manufacturing Plant, New Network Operations Center
- Meijer Inc. - 2014 - New Distribution Center
- Rust-Oleum Corp. - 2014 - New Distribution Center
- Gordon Food Service - 2010 - New Distribution Center

Future Development

Marquette University Law School in Milwaukee has projected that the two metro areas will continue to merge into a single megaregion. They are currently conducting a [running project](#) mapping the interconnection of the two geographic and economic entities while working with policymakers to encourage and facilitate the process going forward.

Connection

The two cities are connected by a major interstate, I-94, as well as a train route, the Hiawatha Service, operated by Amtrak, which includes a stop in the city of Sturtevant in Racine County.

Parameters

Risk

Evaluated through Coefficient of Variance, ratio of the standard deviation to the mean, with an upper-limit set at 50%

Historic Return on Investment

Areas with prove return on investment, with a threshold of top 25% across the existing data's timeframe

Expected Future Returns

Final recommendations will be provided based on future returns forecasted using Time Series modeling

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Packages

```
In [1]: import warnings
warnings.filterwarnings('ignore')

# Import Pandas for Dataframes

import pandas as pd
from IPython.display import display

# Import Numpy and Math for mathematical functions

import numpy as np

import math
from math import sqrt

# Import statsmodels and Scipy Stats for statistical functions
# Import statsmodels and pmdarima for modeling

import statsmodels.api as sm
import statsmodels.formula.api as smf
import statsmodels.stats.api as sms
from statsmodels.tsa.stattools import adfuller
from statsmodels.graphics.tsaplots import plot_acf
from statsmodels.graphics.tsaplots import plot_pacf
from statsmodels.tsa.statespace.sarimax import SARIMAX
from statsmodels.tsa.seasonal import seasonal_decompose

import scipy.stats as stats

import pmdarima
from pmdarima.arima.stationarity import ADFTest
from pmdarima.arima.utils import ndiffs
from pmdarima.arima.utils import nsdiffs

# Import Matplotlib and Seaborn for visualizations

import matplotlib.pyplot as plt
%matplotlib inline
from matplotlib.colors import ListedColormap
from matplotlib.collections import PolyCollection

import seaborn as sns
sns.set(style = 'darkgrid', context = 'talk')

# Import Scikit-learn for modeling

import sklearn.metrics as metrics
from sklearn.metrics import mean_squared_error
```

Data

Monthly median housing sales values between April, 1996 and April, 2018 downloaded from [Zillow](#), an American online real estate marketplace.

```
In [2]: # Import Zillow data
```

```
zillow = pd.read_csv(r'C:\Users\westi\Documents\GitHub\the_chiwauke_group\data\zillow.csv')
zillow.head()
```

```
Out[2]:
```

	RegionID	RegionName	City	State	Metro	CountyName	SizeRank	1996-04	1996-05	1997-06	1998-07	1999-08	2000-09	2001-10	2002-11	2003-12	2004-01	2005-02	2006-03	2007-04	2008-05	2009-06	2010-07	2011-08	2012-09	2013-10	2014-11	2015-12	2016-01	2017-02	2018-03	2019-04	2020-05	2021-06																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
0	84654	60657	Chicago	IL	Chicago	Cook	1	334200.0	335400.0	336600.0	337800.0	339000.0	340200.0	341400.0	342600.0	343800.0	345000.0	346200.0	347400.0	348600.0	349800.0	351000.0	352200.0	353400.0	354600.0	355800.0	357000.0	358200.0	359400.0	360600.0	361800.0	363000.0	364200.0	365400.0	366600.0	367800.0	369000.0	370200.0	371400.0	372600.0	373800.0	375000.0	376200.0	377400.0	378600.0	379800.0	381000.0	382200.0	383400.0	384600.0	385800.0	387000.0	388200.0	389400.0	390600.0	391800.0	393000.0	394200.0	395400.0	396600.0	397800.0	399000.0	400200.0	401400.0	402600.0	403800.0	405000.0	406200.0	407400.0	408600.0	409800.0	411000.0	412200.0	413400.0	414600.0	415800.0	417000.0	418200.0	419400.0	420600.0	421800.0	423000.0	424200.0	425400.0	426600.0	427800.0	429000.0	430200.0	431400.0	432600.0	433800.0	435000.0	436200.0	437400.0	438600.0	439800.0	441000.0	442200.0	443400.0	444600.0	445800.0	447000.0	448200.0	449400.0	450600.0	451800.0	453000.0	454200.0	455400.0	456600.0	457800.0	459000.0	460200.0	461400.0	462600.0	463800.0	465000.0	466200.0	467400.0	468600.0	469800.0	471000.0	472200.0	473400.0	474600.0	475800.0	477000.0	478200.0	479400.0	480600.0	481800.0	483000.0	484200.0	485400.0	486600.0	487800.0	489000.0	490200.0	491400.0	492600.0	493800.0	495000.0	496200.0	497400.0	498600.0	499800.0	501000.0	502200.0	503400.0	504600.0	505800.0	507000.0	508200.0	509400.0	510600.0	511800.0	513000.0	514200.0	515400.0	516600.0	517800.0	519000.0	520200.0	521400.0	522600.0	523800.0	525000.0	526200.0	527400.0	528600.0	529800.0	531000.0	532200.0	533400.0	534600.0	535800.0	537000.0	538200.0	539400.0	540600.0	541800.0	543000.0	544200.0	545400.0	546600.0	547800.0	549000.0	550200.0	551400.0	552600.0	553800.0	555000.0	556200.0	557400.0	558600.0	559800.0	561000.0	562200.0	563400.0	564600.0	565800.0	567000.0	568200.0	569400.0	570600.0	571800.0	573000.0	574200.0	575400.0	576600.0	577800.0	579000.0	580200.0	581400.0	582600.0	583800.0	585000.0	586200.0	587400.0	588600.0	589800.0	591000.0	592200.0	593400.0	594600.0	595800.0	597000.0	598200.0	599400.0	600600.0	601800.0	603000.0	604200.0	605400.0	606600.0	607800.0	609000.0	610200.0	611400.0	612600.0	613800.0	615000.0	616200.0	617400.0	618600.0	619800.0	621000.0	622200.0	623400.0	624600.0	625800.0	627000.0	628200.0	629400.0	630600.0	631800.0	633000.0	634200.0	635400.0	636600.0	637800.0	639000.0	640200.0	641400.0	642600.0	643800.0	645000.0	646200.0	647400.0	648600.0	649800.0	651000.0	652200.0	653400.0	654600.0	655800.0	657000.0	658200.0	659400.0	660600.0	661800.0	663000.0	664200.0	665400.0	666600.0	667800.0	669000.0	670200.0	671400.0	672600.0	673800.0	675000.0	676200.0	677400.0	678600.0	679800.0	681000.0	682200.0	683400.0	684600.0	685800.0	687000.0	688200.0	689400.0	690600.0	691800.0	693000.0	694200.0	695400.0	696600.0	697800.0	699000.0	700200.0	701400.0	702600.0	703800.0	705000.0	706200.0	707400.0	708600.0	709800.0	711000.0	712200.0	713400.0	714600.0	715800.0	717000.0	718200.0	719400.0	720600.0	721800.0	723000.0	724200.0	725400.0	726600.0	727800.0	729000.0	730200.0	731400.0	732600.0	733800.0	735000.0	736200.0	737400.0	738600.0	739800.0	741000.0	742200.0	743400.0	744600.0	745800.0	747000.0	748200.0	749400.0	750600.0	751800.0	753000.0	754200.0	755400.0	756600.0	757800.0	759000.0	760200.0	761400.0	762600.0	763800.0	765000.0	766200.0	767400.0	768600.0	769800.0	771000.0	772200.0	773400.0	774600.0	775800.0	777000.0	778200.0	779400.0	780600.0	781800.0	783000.0	784200.0	785400.0	786600.0	787800.0	789000.0	790200.0	791400.0	792600.0	793800.0	795000.0	796200.0	797400.0	798600.0	799800.0	801000.0	802200.0	803400.0	804600.0	805800.0	807000.0	808200.0	809400.0	810600.0	811800.0	813000.0	814200.0	815400.0	816600.0	817800.0	819000.0	820200.0	821400.0	822600.0	823800.0	825000.0	826200.0	827400.0	828600.0	829800.0	831000.0	832200.0	833400.0	834600.0	835800.0	837000.0	838200.0	839400.0	840600.0	841800.0	843000.0	844200.0	845400.0	846600.0	847800.0	849000.0	850200.0	851400.0	852600.0	853800.0	855000.0	856200.0	857400.0	858600.0	859800.0	861000.0	862200.0	863400.0	864600.0	865800.0	867000.0	868200.0	869400.0	870600.0	871800.0	873000.0	874200.0	875400.0	876600.0	877800.0	879000.0	880200.0	881400.0	882600.0	883800.0	885000.0	886200.0	887400.0	888600.0	889800.0	891000.0	892200.0	893400.0	894600.0	895800.0	897000.0	898200.0	899400.0	900600.0	901800.0	903000.0	904200.0	905400.0	906600.0	907800.0	909000.0	910200.0	911400.0	912600.0	913800.0	915000.0	916200.0	917400.0	918600.0	919800.0	921000.0	922200.0	923400.0	924600.0	925800.0	927000.0	928200.0	929400.0	930600.0	931800.0	933000.0	934200.0	935400.0	936600.0	937800.0	939000.0	940200.0	941400.0	942600.0	943800.0	945000.0	946200.0	947400.0	948600.0	949800.0	951000.0	952200.0	953400.0	954600.0	955800.0	957000.0	958200.0	959400.0	960600.0	961800.0	963000.0	964200.0	965400.0	966600.0	967800.0	969000.0	970200.0	971400.0	972600.0	973800.0	975000.0	976200.0	977400.0	978600.0	979800.0	981000.0	982200.0	983400.0	984600.0	985800.0	987000.0	988200.0	989400.0	990600.0	991800.0	993000.0	994200.0	995400.0	996600.0	997800.0	999000.0	1000200.0	1001400.0	1002600.0	1003800.0	1005000.0	1006200.0	1007400.0	1008600.0	1009800.0	1011000.0	1012200.0	1013400.0	1014600.0	1015800.0	1017000.0	1018200.0	1019400.0	1020600.0	1021800.0	1023000.0	1024200.0	1025400.0	1026600.0	1027800.0	1029000.0	1030200.0	1031400.0	1032600.0	1033800.0	1035000.0	1036200.0	1037400.0	1038600.0	1039800.0	1041000.0	1042200.0	1043400.0	1044600.0	1045800.0	1047000.0	1048200.0	1049400.0	1050600.0	1051800.0	1053000.0	1054200.0	1055400.0	1056600.0	1057800.0	1059000.0	1060200.0	1061400.0	1062600.0	1063800.0	1065000.0	1066200.0	1067400.0	1068600.0	1069800.0	1071000.0	1072200.0	1073400.0	1074600.0	1075800.0	1077000.0	1078200.0	1079400.0	1080600.0	1081800.0	1083000.0	1084200.0	1085400.0	1086600.0	1087800.0	1089000.0	1090200.0	1091400.0	1092600.0	1093800.0	1095000.0	1096200.0	1097400.0	1098600.0	1099800.0	1101000.0	1102200.0	1103400.0	1104600.0	1105800.0	1107000.0	1108200.0	1109400.0	1110600.0	1111800.0	1113000.0	1114200.0	1115400.0	1116600.0	1117800.0	1119000.0	1120200.0	1121400.0	1122600.0	1123800.0	1125000.0	1126200.0	1127400.0	1128600.0	1129800.0	1131000.0	1132200.0	1133400.0	1134600.0	1135800.0	1137000.0	1138200.0	1139400.0	1140600.0	1141800.0	1143000.0	1144200.0	1145400.0	1146600.0	1147800.0	1149000.0	1150200.0	1151400.0	1152600.0	1153800.0	1155000.0	1156200.0	1157400.0	1158600.0	1159800.0	1161000.0	1162200.0	1163400.0	1164600.0	1165800.0	1167000.0	1168200.0	1169400.0	1170600.0	1171800.0	1173000.0	1174200.0	1175400.0	1176600.0	1177800.0	1179000.0	1180200.0	1181400.0	1182600.0	1183800.0	1185000.0	1186200.0	1187400.0	1188600.0	1189800.0	1191000.0	1192200.0	1193400.0	1194600.0	1195800.0	1197000.0	1198200.0	1199400.0	1200600.0	1201800.0	1203000.0	1204200.0	1205400.0	1206600.0	1207800.0	1209000.0	1210200.0	1211400.0	1212600.0	1213800.0	1215000.0	1216200.0	1217400.0	1218600.0	1219800.0	1221000.0	1222200.0	1223400.0	1224600.0	1225800.0	1227000.0	1228200.0	1229400.0	1230600.0	1231800.0	1233000.0	1234200.0	1235400.0	1236600.0	1237800.0	1239000.0	1240200.0	1241400.0	1242600.0	1243800.0	1245000.0	1246200.0	1247400.0	1248600.0	1249800.0	1251000.0	1252200.0	1253400.0	1254600.0	1255800.0	1257000.0	1258200.0	1259400.0	1260600.0	1261800.0	1263000.0	1264200.0	1265400.0	1266600.0	1267800.0	1269000.0	1270200.0	1271400.0	1272600.0	1273800.0	1275000.0	1276200.0	1277400.0	1278600.0	1279800.0	1281000.0	1282200.0	1283400.0	1284600.0	1285800.0	1287000.0	1288200.0	1289400.0	1290600.0	1291800.0	1293000.0	1294200.0	1295400.0	1296600.0	1297800.0	1299000.0	13002

```
In [5]: # Calculate Return on Investment  
chi_mke['ROI'] = ((chi_mke['2018-04'] /  
                    chi_mke['1996-04'])  
                  - 1)  
  
# Calculate Standard Deviation of monthly values  
chi_mke['STD'] = (chi_mke.loc[:, '1996-04' : '2018-04']  
                   .std(skipna = True, axis = 1))  
  
# Calculate historical mean  
chi_mke['Mean'] = (chi_mke.loc[:, '1996-04' : '2018-04']  
                   .mean(skipna = True, axis = 1))  
  
#Calculate Coefficient of Variance  
chi_mke['CV'] = (chi_mke['STD'] /  
                  chi_mke['Mean'])
```

```
In [6]: # Create a dataframe with the mean, standard deviation,  
# and five-point statistics for the STD, Mean, ROI, and CV  
  
chi_mke_stats = pd.DataFrame(chi_mke['STD'].describe())  
  
chi_mke_mean = pd.DataFrame(chi_mke['Mean'].describe())  
chi_mke_stats['Mean'] = chi_mke_mean['Mean']  
  
chi_mke_roi = pd.DataFrame(chi_mke['ROI'].describe())  
chi_mke_stats['ROI'] = chi_mke_roi['ROI']  
  
chi_mke_cv = pd.DataFrame(chi_mke['CV'].describe())  
chi_mke_stats['CV'] = chi_mke_cv['CV']  
  
chi_mke_stats
```

```
Out[6]:
```

	STD	Mean	ROI	CV
count	45.000000	45.000000	43.000000	45.000000
mean	37894.606224	221654.111897	0.558992	0.168266
std	23780.884001	125799.403250	0.265906	0.033581
min	12648.176777	107846.792453	0.176633	0.081532
25%	24769.906710	152288.679245	0.338697	0.155018
50%	29899.075176	177518.125000	0.472995	0.169319
75%	39204.031167	221526.792453	0.728271	0.184721
max	130617.350600	770952.075472	1.155488	0.276589

```
In [7]: # Define the 50%, upper limit for Coefficient of Variance  
  
chi_mke_upper50_cv = chi_mke['CV'].quantile(0.5)  
chi_mke_upper50_cv
```

```
Out[7]: 0.16931919318097513
```

```
In [8]: # Drop zipcodes outside of defined risk profile  
  
chi_mke = (chi_mke[chi_mke['CV'] < chi_mke_upper50_cv])
```

```
In [9]: # Define the 25%, highest Return on Investment  
  
chi_mke_upper25_roi = chi_mke['ROI'].quantile(0.50)  
chi_mke_upper25_roi
```

```
Out[9]: 0.44741147501659906
```

```
In [10]: # Drop zipcodes outside defined historical  
# return on investment parameters  
  
chi_mke = chi_mke[chi_mke['ROI'] > chi_mke_upper25_roi]
```

Convert Datetime Data

```
In [11]: # Define datetime columns v none datetime columns for chi_mke  
  
datetime_col = []  
none_datetime_col = []  
  
for c in chi_mke.columns:  
    if c[0].isnumeric():  
        datetime_col.append(c)  
    else:  
        none_datetime_col.append(c)
```

```
In [12]: # Convert datetime columns to datetime data type for chi_mke  
  
datetimes = list(pd.to_datetime(datetime_col,  
                                format = '%Y-%m'))  
  
chi_mke.columns = none_datetime_col + datetimes
```

Reshape Datetime Data

```
In [13]: # Reshape datetime columns from wide to  
# long format for chi_mke  
  
chi_mke = pd.melt(chi_mke,  
                  id_vars = none_datetime_col,  
                  var_name = 'Date',  
                  value_name = 'Price')
```

Assess NA Values

```
In [14]: # Check chi_mke for NA values  
  
pd.DataFrame(chi_mke.isna().sum())
```

```
Out[14]: 0
RegionID 0
Zipcode 0
City 0
State 0
Metro 0
County 0
SizeRank 0
ROI 0
STD 0
Mean 0
CV 0
Date 0
Price 0
```

```
In [15]: # Calculate percentage of rows with NA values

(((chi_mke['Price'].isna().sum())
 / (chi_mke['Price'].sum()))
 * 100)
```

```
Out[15]: 0.0
```

```
In [16]: # Drop NA values from chi_mke

chi_mke.dropna(inplace = True)
```

Additional Data Cleaning

```
In [17]: # Drop RegionID and Metro columns as they no longer contribute to
# the description of the geographic areas after isolating the
# target counties
# Drop SizeRank column as it does not contribute to evaluation metrics

chi_mke.drop(['RegionID',
               'Metro',
               'SizeRank',
               'ROI',
               'STD',
               'Mean',
               'CV'],
               axis = 1,
               inplace = True)
```

```
In [18]: # Rearrange and sort columns by descending geographic area
```

```
chi_mke = chi_mke.reindex(columns = ['State',
                                         'County',
                                         'City',
                                         'Zipcode',
                                         'Date',
                                         'Price'])

chi_mke.sort_values(by = ['State',
                           'County',
                           'City',
                           'Zipcode',
                           'Date'],
                     inplace = True)
```

```
In [19]: # Drop dates in 1996 and 2018 due to incomplete data
```

```
chi_mke = (chi_mke[~ chi_mke['Date']
                    .isin(pd.date_range(start = '2018-01-01 00:00:00',
                                         end = '2018-04-01 00:00:00'))])

chi_mke = (chi_mke[~ chi_mke['Date']
                    .isin(pd.date_range(start = '1996-04-01 00:00:00',
                                         end = '1996-12-01 00:00:00'))])
```

Working Data

```
In [20]: chi_mke.head()
```

```
Out[20]:
```

	State	County	City	Zipcode	Date	Price
90	IL	Lake	Lake Zurich	60047	1997-01-01	257700.0
100	IL	Lake	Lake Zurich	60047	1997-02-01	254900.0
110	IL	Lake	Lake Zurich	60047	1997-03-01	252500.0
120	IL	Lake	Lake Zurich	60047	1997-04-01	250700.0
130	IL	Lake	Lake Zurich	60047	1997-05-01	249700.0

```
In [21]: chi_mke.to_csv(r'C:\Users\westi\Documents\GitHub\the_chiwauke_group\data\chi_
```

```
In [22]: # Display unique zipcodes for chi_mke with State,
# County, and City

zipcodes = chi_mke['Zipcode'].unique()

working_zipcodes = chi_mke.loc[chi_mke['Zipcode'].isin(zipcodes)]
working_zipcodes = (working_zipcodes[working_zipcodes['Date']
                                     == pd.to_datetime('1997-04-01 00:00:00')]
                     .drop(['Date', 'Price'],
                           axis = 1,
                           inplace = True))

working_zipcodes
```

Out[22]:

	State	County	City	Zipcode
120	IL	Lake	Lake Zurich	60047
121	WI	Kenosha	Kenosha	53142
123	WI	Kenosha	Kenosha	53144
125	WI	Kenosha	Pleasant Prairie	53158
127	WI	Kenosha	Twin Lakes	53181
128	WI	Racine	Caledonia	53108
129	WI	Racine	Eagle Lake	53139
126	WI	Racine	Racine	53404
122	WI	Racine	Racine	53405
124	WI	Racine	Waterford	53185

Zipcodes to be modeled following initial filtering by:

- **Location:** located in Lake County, IL, Kenosha County, IL, or Racine County IL
- **Risk:** Below the 50% coefficient of variance upper-limit
- **Historic Return on Investment:** Above the top-25% threshold

```
In [23]: # Create individual dataframes with timeseries
# for each zipcode

z60047 = chi_mke.loc[chi_mke.Zipcode == 60047]
z53142 = chi_mke.loc[chi_mke.Zipcode == 53142]
z53144 = chi_mke.loc[chi_mke.Zipcode == 53144]
z53158 = chi_mke.loc[chi_mke.Zipcode == 53158]
z53181 = chi_mke.loc[chi_mke.Zipcode == 53181]
z53108 = chi_mke.loc[chi_mke.Zipcode == 53108]
z53139 = chi_mke.loc[chi_mke.Zipcode == 53139]
z53404 = chi_mke.loc[chi_mke.Zipcode == 53404]
z53405 = chi_mke.loc[chi_mke.Zipcode == 53405]
z53185 = chi_mke.loc[chi_mke.Zipcode == 53185]
```

Visualize Data

```
In [24]: # Visualize monthly median housing sales values per zipcode

f, ax = plt.subplots(figsize = (20, 10))

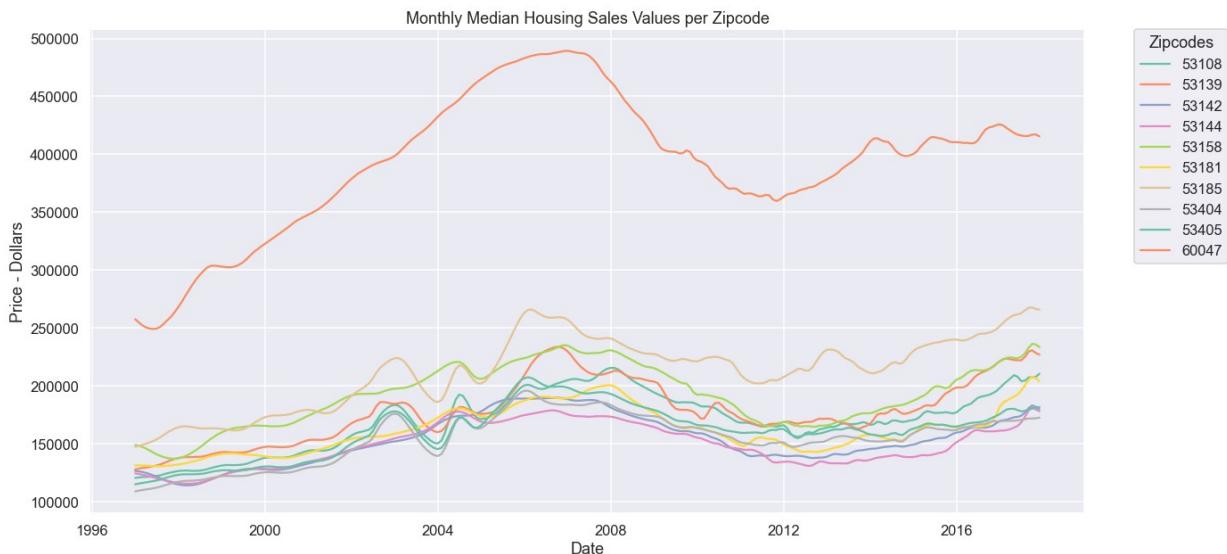
pal = sns.color_palette('Set2', 10)

sns.lineplot(data = chi_mke,
              ax = ax,
              x = 'Date',
              y = 'Price',
              hue = 'Zipcode',
              palette = pal)

ax.set_ylabel('Price - Dollars')

ax.legend(title = 'Zipcodes',
          bbox_to_anchor = (1.05, 1),
          loc = 2,
          borderaxespad = 0)

ax.set_title('Monthly Median Housing Sales Values per Zipcode');
```



An upward trend is visible for all of the zipcodes beginning following the timeperiod in which the recent business development began, 2010-2014.

Stationarity

Functions

```
In [25]: def should_diff(z):  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z['Price'].dropna()  
  
    '''Use pmdarima ADF Test to determine if zipcode should be differenced'''  
  
    adf_test = ADFTest(alpha = 0.05)  
    p_val, should_diff = adf_test.should_diff(price)  
  
    print('Should Difference:', should_diff)
```

```
In [26]: def n_diffs(z):  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z['Price'].dropna()  
  
    '''Use pmdarima to calculate number of differences'''  
  
    n_diffs = ndiffs(price, test = 'adf')  
  
    print('Number of Differences:', n_diffs)
```

```
In [27]: def n_seasonal_diffs(z):  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z['Price'].dropna()  
  
    '''Use pmdarima to calculate number of seasonal differences'''  
  
    n_seasonal_diffs = nsdiffs(price,  
                               m = 12,  
                               max_D = 12,  
                               test = 'ch')  
  
    print('Number of Seasonal Differences:', n_seasonal_diffs)
```

In [28]:

```
def adf(z):

    '''Select Price from zipcode dataframe'''

    price = z['Price'].dropna()

    '''Perform Statsmodel Dickey-Fuller test with a confidence level of 95%'''

    results = adfuller(price)

    '''Create dataframe displaying results'''

    output = pd.Series(results[0 : 4],
                        index = ['Test Statistic',
                                'P-value',
                                'Lags Used',
                                'Number of Observations'])

    '''Add critical values to results dataframe'''

    for key,value in results[4].items():
        output['Critical Value (%s)' %key] = value

    print('Results - Dickey-Fuller Test')
    display(pd.DataFrame(output))
```

```
In [29]: def plot_rolling(z):  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z['Price'].dropna()  
  
    '''Calculate rolling price mean'''  
  
    rolling_mean = (price.rolling(window = 12,  
                                    center = False)  
                    .mean())  
  
    '''Calculate rolling price standard deviation'''  
  
    rolling_std = (price.rolling(window = 12,  
                                 center = False)  
                   .std())  
  
    '''Create Plot'''  
  
    f, ax = plt.subplots(figsize = (20, 10))  
  
    '''Visualize Price v Date'''  
  
    ax = sns.lineplot(data = z,  
                      label = 'Price',  
                      x = 'Date',  
                      y = 'Price',  
                      color = 'blueviolet')  
  
    '''Visualize Rolling Price Mean'''  
  
    ax = sns.lineplot(data = z,  
                      label = 'Rolling Price Mean',  
                      x = 'Date',  
                      y = rolling_mean,  
                      color = 'aqua')  
  
    '''Visualize Rolling Price Mean'''  
  
    ax = sns.lineplot(data = z,  
                      label = 'Rolling Price STD',  
                      x = 'Date',  
                      y = rolling_std + rolling_mean,  
                      color = 'lightcoral')  
  
    ax.legend(title = 'Zipcodes',  
              bbox_to_anchor = (1.05, 1),  
              loc = 2,  
              borderaxespad = 0)  
  
    ax.set_title('Monthly Price v Rolling Price Mean v Rolling Standard Deviation')  
    ax.set_ylabel('Price - Dollars')  
  
    plt.show();
```

60047

```
In [30]: should_diff(z60047)  
n_diffs(z60047)  
n_seasonal_diffs(z60047)
```

Should Difference: True
Number of Differences: 1
Number of Seasonal Differences: 0

```
In [31]: z60047['Price'] = z60047['Price'].diff(periods = 1)  
should_diff(z60047)
```

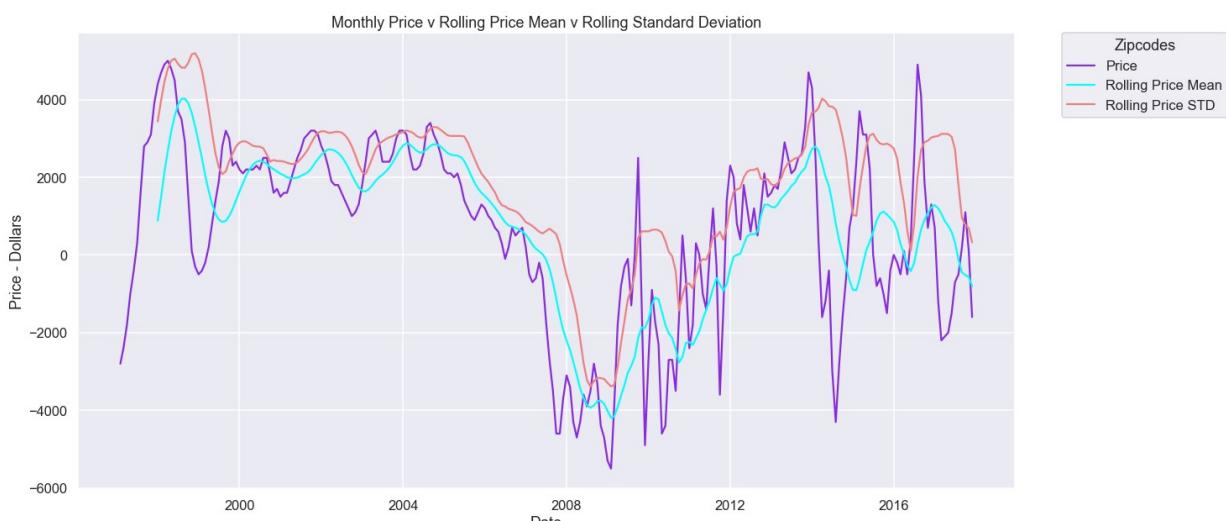
Should Difference: False

```
In [32]: adf(z60047)
```

Results - Dickey-Fuller Test

0	
Test Statistic	-1.804858
P-value	0.378053
Lags Used	15.000000
Number of Observations	235.000000
Critical Value (1%)	-3.458487
Critical Value (5%)	-2.873919
Critical Value (10%)	-2.573367

```
In [33]: plot_rolling(z60047)
```



53142

```
In [34]: should_diff(z53142)
```

```
n_diffs(z53142)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 2  
Number of Seasonal Differences: 0
```

```
In [35]: z53142['Price'] = z53142['Price'].diff(periods = 2)
```

```
should_diff(z53142)
```

```
Should Difference: True
```

```
In [36]: adf(z53142)
```

```
plot_rolling(z53142)
```

```
Results - Dickey-Fuller Test
```

0

Test Statistic	-1.987602
P-value	0.292035
Lags Used	16.000000
Number of Observations	233.000000
Critical Value (1%)	-3.458731
Critical Value (5%)	-2.874026
Critical Value (10%)	-2.573424



53144

```
In [37]: should_diff(z53144)
```

```
n_diffs(z53144)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [38]: z53144['Price'] = z53144['Price'].diff(periods = 1)
```

```
should_diff(z53144)
```

```
Should Difference: False
```

```
In [39]: adf(z53144)
```

```
plot_rolling(z53144)
```

Results - Dickey-Fuller Test

0	
Test Statistic	-2.146548
P-value	0.226214
Lags Used	13.000000
Number of Observations	237.000000
Critical Value (1%)	-3.458247
Critical Value (5%)	-2.873814
Critical Value (10%)	-2.573311



53158

```
In [40]: should_diff(z53158)
```

```
n_diffs(z53158)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [41]: z53158['Price'] = z53158['Price'].diff(periods = 1)
```

```
should_diff(z53158)
```

```
Should Difference: False
```

```
In [42]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

	0
--	---

Test Statistic	-2.488558
----------------	-----------

P-value	0.118283
---------	----------

Lags Used	12.000000
-----------	-----------

Number of Observations	238.000000
------------------------	------------

Critical Value (1%)	-3.458128
---------------------	-----------

Critical Value (5%)	-2.873762
---------------------	-----------

Critical Value (10%)	-2.573283
----------------------	-----------



53181

```
In [43]: should_diff(z53181)
```

```
n_diffs(z53181)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [44]: z53181['Price'] = z53181['Price'].diff(periods = 1)
```

```
should_diff(z53181)
```

```
Should Difference: False
```

```
In [45]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

	0
--	---

Test Statistic	-2.488558
----------------	-----------

P-value	0.118283
---------	----------

Lags Used	12.000000
-----------	-----------

Number of Observations	238.000000
------------------------	------------

Critical Value (1%)	-3.458128
---------------------	-----------

Critical Value (5%)	-2.873762
---------------------	-----------

Critical Value (10%)	-2.573283
----------------------	-----------



53108

```
In [46]: should_diff(z53108)
```

```
n_diffs(z53108)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [47]: z53108['Price'] = z53108['Price'].diff(periods = 1)
```

```
should_diff(z53108)
```

```
Should Difference: False
```

```
In [48]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

	0
Test Statistic	-2.488558
P-value	0.118283
Lags Used	12.000000
Number of Observations	238.000000
Critical Value (1%)	-3.458128
Critical Value (5%)	-2.873762
Critical Value (10%)	-2.573283



53139

```
In [49]: should_diff(z53139)
```

```
n_diffs(z53139)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [50]: z53139['Price'] = z53139['Price'].diff(periods = 1)
```

```
should_diff(z53139)
```

```
Should Difference: False
```

```
In [51]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

	0
--	---

Test Statistic	-2.488558
----------------	-----------

P-value	0.118283
---------	----------

Lags Used	12.000000
-----------	-----------

Number of Observations	238.000000
------------------------	------------

Critical Value (1%)	-3.458128
---------------------	-----------

Critical Value (5%)	-2.873762
---------------------	-----------

Critical Value (10%)	-2.573283
----------------------	-----------



53404

```
In [52]: should_diff(z53404)  
n_diffs(z53404)  
n_seasonal_diffs(z60047)
```

Should Difference: True
Number of Differences: 1
Number of Seasonal Differences: 0

```
In [53]: z53404['Price'] = z53404['Price'].diff(periods = 1)  
should_diff(z53404)
```

Should Difference: False

```
In [54]: adf(z53158)  
plot_rolling(z53158)
```

Results - Dickey-Fuller Test

0	
Test Statistic	-2.488558
P-value	0.118283
Lags Used	12.000000
Number of Observations	238.000000
Critical Value (1%)	-3.458128
Critical Value (5%)	-2.873762
Critical Value (10%)	-2.573283



53405

```
In [55]: should_diff(z53405)
```

```
n_diffs(z53405)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [56]: z53405['Price'] = z53405['Price'].diff(periods = 1)
```

```
should_diff(z53405)
```

```
Should Difference: False
```

```
In [57]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

	0
--	---

Test Statistic	-2.488558
----------------	-----------

P-value	0.118283
---------	----------

Lags Used	12.000000
-----------	-----------

Number of Observations	238.000000
------------------------	------------

Critical Value (1%)	-3.458128
---------------------	-----------

Critical Value (5%)	-2.873762
---------------------	-----------

Critical Value (10%)	-2.573283
----------------------	-----------



53185

```
In [58]: should_diff(z53185)
```

```
n_diffs(z53185)
```

```
n_seasonal_diffs(z60047)
```

```
Should Difference: True  
Number of Differences: 1  
Number of Seasonal Differences: 0
```

```
In [59]: z53185['Price'] = z53185['Price'].diff(periods = 1)
```

```
should_diff(z53185)
```

```
Should Difference: False
```

```
In [60]: adf(z53158)
```

```
plot_rolling(z53158)
```

```
Results - Dickey-Fuller Test
```

0

Test Statistic -2.488558

P-value 0.118283

Lags Used 12.000000

Number of Observations 238.000000

Critical Value (1%) -3.458128

Critical Value (5%) -2.873762

Critical Value (10%) -2.573283



```
In [61]: # Resest zipcode dataframes, remove differencing  
# Autoarima will assess stationarity for modeling  
  
z60047 = chi_mke.loc[chi_mke.Zipcode == 60047]  
z53142 = chi_mke.loc[chi_mke.Zipcode == 53142]  
z53144 = chi_mke.loc[chi_mke.Zipcode == 53144]  
z53158 = chi_mke.loc[chi_mke.Zipcode == 53158]  
z53181 = chi_mke.loc[chi_mke.Zipcode == 53181]  
z53108 = chi_mke.loc[chi_mke.Zipcode == 53108]  
z53139 = chi_mke.loc[chi_mke.Zipcode == 53139]  
z53404 = chi_mke.loc[chi_mke.Zipcode == 53404]  
z53405 = chi_mke.loc[chi_mke.Zipcode == 53405]  
z53185 = chi_mke.loc[chi_mke.Zipcode == 53185]
```

Modeling

Seasonal Auto Regressive Integrated Moving Average with Exogenous Factors

Time Series Model where each data point is associated with a time and the model predicts the next data based on statistical assessment of previous data.

Evaluation Metrics

Akaike Information Criterion (AIC)

- Evaluation of the fit of the model's predictions compared to the training data, measured by error
- Adds a penalty for complexity, higher complexity can increase the likelihood of overfitting
- Provides a standardized score which can be compared relative to other models

Root Mean Square Error (RMSE)

- The standard deviation of the residuals of the model
- A measure of how concentrated the actual data is around the model's prediction
- Used to assess the quality of fit of the final SARIMAX model

Functions

```
In [62]: def acf_pacf(z):  
  
    '''Create plot'''  
  
    f, (ax1, ax2) = plt.subplots(2, 1,  
                                figsize = (20, 10))  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z.loc[ :, 'Price'].dropna()  
  
    '''Visualize Statsmodel Autocorrelation plot'''  
  
    plot_acf(price,  
              lags = [12, 24, 36, 48, 60, 72],  
              color = 'blueviolet',  
              vlines_kwarg = {'colors' : 'blueviolet'},  
              ax = ax1)  
  
    for i in ax1.collections:  
        if type(i) == PolyCollection:  
            i.set_facecolor('blueviolet')  
  
    '''Visualize Statsmodel Partial Autocorrelation plot'''  
  
    plot_pacf(price,  
              lags = [12, 24, 36, 48, 60, 72],  
              color = 'blueviolet',  
              vlines_kwarg = {'colors' : 'blueviolet'},  
              ax = ax2)  
  
    for i in ax2.collections:  
        if type(i) == PolyCollection:  
            i.set_facecolor('blueviolet')  
  
    plt.show();
```

```
In [63]: def seasonal_acf_pacf(z):  
  
    '''Create plot'''  
  
    f, (ax1, ax2) = plt.subplots(2, 1,  
                                figsize = (20, 10))  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z.loc[:, 'Price'].dropna()  
  
    '''Calculate rolling price mean'''  
  
    rolling_mean = (price.rolling(window = 12,  
                                    center = False)  
                    .mean())  
  
    '''Difference the rolling mean'''  
  
    rolling = rolling_mean.diff(periods = 1)  
  
    '''Visualize Statsmodel Autocorrelation plot'''  
  
    plot_acf(rolling.dropna(),  
             lags = [12, 24, 36, 48, 60, 72],  
             color = 'blueviolet',  
             vlines_kwarg = {'colors' : 'blueviolet'},  
             ax = ax1)  
  
    for i in ax1.collections:  
        if type(i) == PolyCollection:  
            i.set_facecolor('blueviolet')  
  
    '''Visualize Statsmodel Partial Autocorrelation plot'''  
  
    plot_pacf(rolling.dropna(),  
              lags = [12, 24, 36, 48, 60, 72],  
              color = 'blueviolet',  
              vlines_kwarg = {'colors' : 'blueviolet'},  
              ax = ax2)  
  
    for i in ax2.collections:  
        if type(i) == PolyCollection:  
            i.set_facecolor('blueviolet')  
  
    plt.show();
```

```
In [64]: def train_test(z):  
  
    '''Select Price from zipcode dataframe'''  
  
    price = z.loc[:, 'Price'].dropna()  
  
    '''Set Train/Test split'''  
  
    train = price[: 216]  
    test = price[-45 :]  
  
    return train, test
```

```
In [65]: def params(z):  
  
    '''Train/Test splot zipcode dataframe'''  
  
    train, test = train_test(z)  
  
    '''Utilize Auto-Arima to find the best parameters for modeling'''  
  
    pmdarima.auto_arima(train,  
                         information_criterion = 'aic',  
                         m = 12,  
                         d = 0,  
                         start_p = 1,  
                         start_q = 1,  
                         max_p = 3,  
                         max_q = 3,  
                         stepwise = True,  
                         trace = True)
```

```
In [66]: def model_fit(z, order, seasonal_order):  
    '''Train/Test splot zipcode dataframe'''  
  
    train, test = train_test(z)  
  
    '''Fit SARIMAX model with parameters from Auto-Arima'''  
  
    model = SARIMAX(train,  
                    order = order,  
                    seasonal_order = seasonal_order,  
                    enforce_stationarity = False,  
                    enforce_invertibility = False)  
  
    '''Display model results summary'''  
  
    results = model.fit()  
  
    results.summary  
  
    display(results.summary())  
  
    '''Visualize Statsmodel diagnostic plots for model results'''  
  
    results.plot_diagnostics(figsize = (15, 15))  
    plt.show();
```

```
In [67]: def train_rmse(z, order, seasonal_order):  
  
    '''Train/Test splot zipcode dataframe'''  
  
    train, test = train_test(z)  
  
    '''Fit SARIMAX model with parameters from Auto-Arima'''  
  
    model = SARIMAX(train,  
                     order = order,  
                     seasonal_order = seasonal_order,  
                     enforce_stationarity = False,  
                     enforce_invertibility = False)  
  
    results = model.fit()  
  
    '''Produce model predictions'''  
  
    prediction = results.predict().dropna()  
  
    '''Calculate Root Mean Squared Error for Train Data v Prediction'''  
  
    rmse = math.sqrt(mean_squared_error(train,  
                                         prediction))  
  
    print('Train RMSE:', rmse)  
  
    '''Create dataframe with train data, model predictions, and date'''  
  
    df = pd.DataFrame({'Train Data' : train,  
                      'Prediction' : prediction,  
                      'Date' : z['Date'][: 216]})  
  
    '''Set dataframe index to date'''  
  
    df.set_index('Date', inplace = True)  
  
    '''Visualize Train Data v Prediction'''  
  
    f, ax = plt.subplots(figsize = (20, 10))  
  
    ax = sns.lineplot(data = df,  
                      label = 'Train Data',  
                      x = 'Date',  
                      y = 'Train Data',  
                      color = 'blueviolet')  
  
    ax = sns.lineplot(data = df,  
                      label = 'Prediction',  
                      x = 'Date',  
                      y = 'Prediction',  
                      color = 'aqua')  
  
    ax.legend(title = 'Zipcodes',  
              bbox_to_anchor = (1.05, 1),  
              loc = 2,  
              borderaxespad = 0)  
    ax.set_title('Train Data v Prediction');
```

```
'''Fit SARIMAX model with parameters from Auto-Arima'''

model = SARIMAX(test,
                  order = order,
                  seasonal_order = seasonal_order,
                  enforce_stationarity = False,
                  enforce_invertibility = False)

results = model.fit()

'''Produce model predictions'''

prediction = results.predict().dropna()

'''Calculate Root Mean Squared Error for Train Data v Prediction'''

rmse = math.sqrt(mean_squared_error(test,
                                     prediction))

print('Train RMSE:', rmse)

'''Create dataframe with train data, model predictions, and date'''

df = pd.DataFrame({'Test Data' : test,
                    'Prediction' : prediction,
                    'Date' : z['Date'][: 216]})

'''Set dataframe index to date'''

df.set_index('Date', inplace = True)

'''Create plot'''

f, ax = plt.subplots(figsize = (20, 10))

'''Visualize Test Data v Prediction'''

ax = sns.lineplot(data = df,
                   label = 'Test Data',
                   x = 'Date',
                   y = 'Test Data',
                   color = 'blueviolet')

ax = sns.lineplot(data = df,
                   label = 'Prediction',
                   x = 'Date',
                   y = 'Prediction',
                   color = 'aqua')

ax.legend(title = 'Zipcodes',
          bbox_to_anchor = (1.05, 1),
```

```
In [68]: def forecast(z, order, seasonal_order):  
  
    '''Train/Test splot zipcode dataframe'''  
  
    price = z.loc[:, 'Price'].dropna()  
  
    '''Fit SARIMAX model with parameters from Auto-Arima'''  
  
    model = SARIMAX(price,  
                     order = order,  
                     seasonal_order = seasonal_order)  
  
    results = model.fit()  
  
    '''Produce model forecast'''  
  
    output = results.get_forecast(steps = 120)  
  
    '''Create dataframe with model forecast and date'''  
  
    df = pd.DataFrame({ 'Price': output.predicted_mean.dropna(),  
                        'Date': pd.to_datetime(pd.date_range(start = '2018-01-  
                                         freq = 'M',  
                                         periods = 120),  
                                         120) },  
                       columns = ['Price', 'Date'])  
  
    '''Set dataframe index to date'''  
  
    df.set_index('Date', inplace = True)  
  
    '''Produce forecast confidence interval'''  
  
    forecast_ci = output.conf_int()  
  
    '''Create plot'''  
  
    fig, ax = plt.subplots(figsize = (20, 10))  
  
    '''Visualize forecasted price with confidence interval'''  
  
    ax = sns.lineplot(data = df,  
                      label = 'Price',  
                      x = 'Date',  
                      y = 'Price',  
                      color = 'blueviolet')  
  
    ax.fill_between(df['Price'].index,  
                    forecast_ci.iloc[:, 0],  
                    forecast_ci.iloc[:, 1],  
                    color = 'blueviolet',  
                    alpha = 0.05)
```

```
    autocorrelation = z,
    plt.show()

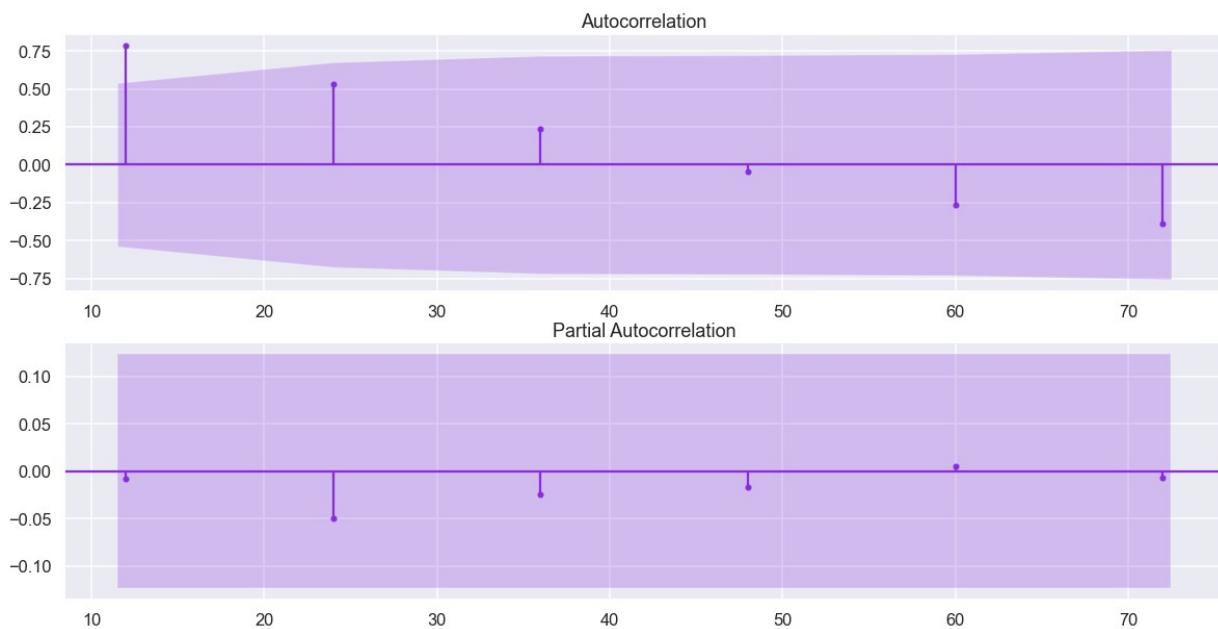
    '''Calculate difference in forecasted 5-year price from starting price'''

    start = z['Price'].iloc[1].item()
    year_5 = ((output.predicted_mean[:60].iloc[-1]) - start)

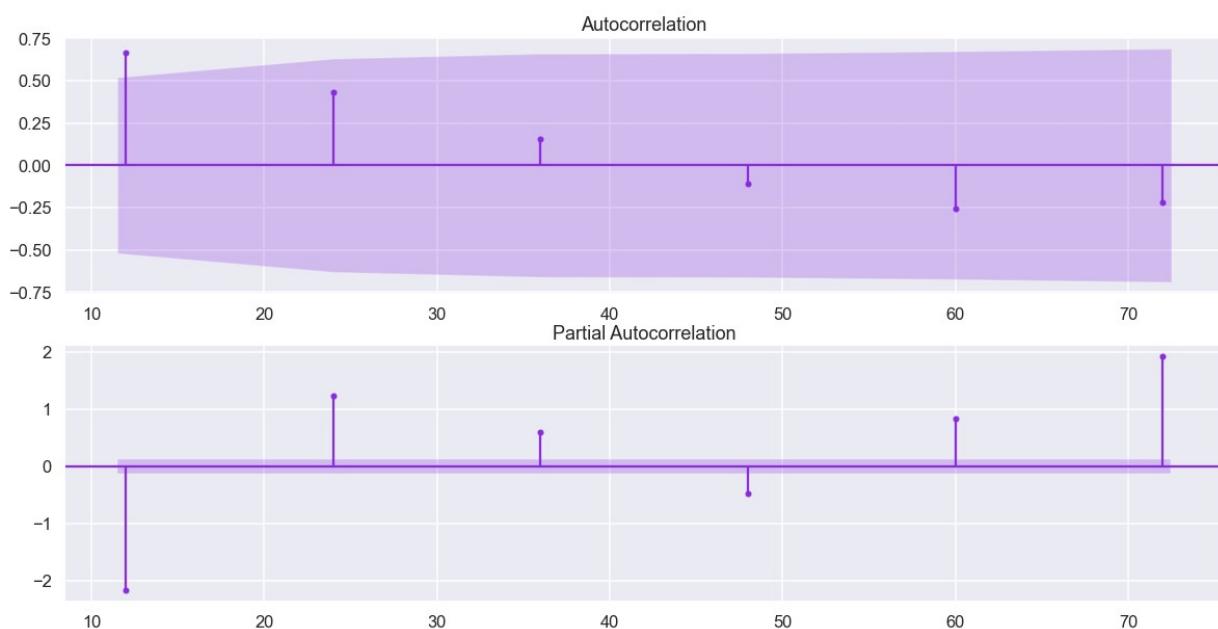
    print(f'Expected Return - Five-Years: ${year_5.round(2)}')
```

60047

In [69]: acf_pacf(z60047)



In [70]: seasonal_acf_pacf(z60047)



In [71]: `params(z60047)`

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept : AIC=3741.535, Time=1.89 sec
ARIMA(0,0,0)(0,0,0)[12] intercept : AIC=5395.043, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept : AIC=4007.797, Time=2.49 sec
ARIMA(0,0,1)(0,0,1)[12] intercept : AIC=inf, Time=1.29 sec
ARIMA(0,0,0)(0,0,0)[12] intercept : AIC=6180.905, Time=0.02 sec
ARIMA(1,0,1)(0,0,1)[12] intercept : AIC=inf, Time=0.89 sec
ARIMA(1,0,1)(1,0,0)[12] intercept : AIC=inf, Time=1.03 sec
ARIMA(1,0,1)(2,0,1)[12] intercept : AIC=inf, Time=11.57 sec
ARIMA(1,0,1)(1,0,2)[12] intercept : AIC=inf, Time=4.82 sec
ARIMA(1,0,1)(0,0,0)[12] intercept : AIC=3782.524, Time=0.45 sec
ARIMA(1,0,1)(0,0,2)[12] intercept : AIC=inf, Time=2.31 sec
ARIMA(1,0,1)(2,0,0)[12] intercept : AIC=6120.464, Time=4.79 sec
ARIMA(1,0,1)(2,0,2)[12] intercept : AIC=3802.417, Time=8.77 sec
ARIMA(0,0,1)(1,0,1)[12] intercept : AIC=5199.730, Time=0.62 sec
ARIMA(1,0,0)(1,0,1)[12] intercept : AIC=3999.480, Time=0.48 sec
ARIMA(2,0,1)(1,0,1)[12] intercept : AIC=inf, Time=1.57 sec
ARIMA(1,0,2)(1,0,1)[12] intercept : AIC=inf, Time=2.29 sec
ARIMA(0,0,0)(1,0,1)[12] intercept : AIC=5277.642, Time=0.39 sec
ARIMA(0,0,2)(1,0,1)[12] intercept : AIC=5159.874, Time=0.77 sec
ARIMA(2,0,0)(1,0,1)[12] intercept : AIC=3571.238, Time=1.70 sec
ARIMA(2,0,0)(0,0,1)[12] intercept : AIC=3572.831, Time=0.42 sec
ARIMA(2,0,0)(1,0,0)[12] intercept : AIC=3572.094, Time=4.38 sec
ARIMA(2,0,0)(2,0,1)[12] intercept : AIC=36368.035, Time=7.63 sec
ARIMA(2,0,0)(1,0,2)[12] intercept : AIC=3569.141, Time=2.56 sec
ARIMA(2,0,0)(0,0,2)[12] intercept : AIC=3566.365, Time=3.55 sec
ARIMA(1,0,0)(0,0,2)[12] intercept : AIC=3971.539, Time=0.67 sec
ARIMA(3,0,0)(0,0,2)[12] intercept : AIC=inf, Time=4.82 sec
ARIMA(2,0,1)(0,0,2)[12] intercept : AIC=3495.174, Time=2.86 sec
ARIMA(2,0,1)(0,0,1)[12] intercept : AIC=3498.051, Time=0.86 sec
ARIMA(2,0,1)(1,0,2)[12] intercept : AIC=3494.932, Time=4.51 sec
ARIMA(2,0,1)(2,0,2)[12] intercept : AIC=inf, Time=6.72 sec
ARIMA(2,0,1)(2,0,1)[12] intercept : AIC=5355.473, Time=13.28 sec
ARIMA(3,0,1)(1,0,2)[12] intercept : AIC=3502.993, Time=5.81 sec
ARIMA(2,0,2)(1,0,2)[12] intercept : AIC=3494.032, Time=6.36 sec
ARIMA(2,0,2)(0,0,2)[12] intercept : AIC=3494.736, Time=2.43 sec
ARIMA(2,0,2)(1,0,1)[12] intercept : AIC=inf, Time=2.34 sec
ARIMA(2,0,2)(2,0,2)[12] intercept : AIC=inf, Time=8.64 sec
ARIMA(2,0,2)(0,0,1)[12] intercept : AIC=3497.299, Time=1.48 sec
ARIMA(2,0,2)(2,0,1)[12] intercept : AIC=inf, Time=nan sec
ARIMA(1,0,2)(1,0,2)[12] intercept : AIC=inf, Time=8.74 sec
ARIMA(3,0,2)(1,0,2)[12] intercept : AIC=3474.887, Time=8.15 sec
ARIMA(3,0,2)(0,0,2)[12] intercept : AIC=3477.227, Time=6.54 sec
ARIMA(3,0,2)(1,0,1)[12] intercept : AIC=3478.996, Time=2.97 sec
ARIMA(3,0,2)(2,0,2)[12] intercept : AIC=4042.566, Time=19.09 sec
ARIMA(3,0,2)(0,0,1)[12] intercept : AIC=3480.261, Time=1.65 sec
ARIMA(3,0,2)(2,0,1)[12] intercept : AIC=5558.382, Time=21.94 sec
ARIMA(3,0,3)(1,0,2)[12] intercept : AIC=3456.782, Time=8.56 sec
ARIMA(3,0,3)(0,0,2)[12] intercept : AIC=3455.851, Time=6.50 sec
ARIMA(3,0,3)(0,0,1)[12] intercept : AIC=3456.113, Time=2.55 sec
ARIMA(3,0,3)(1,0,1)[12] intercept : AIC=3459.130, Time=2.89 sec
ARIMA(2,0,3)(0,0,2)[12] intercept : AIC=3460.855, Time=5.23 sec
ARIMA(3,0,3)(0,0,2)[12] intercept : AIC=3459.036, Time=5.61 sec
```

Best model: ARIMA(3,0,3)(0,0,2)[12] intercept
Total fit time: 231.591 seconds

In [72]: `model_fit(z60047, (3, 0, 3), (0, 0, 2, 12))`

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\mod
el.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to conve
rge. Check mle_retrvals
~~~~~ "Maximum Likelihood optimization failed to ~"
```

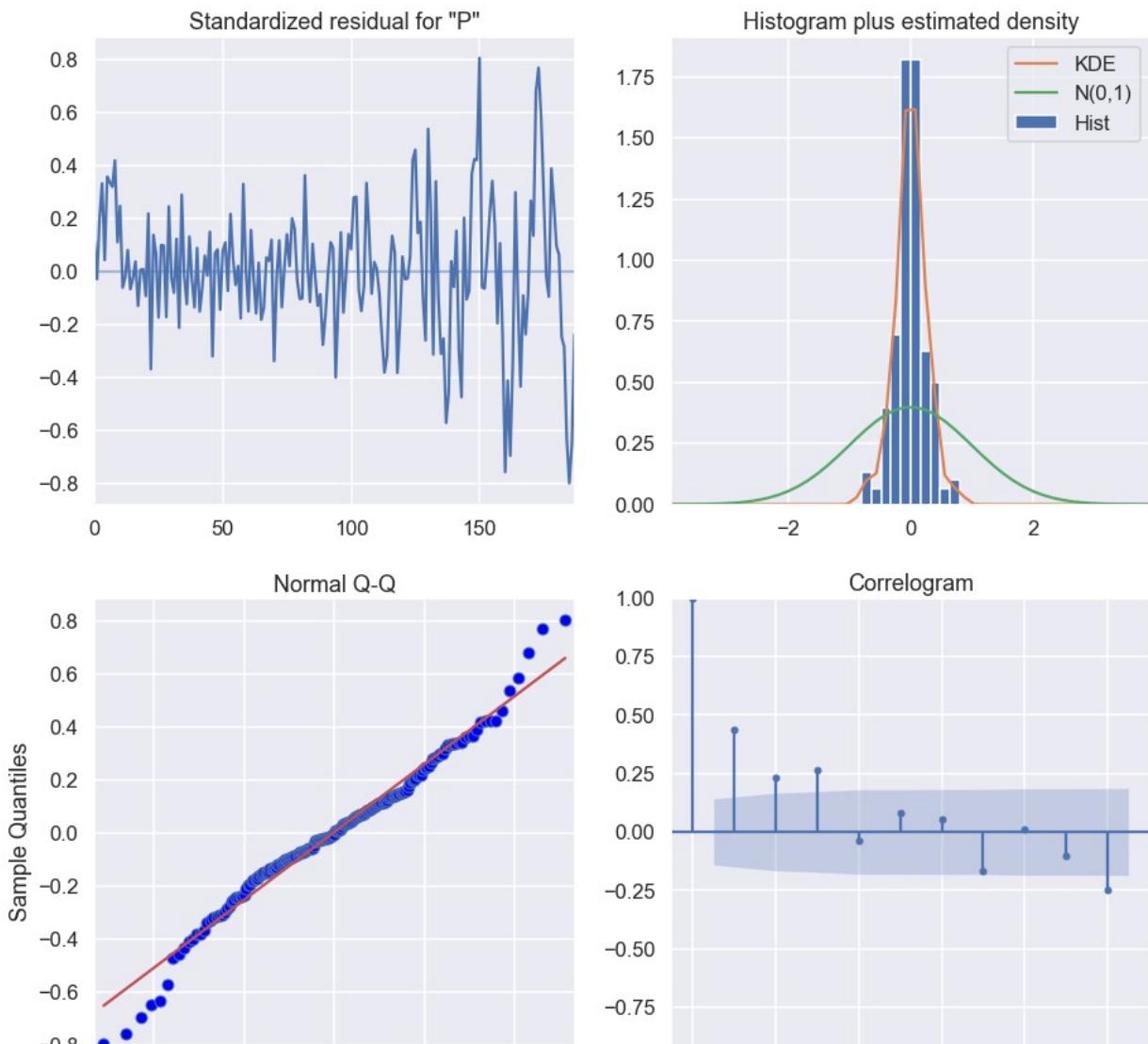
SARIMAX Results

Dep. Variable:	Price	No. Observations:	216			
Model:	SARIMAX(3, 0, 3)x(0, 0, [1, 2], 12)	Log Likelihood	-2048.065			
Date:	Fri, 21 May 2021	AIC	4114.129			
Time:	14:01:02	BIC	4143.257			
Sample:	0	HQIC	4125.931			
	- 216					
Covariance Type:	opg					
	coef	std err	z	P> z 	[0.025	.975]
ar.L1	1.3769	0.497	2.772	0.006	0.403	2.350
ar.L2	-0.1870	0.933	-0.200	0.841	-2.016	1.642
ar.L3	-0.1882	0.550	-0.342	0.732	-1.267	0.890
ma.L1	2.0752	1.328	1.563	0.118	-0.527	4.677
ma.L2	2.0353	1.612	1.262	0.207	-1.124	5.195
ma.L3	0.9188	1.317	0.698	0.485	-1.662	3.499
ma.S.L12	27.1616	3.297	8.238	0.000	20.700	33.624
ma.S.L24	33.8335	3.124	10.830	0.000	27.711	39.956
sigma2	5.118e+05	0.000	3.09e+09	0.000	5.12e+05	5.12e+05
Ljung-Box (L1) (Q):	36.08	Jarque-Bera (JB):	10.71			
Prob(Q):	0.00	Prob(JB):	0.00			
Heteroskedasticity (H):	4.75	Skew:	-0.11			
Prob(H) (two-sided):	0.00	Kurtosis:	4.15			

Warnings:

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

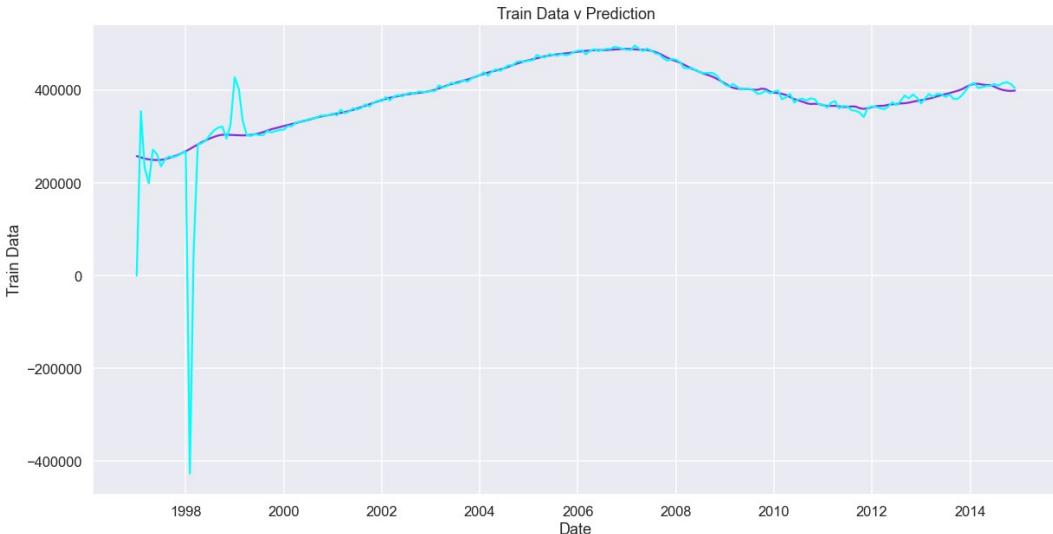
[2] Covariance matrix is singular or near-singular, with condition number 4.76e+24. Standard errors may be unstable.



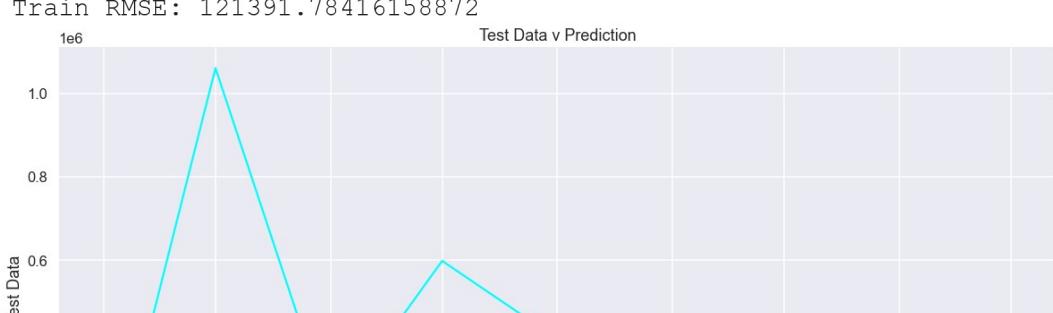
```
In [73]: train_rmse(z60047, (3, 0, 3), (0, 0, 2, 12))

test_rmse(z60047, (3, 0, 3), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
  warnings.warn("Maximum Likelihood optimization failed to "
Train RMSE: 55112.78713231076
```



```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
Train RMSE: 121391.78416158872
```



```
In [74]: forecast(z60047, (3, 0, 3), (0, 0, 2, 12))
```

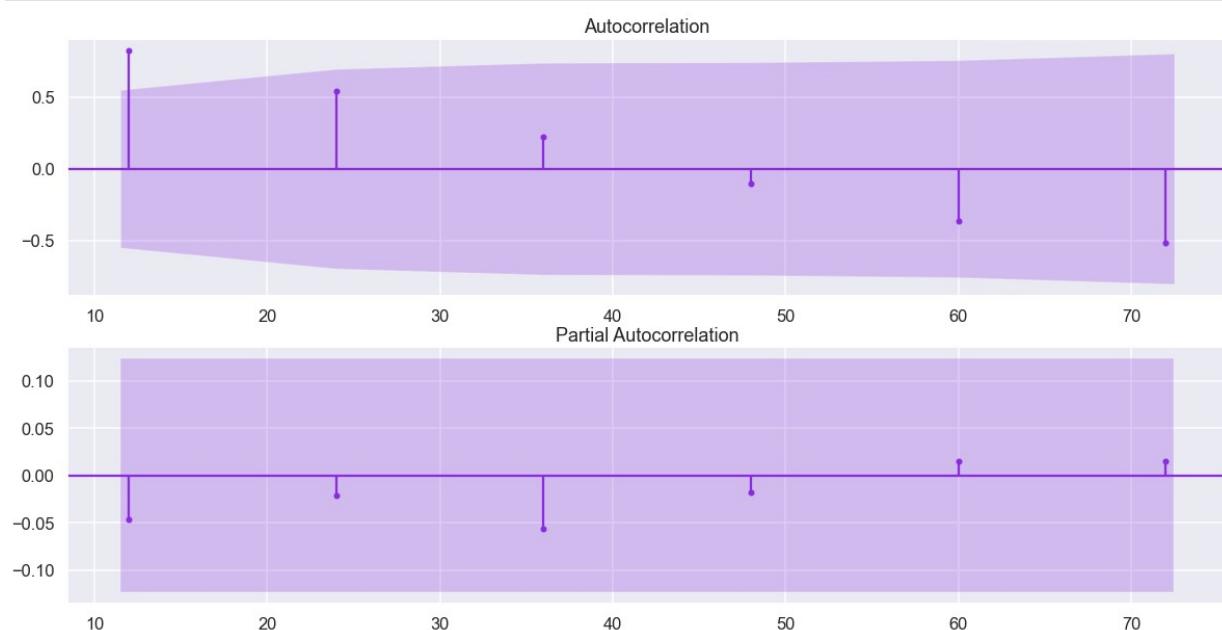
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.  
    warnings.warn('No supported index is available.'
```



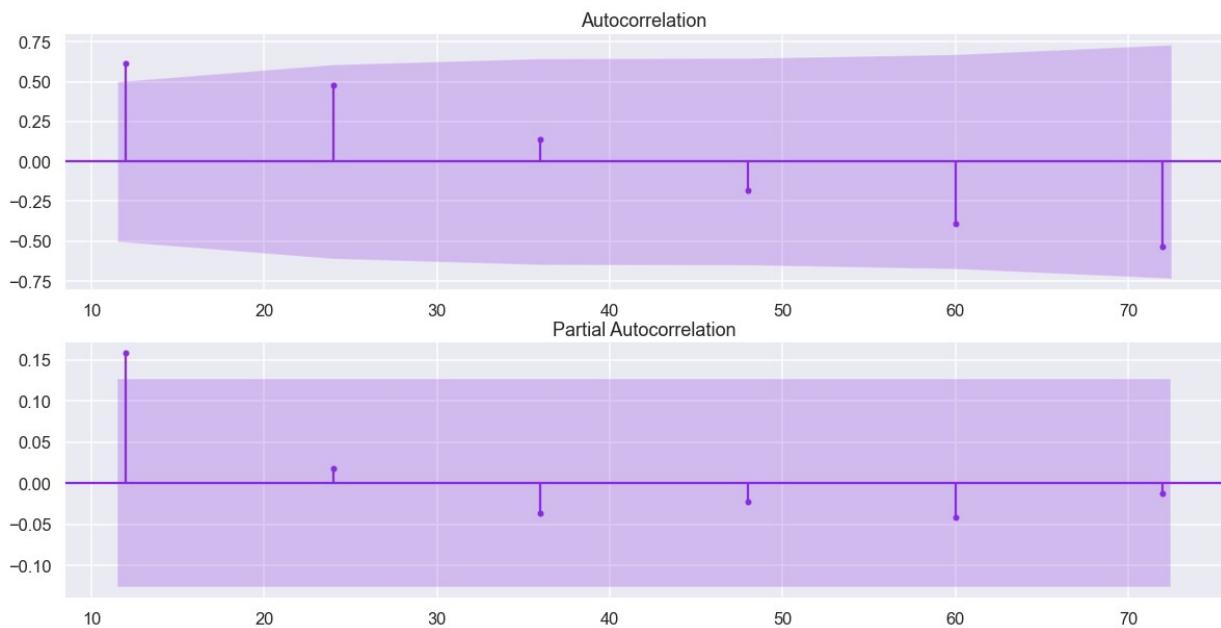
```
In [75]: zipcode = ['60047']
year5 = [149388.39]
```

53142

```
In [76]: acf_pacf(z53142)
```



```
In [77]: seasonal_acf_pacf(z53142)
```



```
In [78]: params(z53142)
```

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept      : AIC=3300.826, Time=2.42 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=4943.020, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=inf, Time=8.71 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.67 sec
ARIMA(0,0,0)(0,0,0)[12]               : AIC=5773.868, Time=0.02 sec
ARIMA(1,0,1)(0,0,1)[12] intercept      : AIC=3308.195, Time=0.77 sec
ARIMA(1,0,1)(1,0,0)[12] intercept      : AIC=3299.385, Time=1.19 sec
ARIMA(1,0,1)(0,0,0)[12] intercept      : AIC=3327.346, Time=0.33 sec
ARIMA(1,0,1)(2,0,0)[12] intercept      : AIC=3296.351, Time=3.41 sec
ARIMA(1,0,1)(2,0,1)[12] intercept      : AIC=inf, Time=9.11 sec
ARIMA(0,0,1)(2,0,0)[12] intercept      : AIC=4781.965, Time=2.04 sec
ARIMA(1,0,0)(2,0,0)[12] intercept      : AIC=inf, Time=25.78 sec
ARIMA(2,0,1)(2,0,0)[12] intercept      : AIC=3035.935, Time=5.84 sec
ARIMA(2,0,1)(1,0,0)[12] intercept      : AIC=3039.418, Time=1.95 sec
ARIMA(2,0,1)(2,0,1)[12] intercept      : AIC=3054.628, Time=10.98 sec
ARIMA(2,0,1)(1,0,1)[12] intercept      : AIC=3037.241, Time=2.10 sec
ARIMA(2,0,0)(2,0,0)[12] intercept      : AIC=3097.439, Time=45.97 sec
ARIMA(3,0,1)(2,0,0)[12] intercept      : AIC=3036.987, Time=7.95 sec
ARIMA(2,0,2)(2,0,0)[12] intercept      : AIC=3035.315, Time=5.75 sec
ARIMA(2,0,2)(1,0,0)[12] intercept      : AIC=3037.438, Time=2.23 sec
ARIMA(2,0,2)(2,0,1)[12] intercept      : AIC=3428.921, Time=11.63 sec
ARIMA(2,0,2)(1,0,1)[12] intercept      : AIC=3037.091, Time=1.37 sec
ARIMA(1,0,2)(2,0,0)[12] intercept      : AIC=3146.203, Time=5.28 sec
ARIMA(3,0,2)(2,0,0)[12] intercept      : AIC=3033.763, Time=10.85 sec
ARIMA(3,0,2)(1,0,0)[12] intercept      : AIC=3035.494, Time=5.08 sec
ARIMA(3,0,2)(2,0,1)[12] intercept      : AIC=3668.809, Time=14.66 sec
ARIMA(3,0,2)(1,0,1)[12] intercept      : AIC=3034.640, Time=3.56 sec
ARIMA(3,0,3)(2,0,0)[12] intercept      : AIC=3027.441, Time=8.80 sec
ARIMA(3,0,3)(1,0,0)[12] intercept      : AIC=3028.658, Time=3.03 sec
ARIMA(3,0,3)(2,0,1)[12] intercept      : AIC=3743.898, Time=21.03 sec
ARIMA(3,0,3)(1,0,1)[12] intercept      : AIC=3030.604, Time=3.27 sec
ARIMA(2,0,3)(2,0,0)[12] intercept      : AIC=3025.750, Time=5.20 sec
ARIMA(2,0,3)(1,0,0)[12] intercept      : AIC=3027.193, Time=2.23 sec
ARIMA(2,0,3)(2,0,1)[12] intercept      : AIC=inf, Time=15.94 sec
ARIMA(2,0,3)(1,0,1)[12] intercept      : AIC=3028.637, Time=2.68 sec
ARIMA(1,0,3)(2,0,0)[12] intercept      : AIC=3147.233, Time=5.93 sec
ARIMA(2,0,3)(2,0,0)[12]               : AIC=inf, Time=nan sec
```

Best model: ARIMA(2,0,3)(2,0,0)[12] intercept

```
In [79]: model_fit(z53142, (2, 0, 3), (2, 0, 0, 12))
```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

warnings.warn('An unsupported index was provided and will be')

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

warnings.warn('An unsupported index was provided and will be')

SARIMAX Results

Dep. Variable:	Price	No. Observations:	216
-----------------------	-------	--------------------------	-----

Model:	SARIMAX(2, 0, 3)x(2, 0, 0, 12)	Log Likelihood	-1338.198
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Date:	Fri, 21 May 2021	AIC	2692.395
--------------	------------------	------------	----------

Time:	14:06:07	BIC	2718.371
--------------	----------	------------	----------

Sample:	0	HQIC	2702.918
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- 216

Covariance Type:	opg
-------------------------	-----

	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	1.6425	0.105	15.682	0.000	1.437	1.848
ar.L2	-0.6423	0.105	-6.131	0.000	-0.848	-0.437
ma.L1	0.9459	0.132	7.181	0.000	0.688	1.204
ma.L2	0.3049	0.184	1.661	0.097	-0.055	0.665
ma.L3	-0.1409	0.113	-1.244	0.214	-0.363	0.081
ar.S.L12	0.0957	0.066	1.457	0.145	-0.033	0.224
ar.S.L24	0.0226	0.062	0.363	0.717	-0.100	0.145
sigma2	6.732e+04	5.02e-06	1.34e+10	0.000	6.73e+04	6.73e+04

Ljung-Box (L1) (Q): 2.32 **Jarque-Bera (JB):** 2.19

Prob(Q):	0.13	Prob(JB):	0.33
-----------------	------	------------------	------

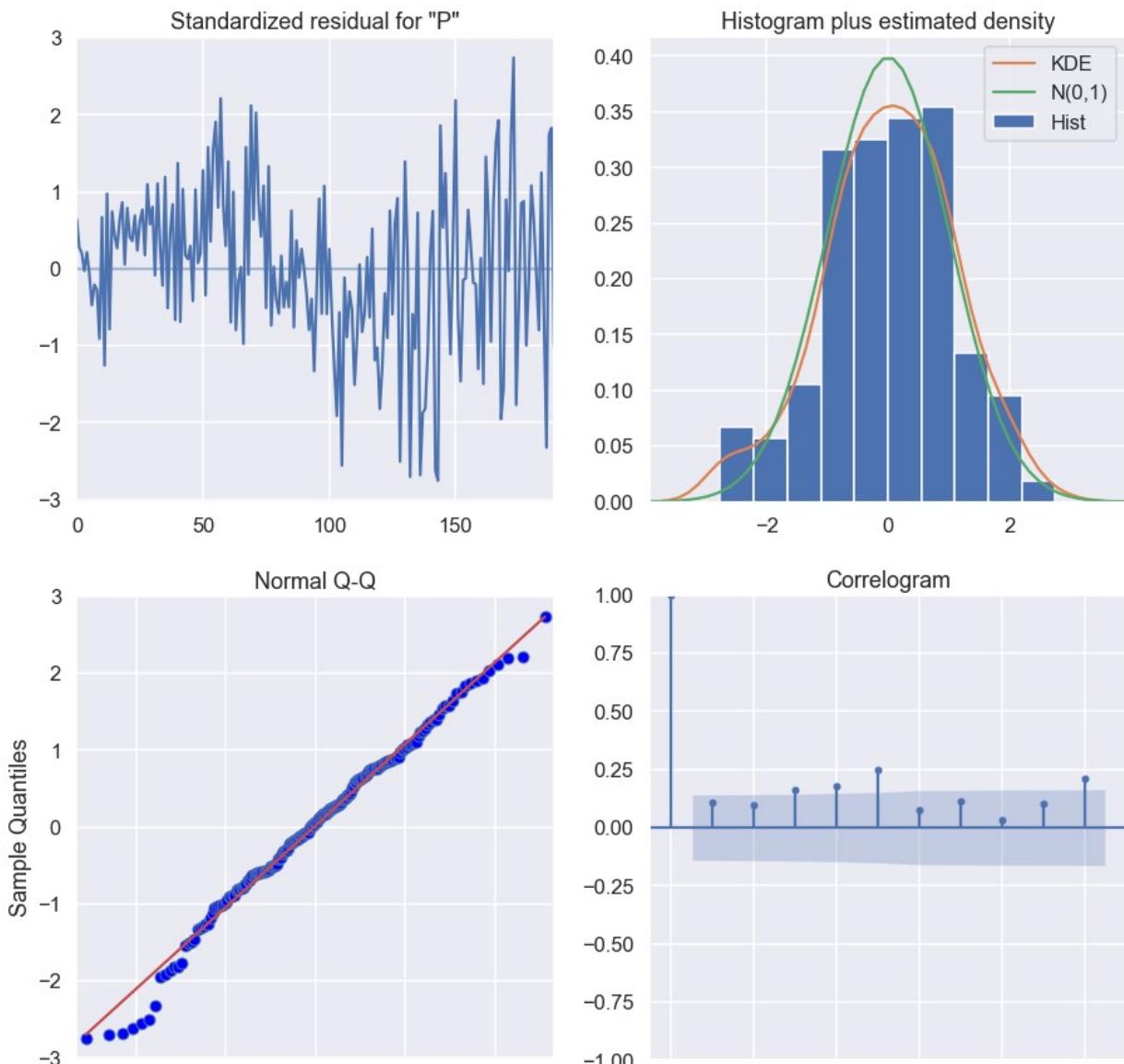
Heteroskedasticity (H):	2.88	Skew:	-0.26
--------------------------------	------	--------------	-------

Prob(H) (two-sided):	0.00	Kurtosis:	3.06
-----------------------------	------	------------------	------

Warnings:

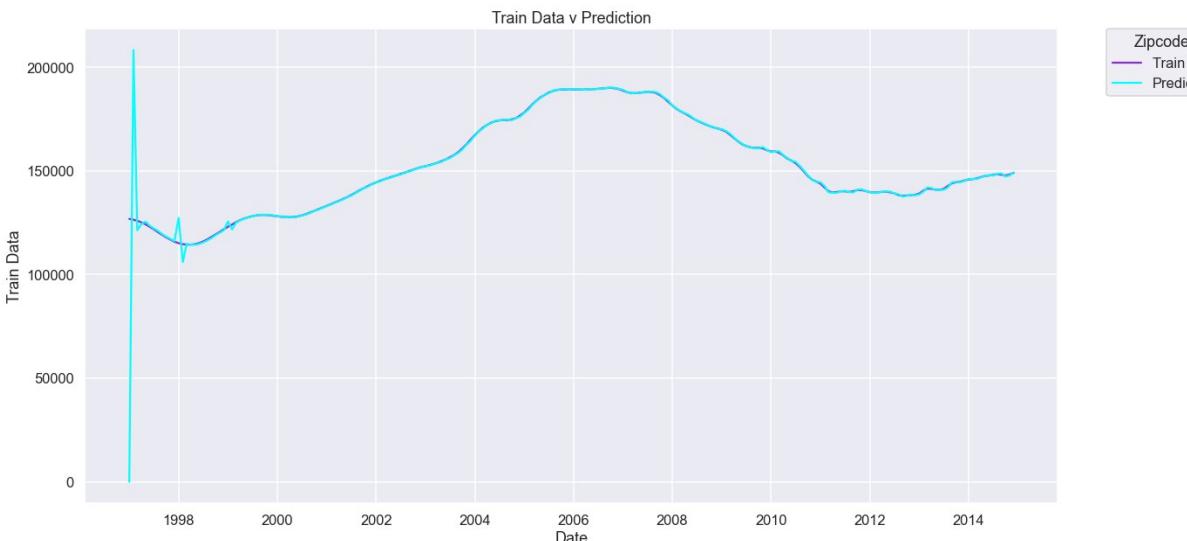
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

[2] Covariance matrix is singular or near-singular, with condition number 6.38e+26. Standard errors may be unstable.



```
In [80]: train_rmse(z53142, (2, 0, 3), (2, 0, 0, 12))  
test_rmse(z53142, (2, 0, 3), (2, 0, 0, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
Train RMSE: 10331.73595465559
```

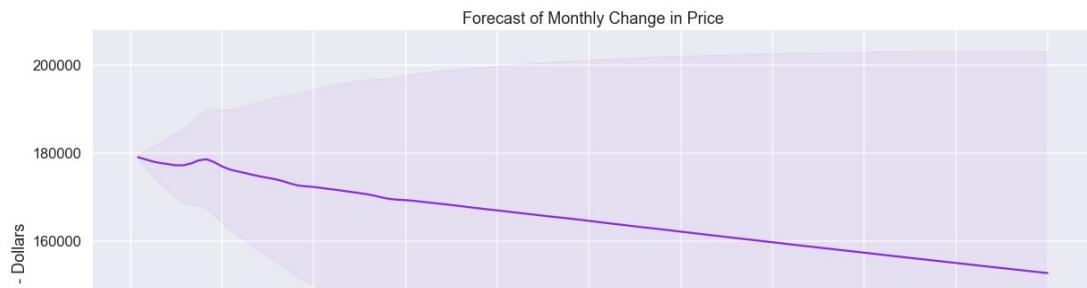


```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
Train RMSE: 28628.751604024816
```



```
In [81]: forecast(z53142, (2, 0, 3), (2, 0, 0, 12))
```

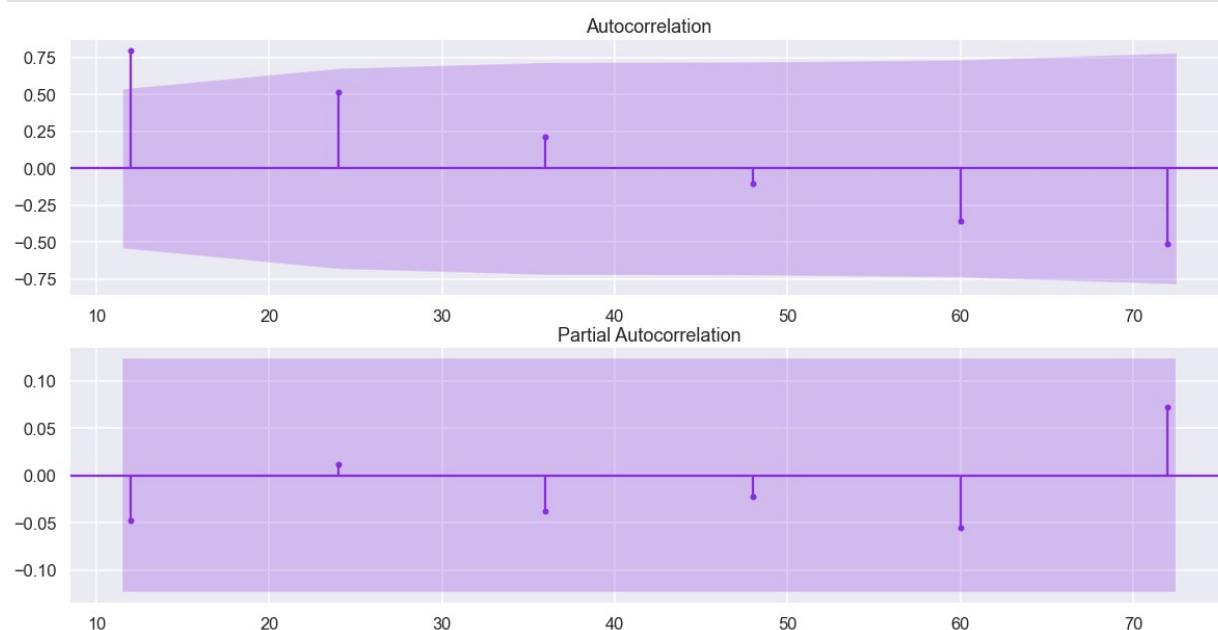
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.  
    warnings.warn('No supported index is available.'
```



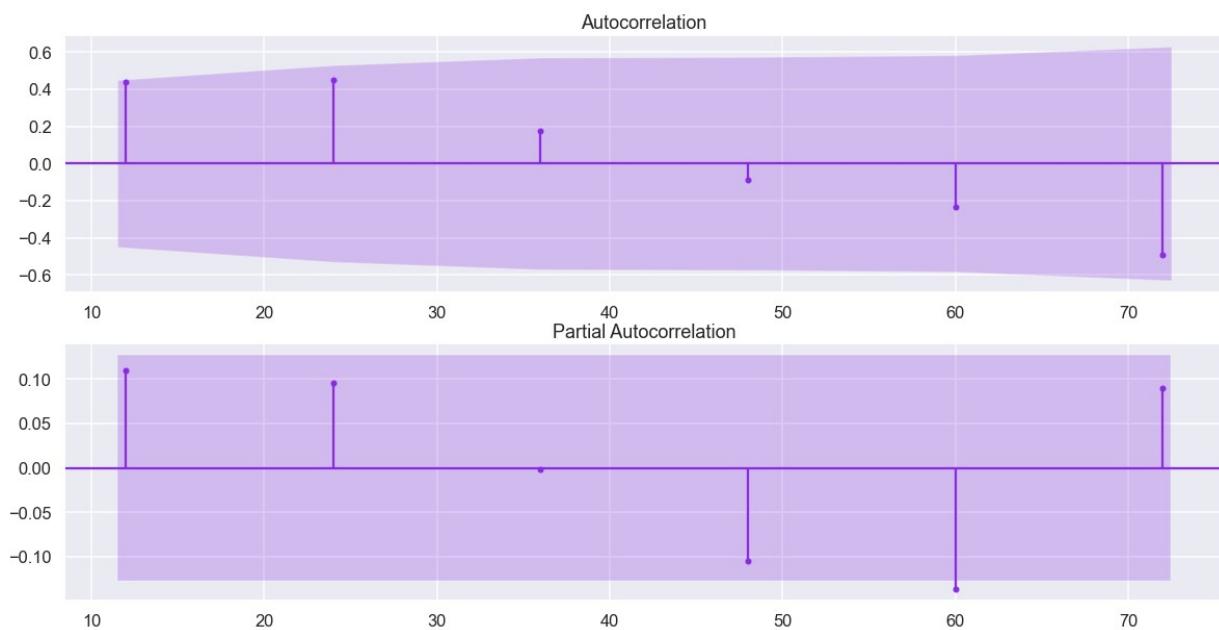
```
In [82]: zipcode.append('53142')
year5.append('38127.55')
```

53144

```
In [83]: acf_pacf(z53144)
```



```
In [84]: seasonal_acf_pacf(z53144)
```



```
In [85]: params(z53144)
```

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept      : AIC=3328.526, Time=1.77 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=4877.741, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=inf, Time=0.99 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.95 sec
ARIMA(0,0,0)(0,0,0)[12]                : AIC=5761.907, Time=0.02 sec
ARIMA(1,0,1)(0,0,1)[12] intercept      : AIC=3330.515, Time=0.76 sec
ARIMA(1,0,1)(1,0,0)[12] intercept      : AIC=3329.490, Time=1.10 sec
ARIMA(1,0,1)(2,0,1)[12] intercept      : AIC=4085.284, Time=8.19 sec
ARIMA(1,0,1)(1,0,2)[12] intercept      : AIC=3362.484, Time=6.14 sec
ARIMA(1,0,1)(0,0,0)[12] intercept      : AIC=3330.989, Time=0.30 sec
ARIMA(1,0,1)(0,0,2)[12] intercept      : AIC=3322.606, Time=2.36 sec
ARIMA(0,0,1)(0,0,2)[12] intercept      : AIC=inf, Time=3.37 sec
ARIMA(1,0,0)(0,0,2)[12] intercept      : AIC=3544.543, Time=1.67 sec
ARIMA(2,0,1)(0,0,2)[12] intercept      : AIC=3105.604, Time=2.22 sec
ARIMA(2,0,1)(0,0,1)[12] intercept      : AIC=3109.562, Time=0.84 sec
ARIMA(2,0,1)(1,0,2)[12] intercept      : AIC=3108.049, Time=4.97 sec
ARIMA(2,0,1)(1,0,1)[12] intercept      : AIC=3106.311, Time=1.93 sec
ARIMA(2,0,0)(0,0,2)[12] intercept      : AIC=3164.168, Time=3.38 sec
ARIMA(3,0,1)(0,0,2)[12] intercept      : AIC=3105.789, Time=5.55 sec
ARIMA(2,0,2)(0,0,2)[12] intercept      : AIC=3100.306, Time=3.53 sec
ARIMA(2,0,2)(0,0,1)[12] intercept      : AIC=3102.121, Time=1.13 sec
ARIMA(2,0,2)(1,0,2)[12] intercept      : AIC=3101.270, Time=6.48 sec
ARIMA(2,0,2)(1,0,1)[12] intercept      : AIC=3100.440, Time=2.36 sec
ARIMA(1,0,2)(0,0,2)[12] intercept      : AIC=3180.435, Time=3.20 sec
ARIMA(3,0,2)(0,0,2)[12] intercept      : AIC=3097.384, Time=5.00 sec
ARIMA(3,0,2)(0,0,1)[12] intercept      : AIC=3100.080, Time=1.91 sec
ARIMA(3,0,2)(1,0,2)[12] intercept      : AIC=3103.430, Time=7.21 sec
ARIMA(3,0,2)(1,0,1)[12] intercept      : AIC=3094.696, Time=2.36 sec
ARIMA(3,0,2)(1,0,0)[12] intercept      : AIC=3101.016, Time=1.90 sec
ARIMA(3,0,2)(2,0,1)[12] intercept      : AIC=4099.663, Time=12.59 sec
ARIMA(3,0,2)(0,0,0)[12] intercept      : AIC=3101.362, Time=0.84 sec
ARIMA(3,0,2)(2,0,0)[12] intercept      : AIC=3100.065, Time=5.43 sec
ARIMA(3,0,2)(2,0,2)[12] intercept      : AIC=3099.146, Time=8.57 sec
ARIMA(3,0,1)(1,0,1)[12] intercept      : AIC=3107.789, Time=3.46 sec
ARIMA(3,0,3)(1,0,1)[12] intercept      : AIC=3099.077, Time=2.71 sec
ARIMA(2,0,3)(1,0,1)[12] intercept      : AIC=3099.836, Time=2.98 sec
ARIMA(3,0,2)(1,0,1)[12]                : AIC=inf, Time=5.32 sec
```

Best model: ARIMA(3,0,2)(1,0,1)[12] intercept

```
In [86]: model_fit(z53144, (3, 0, 2), (1, 0, 1, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
warnings.warn("Maximum Likelihood optimization failed to "
```

SARIMAX Results

Dep. Variable: Price **No. Observations:** 216

Model: SARIMAX(3, 0, 2)x(1, 0, [1], 12) **Log Likelihood:** -1528.414

Date: Fri, 21 May 2021 **AIC:** 3072.829

Time: 14:08:33 **BIC:** 3099.255

Sample: 0 **HQIC:** 3083.522

- 216

Covariance Type: opg

	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	1.4054	0.052	26.829	0.000	1.303	1.508
ar.L2	-0.1464	0.065	-2.254	0.024	-0.274	-0.019
ar.L3	-0.2592	0.048	-5.433	0.000	-0.353	-0.166
ma.L1	0.7603	0.082	9.266	0.000	0.599	0.921
ma.L2	-0.0799	0.079	-1.014	0.311	-0.234	0.075
ar.S.L12	-0.0936	0.012	-7.617	0.000	-0.118	-0.069
ma.S.L12	1.7343	0.082	21.124	0.000	1.573	1.895
sigma2	9.365e+04	6.42e-07	1.46e+11	0.000	9.37e+04	9.37e+04

Ljung-Box (L1) (Q): 20.80 **Jarque-Bera (JB):** 9.47

Prob(Q): 0.00 **Prob(JB):** 0.01

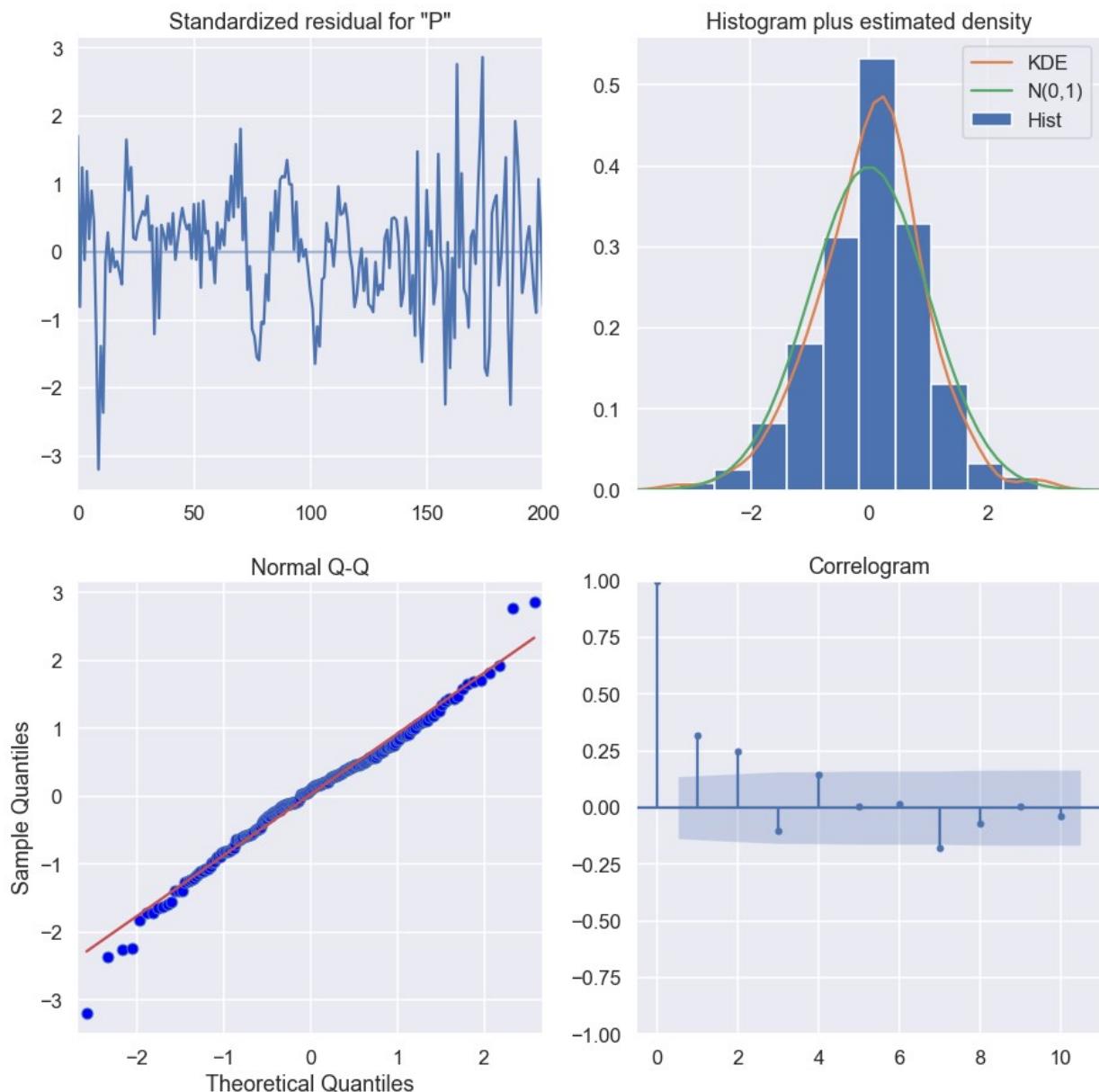
Heteroskedasticity (H): 1.72 **Skew:** -0.21

Prob(H) (two-sided): 0.03 **Kurtosis:** 3.98

Warnings:

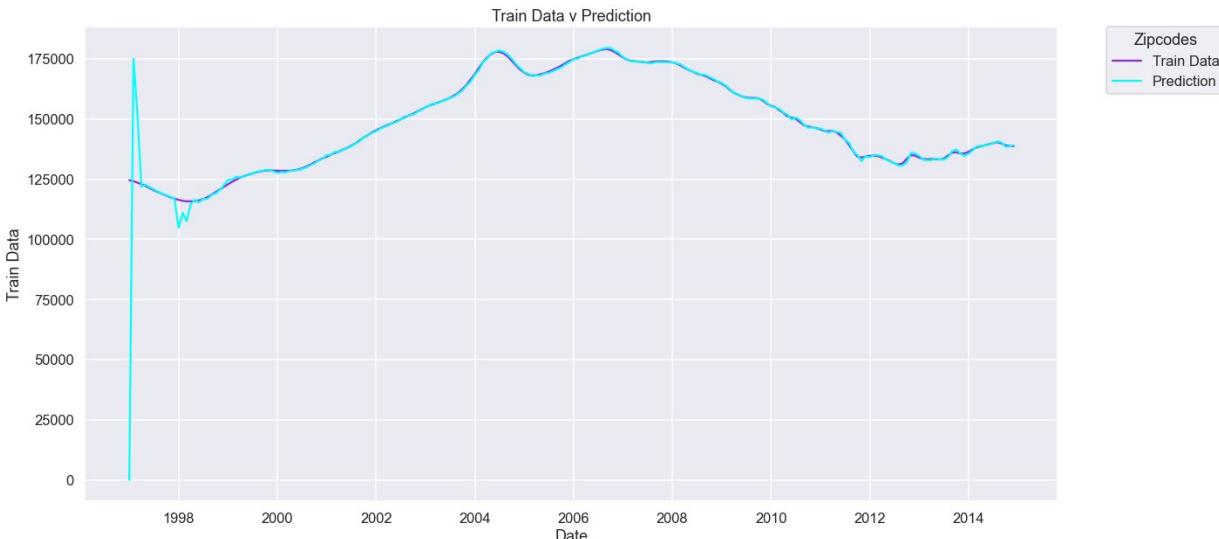
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

[2] Covariance matrix is singular or near-singular, with condition number 1.5e+27. Standard



```
In [87]: train_rmse(z53144, (3, 0, 2), (1, 0, 1, 12))  
test_rmse(z53144, (3, 0, 2), (1, 0, 1, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
Train RMSE: 9442.47175603376
```

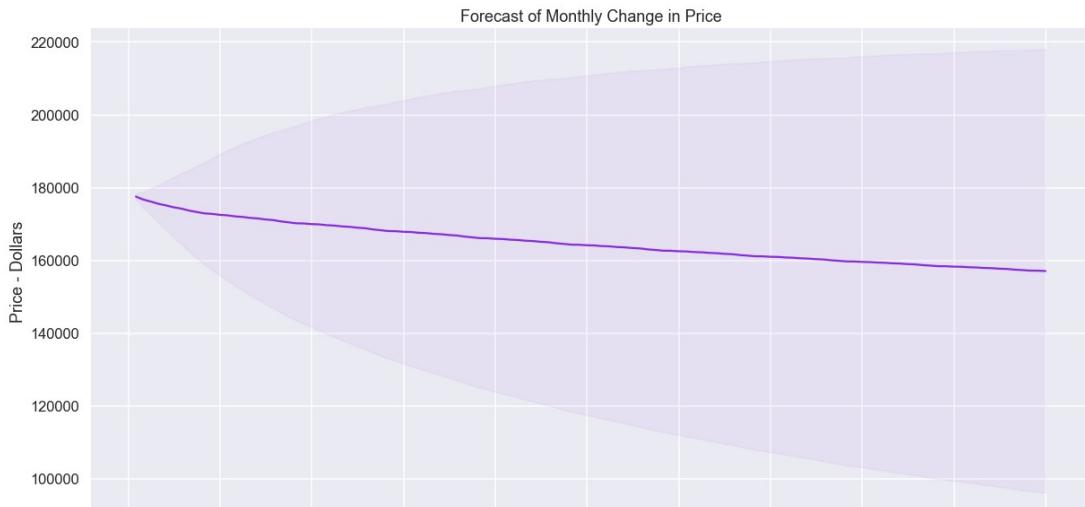


```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
Train RMSE: 2.153103073335666e+16
```



```
In [88]: forecast(z53144, (3, 0, 2), (1, 0, 1, 12))
```

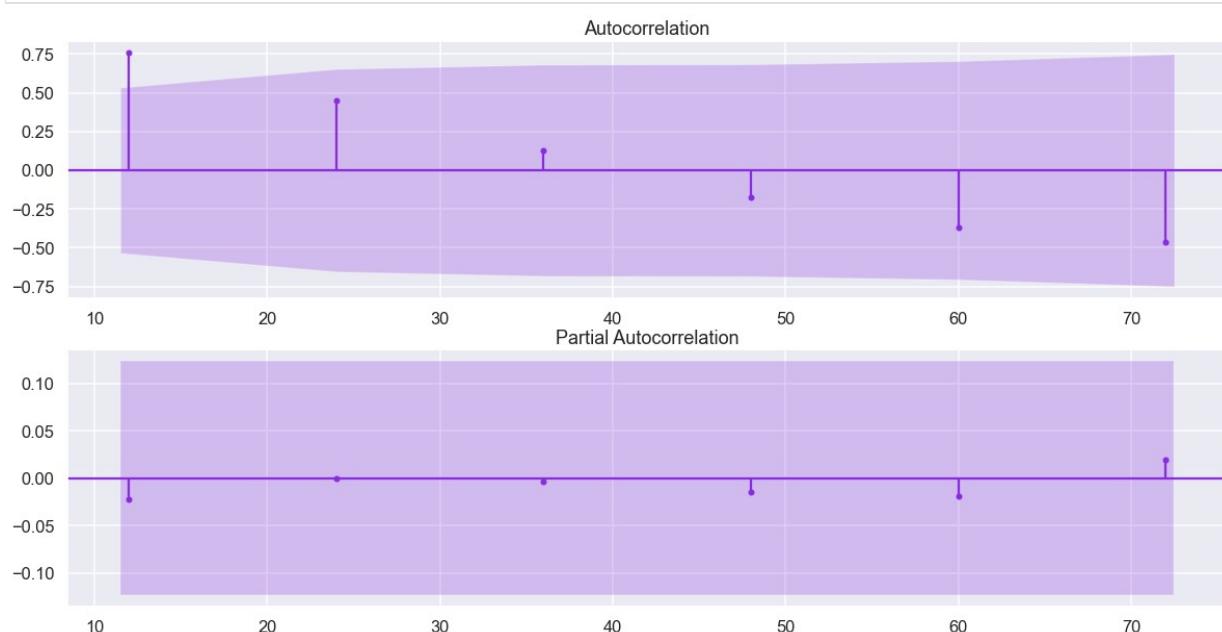
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.  
    warnings.warn('No supported index is available.'
```



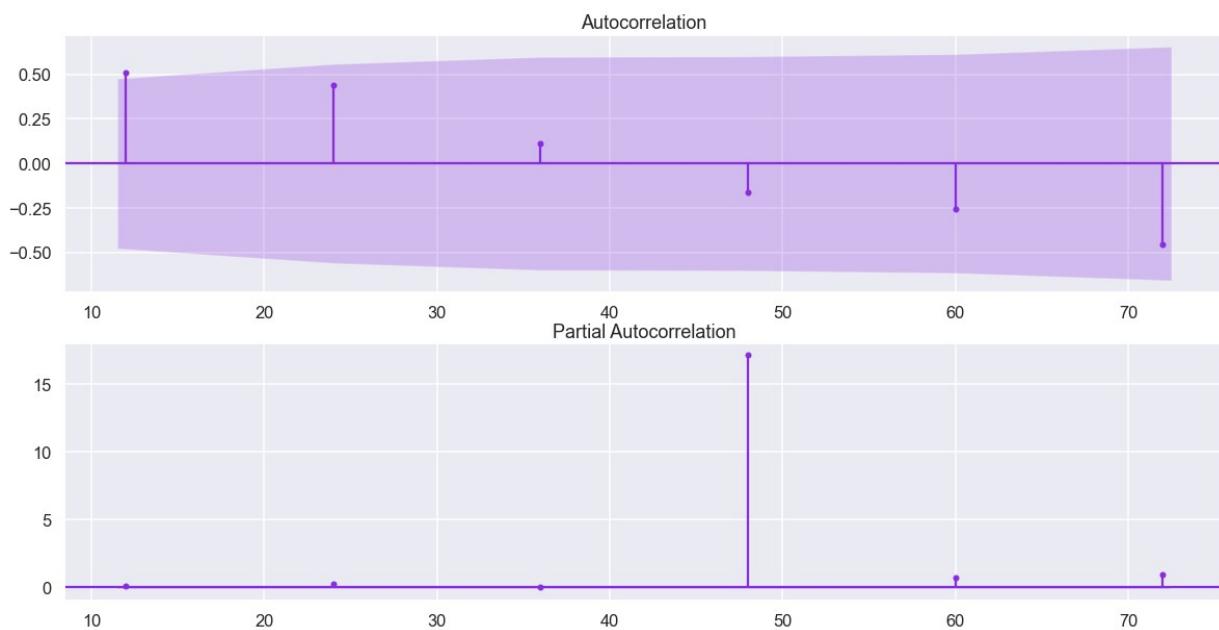
```
In [89]: zipcode.append('53144')
year5.append('39968.79')
```

53158

```
In [90]: acf_pacf(z53158)
```



```
In [91]: seasonal_acf_pacf(z53158)
```



```
In [92]: params(z53158)
```

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept      : AIC=3530.839, Time=2.01 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=5023.796, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=inf, Time=1.17 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.74 sec
ARIMA(0,0,0)(0,0,0)[12]                : AIC=5867.451, Time=0.01 sec
ARIMA(1,0,1)(0,0,1)[12] intercept      : AIC=3527.976, Time=0.80 sec
ARIMA(1,0,1)(0,0,0)[12] intercept      : AIC=3531.343, Time=0.29 sec
ARIMA(1,0,1)(0,0,2)[12] intercept      : AIC=3529.696, Time=2.36 sec
ARIMA(1,0,1)(1,0,0)[12] intercept      : AIC=3528.223, Time=0.95 sec
ARIMA(1,0,1)(1,0,2)[12] intercept      : AIC=3549.165, Time=5.40 sec
ARIMA(1,0,0)(0,0,1)[12] intercept      : AIC=3746.712, Time=0.27 sec
ARIMA(2,0,1)(0,0,1)[12] intercept      : AIC=3323.854, Time=0.82 sec
ARIMA(2,0,1)(0,0,0)[12] intercept      : AIC=3326.708, Time=0.37 sec
ARIMA(2,0,1)(1,0,1)[12] intercept      : AIC=inf, Time=2.14 sec
ARIMA(2,0,1)(0,0,2)[12] intercept      : AIC=inf, Time=2.91 sec
ARIMA(2,0,1)(1,0,0)[12] intercept      : AIC=3326.502, Time=3.26 sec
ARIMA(2,0,1)(1,0,2)[12] intercept      : AIC=inf, Time=5.22 sec
ARIMA(2,0,0)(0,0,1)[12] intercept      : AIC=3370.005, Time=1.28 sec
ARIMA(3,0,1)(0,0,1)[12] intercept      : AIC=3325.211, Time=1.94 sec
ARIMA(2,0,2)(0,0,1)[12] intercept      : AIC=3324.577, Time=0.88 sec
ARIMA(1,0,2)(0,0,1)[12] intercept      : AIC=3370.852, Time=1.32 sec
ARIMA(3,0,0)(0,0,1)[12] intercept      : AIC=3338.221, Time=0.59 sec
ARIMA(3,0,2)(0,0,1)[12] intercept      : AIC=3304.873, Time=2.31 sec
ARIMA(3,0,2)(0,0,0)[12] intercept      : AIC=3306.959, Time=0.87 sec
ARIMA(3,0,2)(1,0,1)[12] intercept      : AIC=inf, Time=2.62 sec
ARIMA(3,0,2)(0,0,2)[12] intercept      : AIC=3294.895, Time=5.63 sec
ARIMA(3,0,2)(1,0,2)[12] intercept      : AIC=inf, Time=7.54 sec
ARIMA(2,0,2)(0,0,2)[12] intercept      : AIC=inf, Time=5.22 sec
ARIMA(3,0,1)(0,0,2)[12] intercept      : AIC=inf, Time=4.51 sec
ARIMA(3,0,3)(0,0,2)[12] intercept      : AIC=3301.690, Time=6.19 sec
ARIMA(2,0,3)(0,0,2)[12] intercept      : AIC=inf, Time=4.73 sec
ARIMA(3,0,2)(0,0,2)[12]                : AIC=inf, Time=nan sec
```

Best model: ARIMA(3,0,2)(0,0,2)[12] intercept
Total fit time: 82.645 seconds

```
In [93]: model_fit(z53158, (3, 0, 2), (0, 0, 2, 12))
```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas

```
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\mod
el.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to conve
rge. Check mle_retrvals
Maximum Likelihood optimization failed to converge.
```

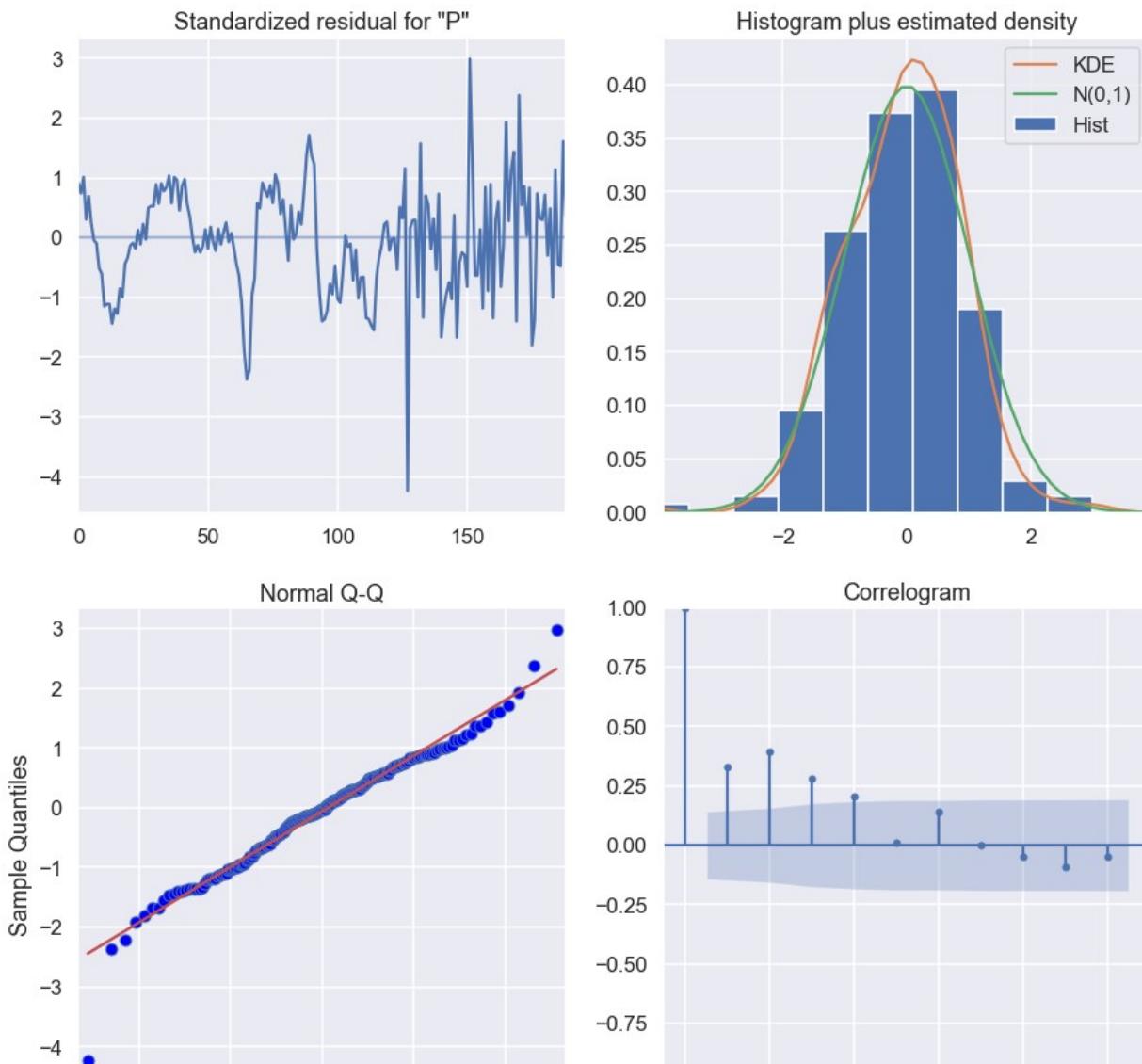
SARIMAX Results

Dep. Variable:	Price	No. Observations:	216			
Model:	SARIMAX(3, 0, 2)x(0, 0, 2, 12)	Log Likelihood	-1529.704			
Date:	Fri, 21 May 2021	AIC	3075.409			
Time:	14:10:18	BIC	3101.343			
Sample:	0	HQIC	3085.915			
	- 216					
Covariance Type:	opg					
	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	1.0314	0.057	18.129	0.000	0.920	1.143
ar.L2	-0.0394	0.082	-0.481	0.631	-0.200	0.121
ar.L3	0.0098	0.034	0.292	0.770	-0.056	0.076
ma.L1	1.3848	0.089	15.578	0.000	1.211	1.559
ma.L2	0.7194	0.085	8.513	0.000	0.554	0.885
ma.S.L12	0.3248	0.075	4.358	0.000	0.179	0.471
ma.S.L24	1.6512	0.064	25.966	0.000	1.527	1.776
sigma2	2.618e+05	1.38e-07	1.89e+12	0.000	2.62e+05	2.62e+05

Ljung-Box (L1) (Q): 21.03 **Jarque-Bera (JB):** 26.77
Prob(Q): 0.00 **Prob(JB):** 0.00
Heteroskedasticity (H): 3.28 **Skew:** -0.38
Prob(H) (two-sided): 0.00 **Kurtosis:** 4.68

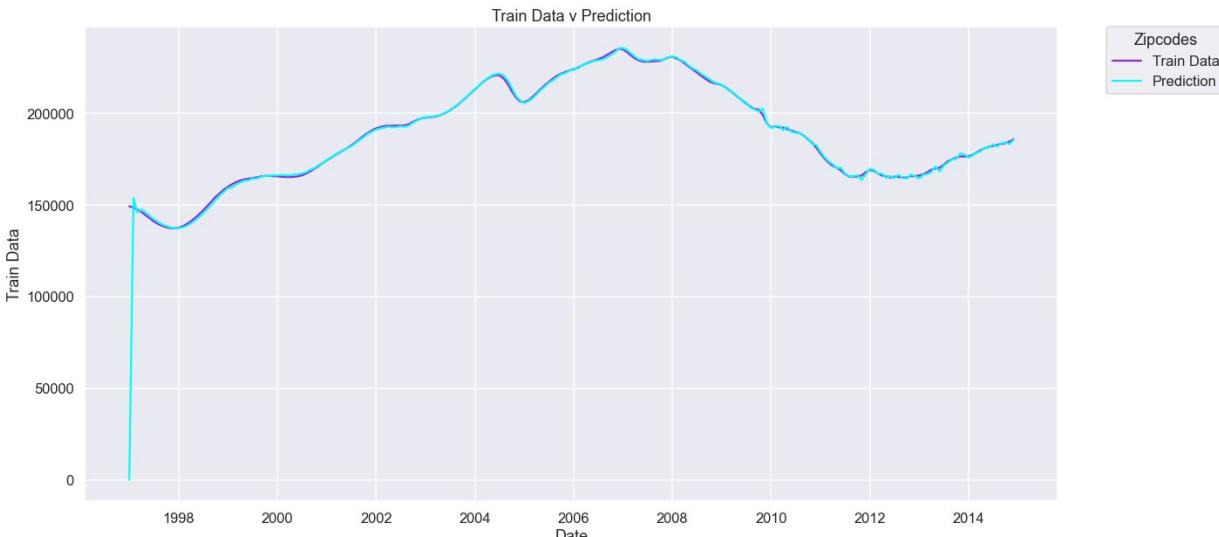
Warnings:

- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 3.04e+27. Standard errors may be unstable.



```
In [94]: train_rmse(z53158, (3, 0, 2), (0, 0, 2, 12))
test_rmse(z53158, (3, 0, 2), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
    warnings.warn("Maximum Likelihood optimization failed to "
Train RMSE: 10200.689298677464
```



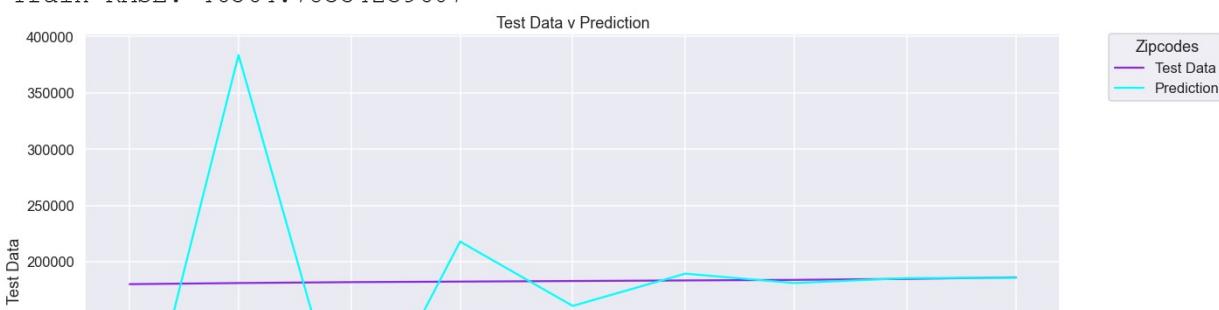
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
Train RMSE: 46564.78354239607
```



```
In [95]: forecast(z53158, (3, 0, 2), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
```

```
    warnings.warn("Maximum Likelihood optimization failed to "
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.
```

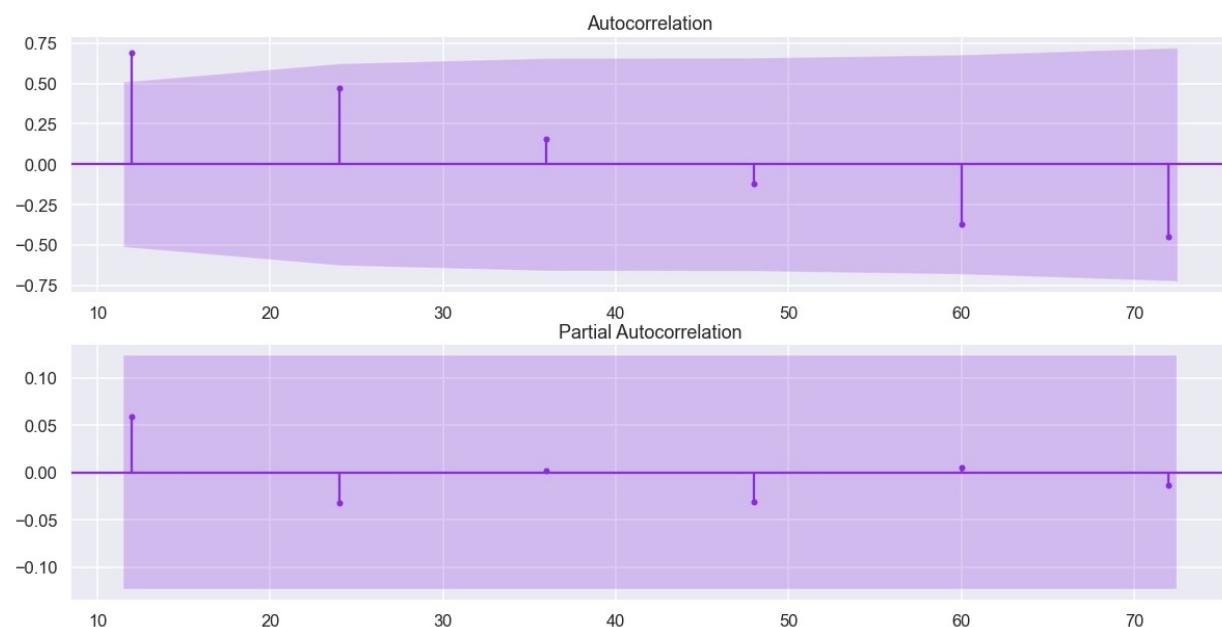
```
    warnings.warn('No supported index is available.'
```



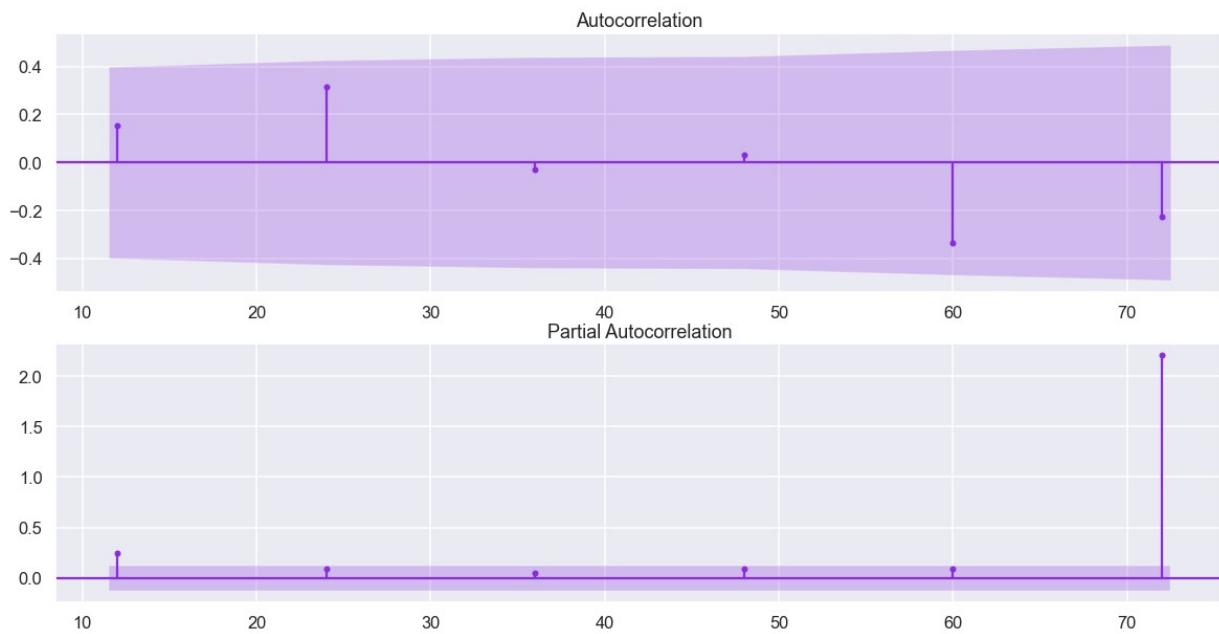
```
In [96]: zipcode.append('53158')
year5.append('44133.74')
```

53181

```
In [97]: acf_pacf(z53181)
```



```
In [98]: seasonal_acf_pacf(z53181)
```



```
In [99]: params(z53181)
```

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept : AIC=3422.392, Time=1.30 sec
ARIMA(0,0,0)(0,0,0)[12] intercept : AIC=4879.729, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept : AIC=inf, Time=2.25 sec
ARIMA(0,0,1)(0,0,1)[12] intercept : AIC=inf, Time=0.82 sec
ARIMA(0,0,0)(0,0,0)[12] intercept : AIC=5794.293, Time=0.02 sec
ARIMA(1,0,1)(0,0,1)[12] intercept : AIC=3428.135, Time=1.25 sec
ARIMA(1,0,1)(1,0,0)[12] intercept : AIC=3428.082, Time=1.33 sec
ARIMA(1,0,1)(2,0,1)[12] intercept : AIC=3417.697, Time=3.79 sec
ARIMA(1,0,1)(2,0,0)[12] intercept : AIC=3423.013, Time=2.77 sec
ARIMA(1,0,1)(2,0,2)[12] intercept : AIC=inf, Time=6.51 sec
ARIMA(1,0,1)(1,0,2)[12] intercept : AIC=inf, Time=5.77 sec
ARIMA(0,0,1)(2,0,1)[12] intercept : AIC=inf, Time=3.25 sec
ARIMA(1,0,0)(2,0,1)[12] intercept : AIC=3648.447, Time=1.58 sec
ARIMA(2,0,1)(2,0,1)[12] intercept : AIC=3156.594, Time=4.63 sec
ARIMA(2,0,1)(1,0,1)[12] intercept : AIC=3154.425, Time=1.72 sec
ARIMA(2,0,1)(0,0,1)[12] intercept : AIC=3158.085, Time=0.83 sec
ARIMA(2,0,1)(1,0,0)[12] intercept : AIC=3162.617, Time=1.96 sec
ARIMA(2,0,1)(1,0,2)[12] intercept : AIC=inf, Time=5.06 sec
ARIMA(2,0,1)(0,0,0)[12] intercept : AIC=3174.402, Time=0.32 sec
ARIMA(2,0,1)(0,0,2)[12] intercept : AIC=3154.534, Time=2.63 sec
ARIMA(2,0,1)(2,0,0)[12] intercept : AIC=3164.286, Time=4.63 sec
ARIMA(2,0,1)(2,0,2)[12] intercept : AIC=inf, Time=nan sec
ARIMA(2,0,0)(1,0,1)[12] intercept : AIC=3220.636, Time=1.50 sec
ARIMA(3,0,1)(1,0,1)[12] intercept : AIC=3159.067, Time=2.62 sec
ARIMA(2,0,2)(1,0,1)[12] intercept : AIC=3155.485, Time=2.15 sec
ARIMA(1,0,0)(1,0,1)[12] intercept : AIC=3654.841, Time=0.70 sec
ARIMA(1,0,2)(1,0,1)[12] intercept : AIC=inf, Time=2.55 sec
ARIMA(3,0,0)(1,0,1)[12] intercept : AIC=3170.170, Time=1.77 sec
ARIMA(3,0,2)(1,0,1)[12] intercept : AIC=3164.874, Time=2.68 sec
ARIMA(2,0,1)(1,0,1)[12] intercept : AIC=inf, Time=2.70 sec
```

```
Best model: ARIMA(2,0,1)(1,0,1)[12] intercept
Total fit time: 74.452 seconds
```

```
In [100]: model_fit(z53181, (2, 0, 1), (1, 0, 1, 12))
```

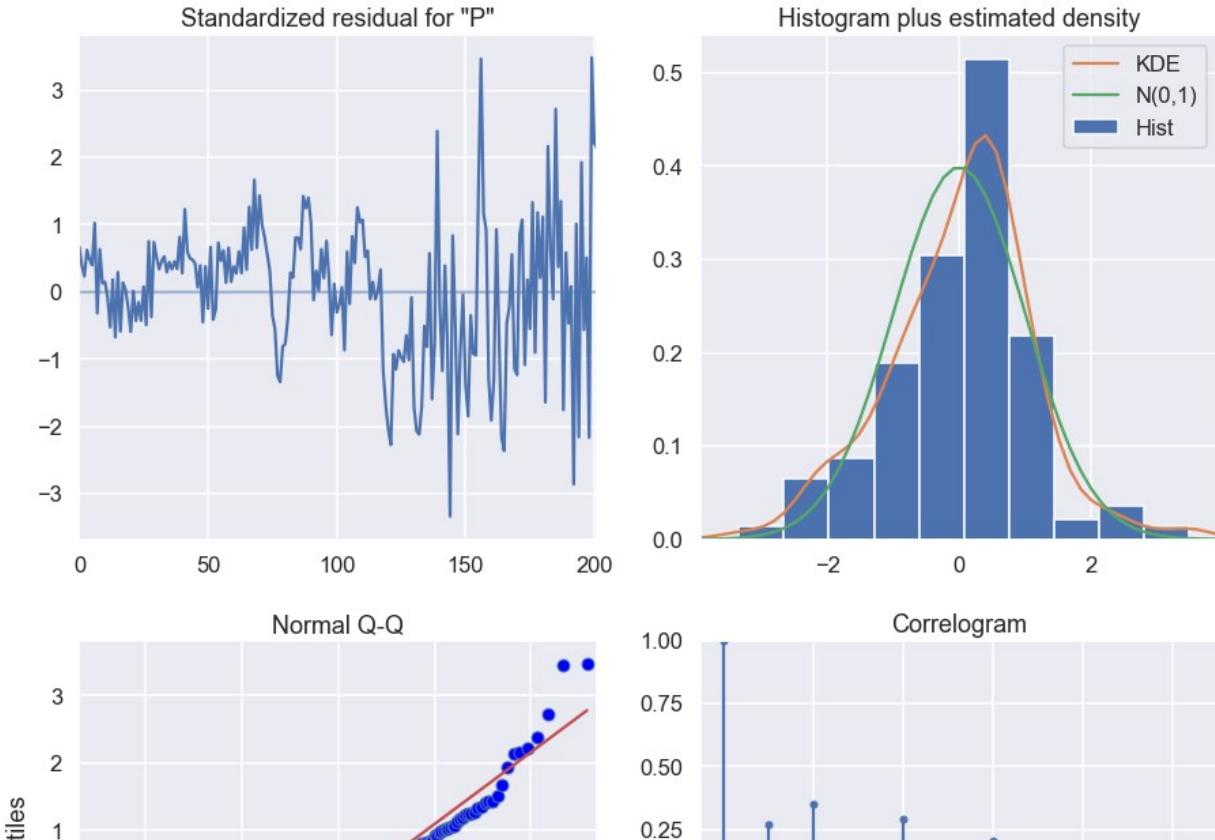
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
SARIMAX Results
```

Dep. Variable:	Price	No. Observations:	216			
Model:	SARIMAX(2, 0, 1)x(1, 0, 1, 12)	Log Likelihood	-1494.713			
Date:	Fri, 21 May 2021	AIC	3001.425			
Time:	14:11:57	BIC	3021.275			
Sample:	0	HQIC	3009.457			
	- 216					
Covariance Type:	opg					
	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	1.6779	0.035	47.298	0.000	1.608	1.747
ar.L2	-0.6777	0.035	-19.117	0.000	-0.747	-0.608
ma.L1	0.6457	0.038	17.213	0.000	0.572	0.719
ar.S.L12	-0.0711	0.053	-1.340	0.180	-0.175	0.033
ma.S.L12	-0.0849	0.055	-1.535	0.125	-0.193	0.023
sigma2	1.353e+05	6.24e-08	2.17e+12	0.000	1.35e+05	1.35e+05
Ljung-Box (L1) (Q):	14.91	Jarque-Bera (JB):	7.35			
Prob(Q):	0.00	Prob(JB):	0.03			
Heteroskedasticity (H):	8.52	Skew:	-0.13			
Prob(H) (two-sided):	0.00	Kurtosis:	3.90			

Warnings:

- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 2.2e+28. Standard errors may be unstable.



```
In [101]: train_rmse(z53181, (2, 0, 1), (1, 0, 1, 12))
test_rmse(z53181, (2, 0, 1), (1, 0, 1, 12))
```

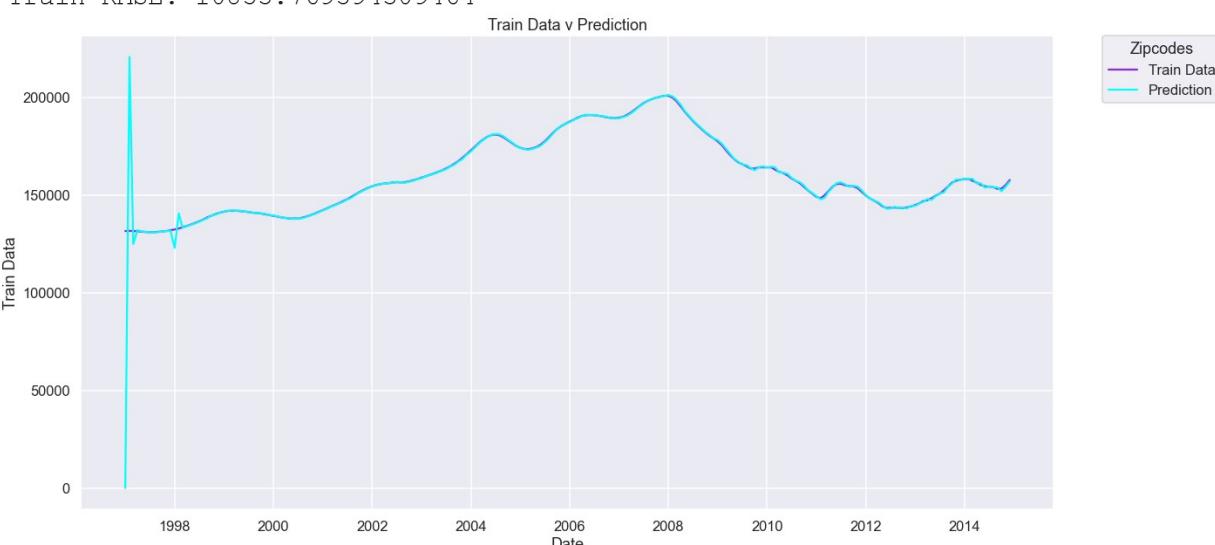
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

warnings.warn('An unsupported index was provided and will be')

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

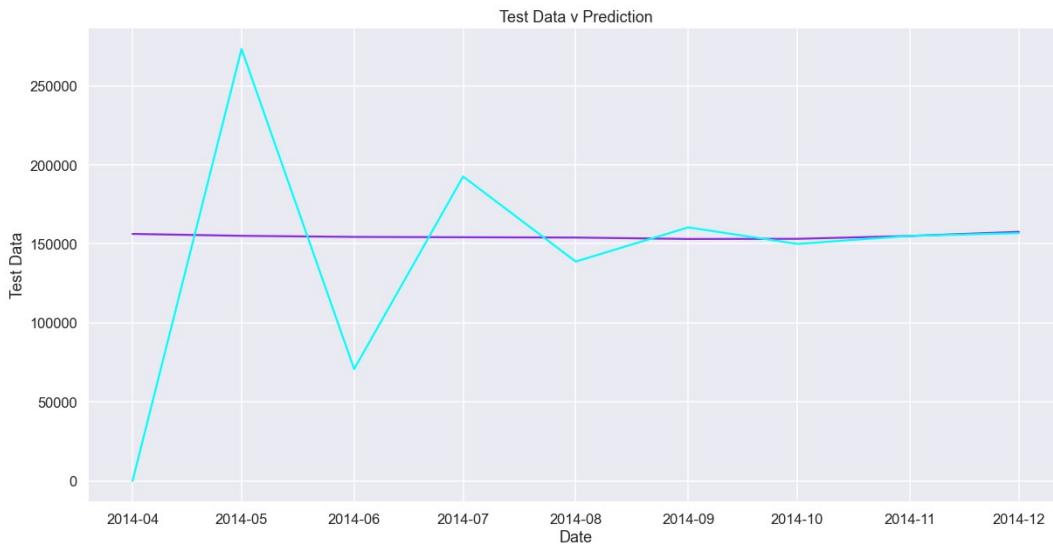
warnings.warn('An unsupported index was provided and will be')

Train RMSE: 10853.769594309464



C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

```
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\mod
el.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to conve
rge. Check mle_retrvals
warnings.warn("Maximum Likelihood optimization failed to "
Train RMSE: 7381369923704052.0
```



```
In [102]: forecast(z53181, (2, 0, 1), (1, 0, 1, 12))
```

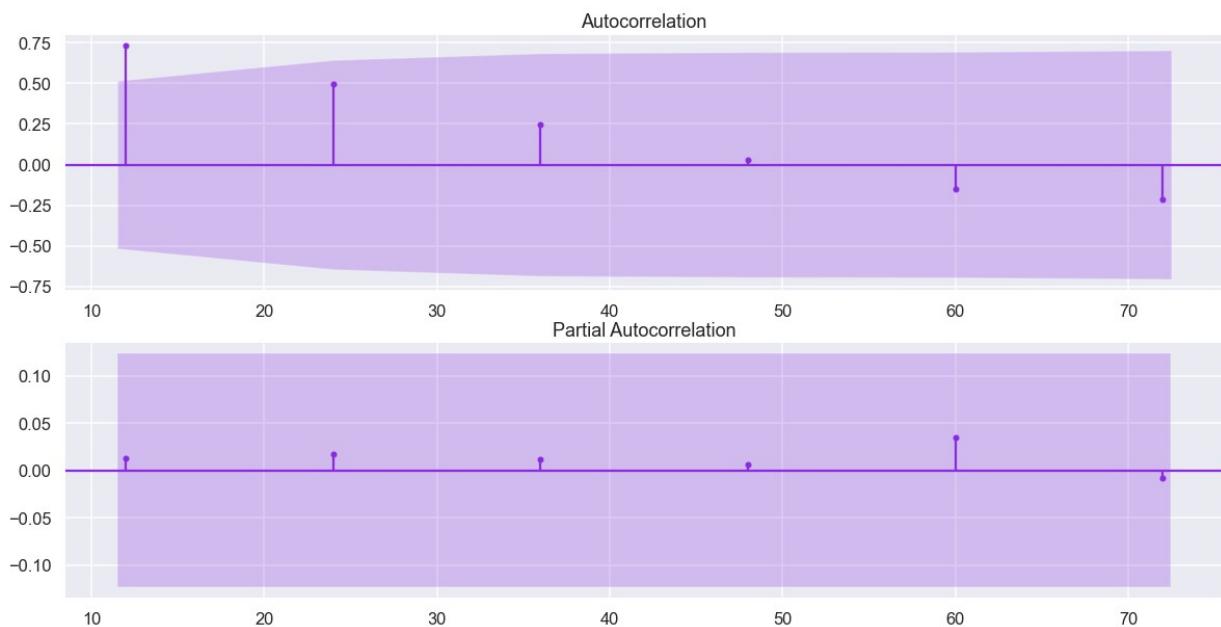
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
e ignored when e.g. forecasting.
warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\mod
el.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to conve
rge. Check mle_retrvals
warnings.warn("Maximum Likelihood optimization failed to "
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:376: ValueWarning: No supported index is available. Prediction
results will be given with an integer index beginning at `start`.
warnings.warn('No supported index is available.'
```



53108

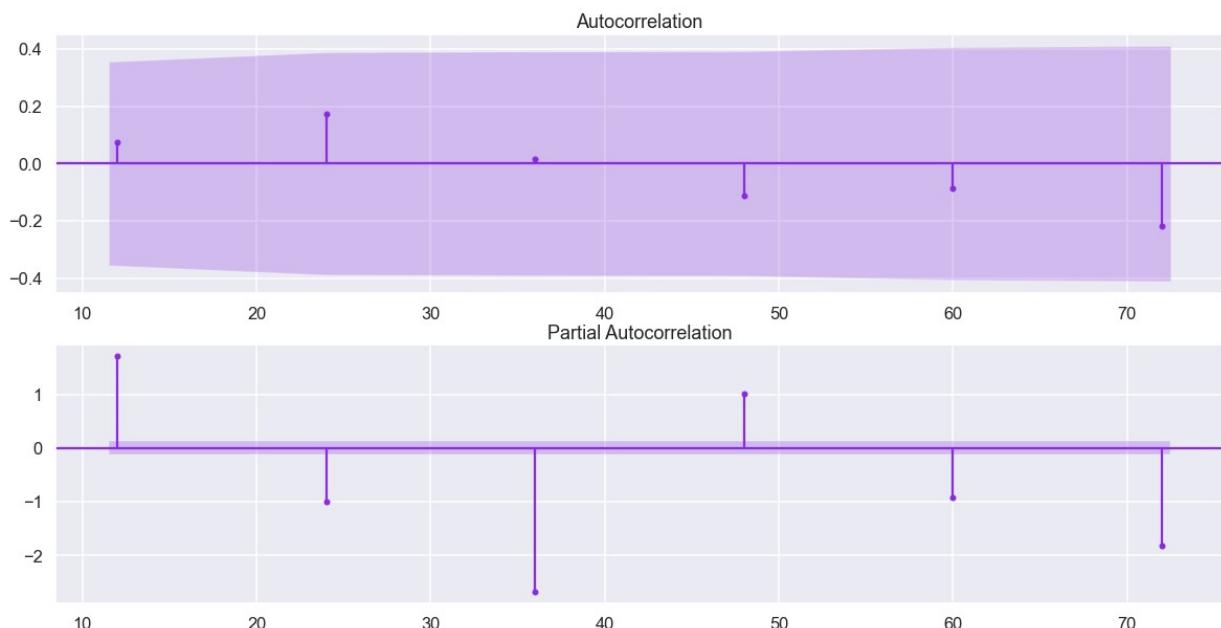
In [104]:

```
acf_pacf(z53108)
```



In [105]:

```
seasonal_acf_pacf(z53108)
```



In [106]:

```
params(z53108)
```

Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept : AIC=3687.125, Time=1.84 sec

```

ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=4999.002, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=3942.649, Time=1.28 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.82 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=5815.125, Time=0.03 sec
ARIMA(1,0,1)(0,0,1)[12] intercept      : AIC=3685.642, Time=0.79 sec
ARIMA(1,0,1)(0,0,0)[12] intercept      : AIC=3684.238, Time=0.24 sec
ARIMA(1,0,1)(1,0,0)[12] intercept      : AIC=3685.762, Time=0.83 sec
ARIMA(0,0,1)(0,0,0)[12] intercept      : AIC=inf, Time=0.24 sec
ARIMA(1,0,0)(0,0,0)[12] intercept      : AIC=3941.479, Time=0.05 sec
ARIMA(2,0,1)(0,0,0)[12] intercept      : AIC=3486.640, Time=0.35 sec
ARIMA(2,0,1)(1,0,0)[12] intercept      : AIC=3486.426, Time=1.13 sec
ARIMA(2,0,1)(2,0,0)[12] intercept      : AIC=3477.672, Time=2.72 sec
ARIMA(2,0,1)(2,0,1)[12] intercept      : AIC=3468.384, Time=4.30 sec
ARIMA(2,0,1)(1,0,1)[12] intercept      : AIC=3475.343, Time=1.84 sec
ARIMA(2,0,1)(2,0,2)[12] intercept      : AIC=inf, Time=6.54 sec
ARIMA(2,0,1)(1,0,2)[12] intercept      : AIC=3474.429, Time=6.41 sec
ARIMA(1,0,1)(2,0,1)[12] intercept      : AIC=inf, Time=4.10 sec
ARIMA(2,0,0)(2,0,1)[12] intercept      : AIC=3624.233, Time=1.98 sec
ARIMA(3,0,1)(2,0,1)[12] intercept      : AIC=3451.526, Time=5.61 sec
ARIMA(3,0,1)(1,0,1)[12] intercept      : AIC=3459.117, Time=2.41 sec
ARIMA(3,0,1)(2,0,0)[12] intercept      : AIC=3449.421, Time=3.44 sec
ARIMA(3,0,1)(1,0,0)[12] intercept      : AIC=3456.390, Time=1.79 sec
ARIMA(3,0,0)(2,0,0)[12] intercept      : AIC=3503.596, Time=28.38 sec
ARIMA(3,0,2)(2,0,0)[12] intercept      : AIC=3427.652, Time=5.60 sec
ARIMA(3,0,2)(1,0,0)[12] intercept      : AIC=3433.770, Time=2.47 sec
ARIMA(3,0,2)(2,0,1)[12] intercept      : AIC=3417.702, Time=7.11 sec
ARIMA(3,0,2)(1,0,1)[12] intercept      : AIC=inf, Time=2.87 sec
ARIMA(3,0,2)(2,0,2)[12] intercept      : AIC=inf, Time=9.48 sec
ARIMA(3,0,2)(1,0,2)[12] intercept      : AIC=inf, Time=7.28 sec
ARIMA(2,0,2)(2,0,1)[12] intercept      : AIC=3420.304, Time=5.25 sec
ARIMA(3,0,3)(2,0,1)[12] intercept      : AIC=3418.002, Time=7.68 sec
ARIMA(2,0,3)(2,0,1)[12] intercept      : AIC=3420.052, Time=6.07 sec
ARIMA(3,0,2)(2,0,1)[12]      : AIC=inf, Time=9.96 sec

```

Best model: ARIMA(3,0,2)(2,0,1)[12] intercept
 Total fit time: 141.019 seconds

In [142]: model_fit(z53108, (3, 0, 2), (2, 0, 1, 12))

```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
  warnings.warn("Maximum Likelihood optimization failed to "

```

SARIMAX Results

Dep. Variable:	Price	No. Observations:	216
-----------------------	-------	--------------------------	-----

Model:	SARIMAX(3, 0, 2)x(2, 0, [1], 12)	Log Likelihood	-1589.573
---------------	----------------------------------	-----------------------	-----------

Date:	Fri, 21 May 2021	AIC	3197.145
--------------	------------------	------------	----------

Time:	14:26:25	BIC	3226.321
--------------	----------	------------	----------

Sample:	0	HQIC	3208.965
----------------	---	-------------	----------

Covariance Type: opg

	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	2.2484	0.093	24.284	0.000	2.067	2.430
ar.L2	-1.8011	0.154	-11.660	0.000	-2.104	-1.498
ar.L3	0.5531	0.070	7.957	0.000	0.417	0.689
ma.L1	0.0323	0.117	0.276	0.783	-0.197	0.262
ma.L2	-0.0249	0.092	-0.272	0.786	-0.205	0.155
ar.S.L12	-0.4933	0.116	-4.251	0.000	-0.721	-0.266
ar.S.L24	-0.0642	0.043	-1.479	0.139	-0.149	0.021
ma.S.L12	1.4555	0.083	17.626	0.000	1.294	1.617
sigma2	4.541e+05	1.31e-07	3.46e+12	0.000	4.54e+05	4.54e+05

Ljung-Box (L1) (Q): 28.37 **Jarque-Bera (JB):** 161.12

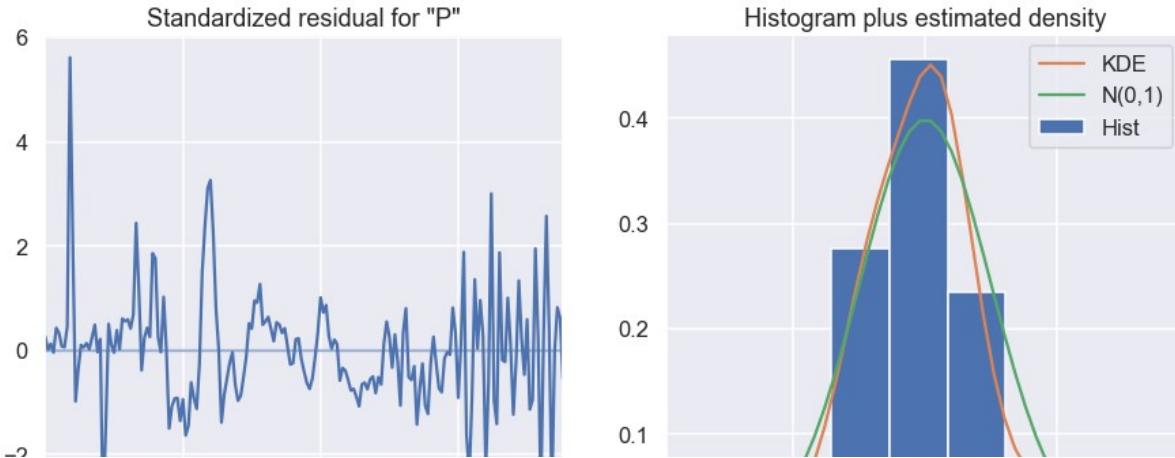
Prob(Q): 0.00 **Prob(JB):** 0.00

Heteroskedasticity (H): 0.71 **Skew:** 0.92

Prob(H) (two-sided): 0.18 **Kurtosis:** 7.13

Warnings:

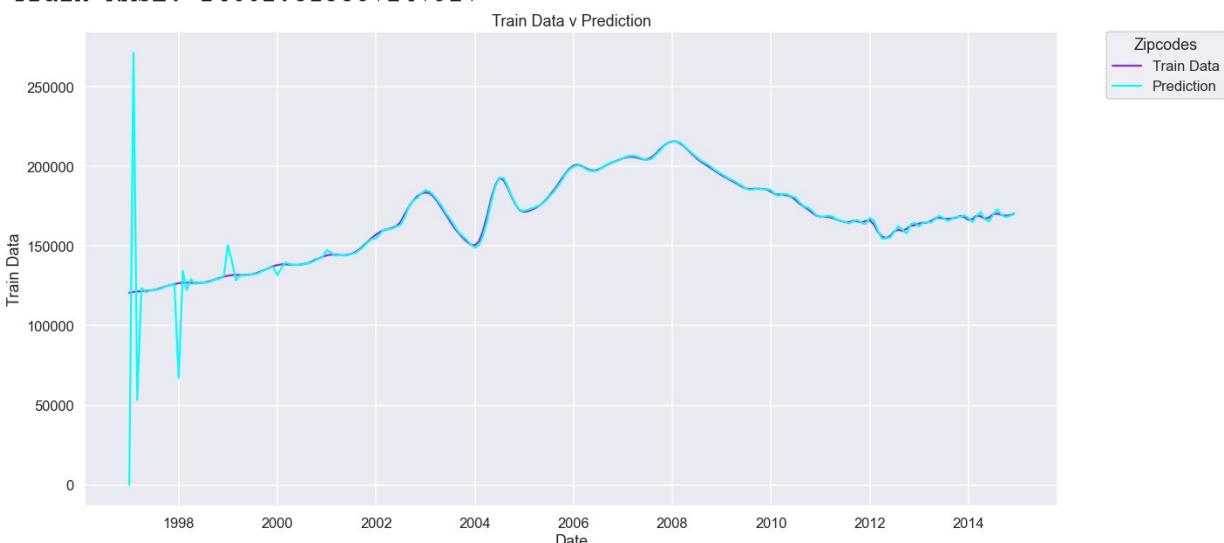
- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 2.58e+28. Standard



```
In [143]: train_rmse(z53108, (3, 0, 2), (2, 0, 1, 12))

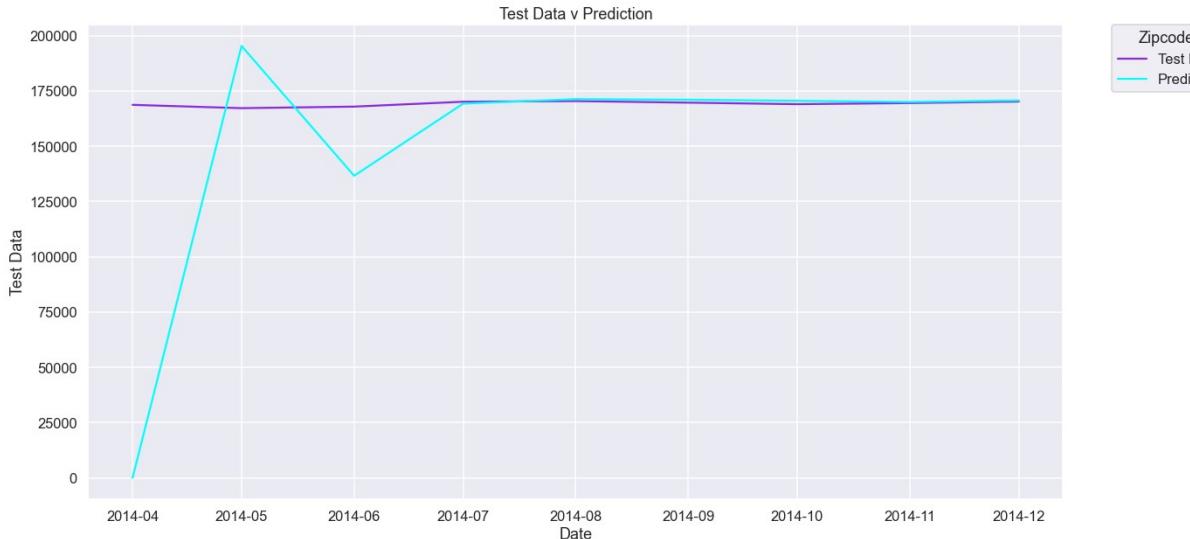
test_rmse(z53108, (3, 0, 2), (2, 0, 1, 12))
```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
 warnings.warn('An unsupported index was provided and will be'
 C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
 warnings.warn('An unsupported index was provided and will be'
 C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
 warnings.warn("Maximum Likelihood optimization failed to "
 Train RMSE: 14602.313387247927



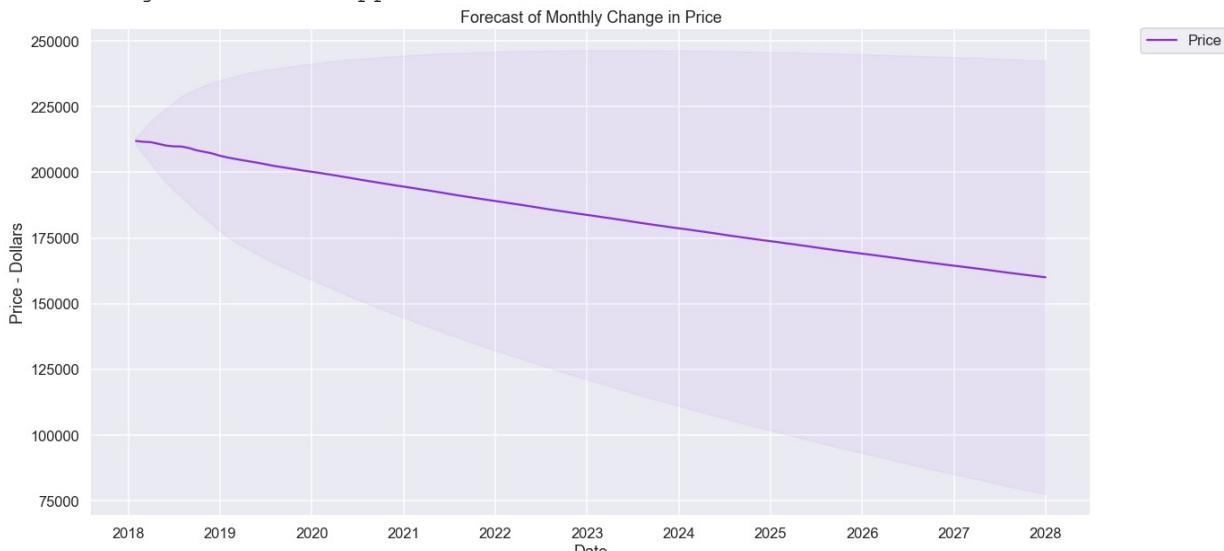
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
 warnings.warn('An unsupported index was provided and will be'
 C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
 warnings.warn('An unsupported index was provided and will be'
 C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
 warnings.warn("Maximum Likelihood optimization failed to "

Train RMSE: 348788.47922181094



In [144]: `forecast(z53108, (3, 0, 2), (2, 0, 1, 12))`

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.
  warnings.warn('No supported index is available.'
```



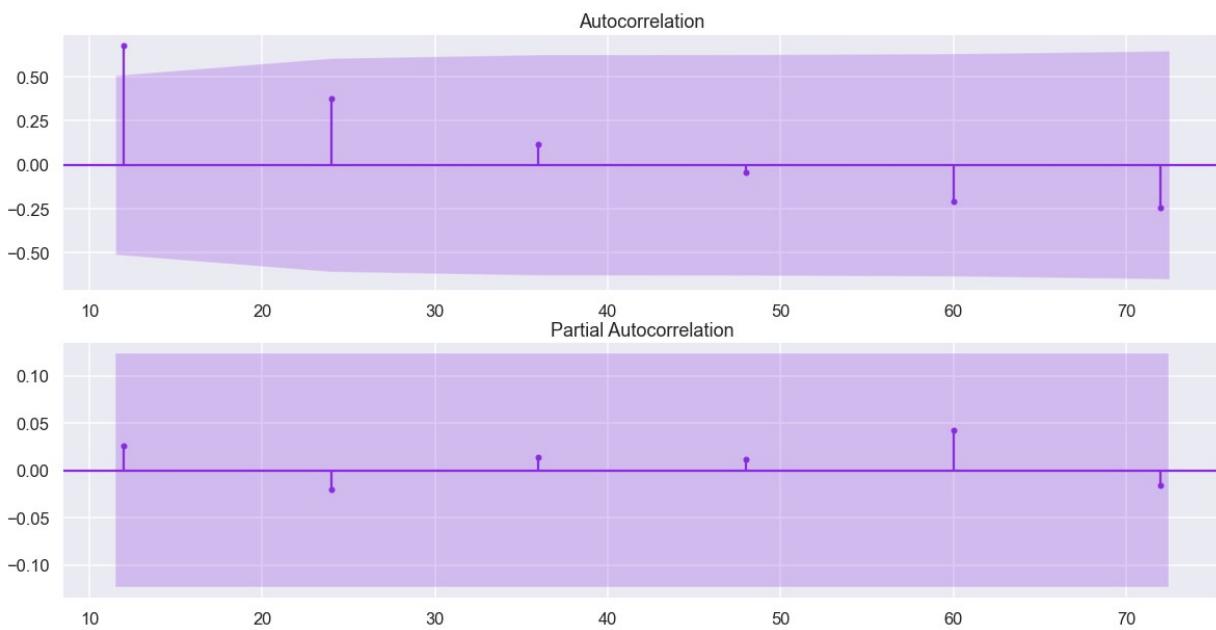
Expected Return - Five-Years: \$62568.97

In [110]: `zipcode.append('53108')
year5.append('62568.97')`

53139

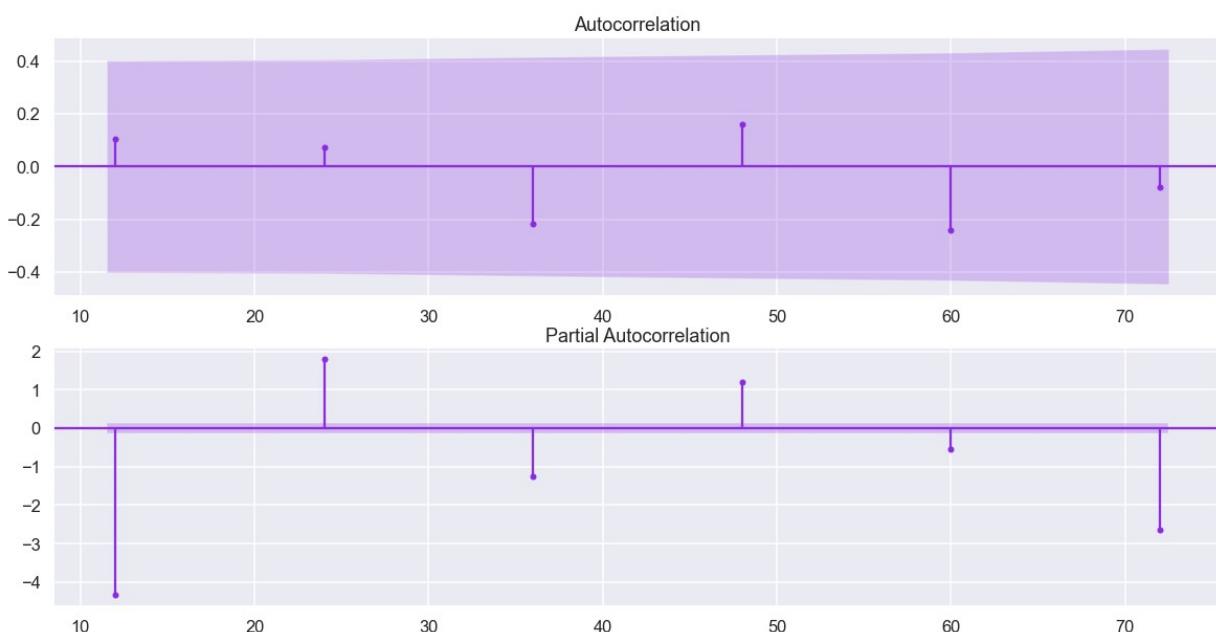
In [111...]

acf_pacf(z53139)



In [112...]

seasonal_acf_pacf(z53139)



In [113...]

params(z53139)

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept      : AIC=inf, Time=1.79 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=4997.209, Time=0.03 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=3920.679, Time=0.83 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.82 sec
ARIMA(0,0,0)(0,0,0)[12]                : AIC=5832.189, Time=0.03 sec
ARIMA(1,0,0)(0,0,0)[12] intercept      : AIC=3922.309, Time=0.05 sec
ARIMA(1,0,0)(2,0,0)[12] intercept      : AIC=3922.638, Time=8.63 sec
ARIMA(1,0,0)(1,0,1)[12] intercept      : AIC=inf, Time=1.35 sec
ARIMA(1,0,0)(0,0,1)[12] intercept      : AIC=3922.338, Time=0.28 sec
ARIMA(1,0,0)(2,0,1)[12] intercept      : AIC=inf, Time=4.32 sec
ARIMA(0,0,0)(1,0,0)[12] intercept      : AIC=4996.873, Time=0.52 sec
ARIMA(2,0,0)(1,0,0)[12] intercept      : AIC=3591.662, Time=2.49 sec
```

```

ARIMA(2,0,0)(0,0,0)[12] intercept : AIC=3595.221, Time=0.10 sec
ARIMA(2,0,0)(2,0,0)[12] intercept : AIC=3589.157, Time=11.44 sec
ARIMA(2,0,0)(2,0,1)[12] intercept : AIC=3590.647, Time=3.68 sec
ARIMA(2,0,0)(1,0,1)[12] intercept : AIC=3592.959, Time=0.67 sec
ARIMA(3,0,0)(2,0,0)[12] intercept : AIC=3493.726, Time=31.23 sec
ARIMA(3,0,0)(1,0,0)[12] intercept : AIC=3494.590, Time=10.04 sec
ARIMA(3,0,0)(2,0,1)[12] intercept : AIC=3495.569, Time=2.61 sec
ARIMA(3,0,0)(1,0,1)[12] intercept : AIC=3496.549, Time=0.87 sec
ARIMA(3,0,1)(2,0,0)[12] intercept : AIC=3439.547, Time=5.75 sec
ARIMA(3,0,1)(1,0,0)[12] intercept : AIC=3438.831, Time=2.03 sec
ARIMA(3,0,1)(0,0,0)[12] intercept : AIC=3441.402, Time=0.60 sec
ARIMA(3,0,1)(1,0,1)[12] intercept : AIC=3439.919, Time=2.28 sec
ARIMA(3,0,1)(0,0,1)[12] intercept : AIC=3438.363, Time=1.63 sec
ARIMA(3,0,1)(0,0,2)[12] intercept : AIC=3436.749, Time=5.15 sec
ARIMA(3,0,1)(1,0,2)[12] intercept : AIC=3450.466, Time=8.15 sec
ARIMA(2,0,1)(0,0,2)[12] intercept : AIC=inf, Time=4.38 sec
ARIMA(3,0,0)(0,0,2)[12] intercept : AIC=3492.262, Time=3.84 sec
ARIMA(3,0,2)(0,0,2)[12] intercept : AIC=3403.351, Time=4.34 sec
ARIMA(3,0,2)(0,0,1)[12] intercept : AIC=3408.779, Time=1.68 sec
ARIMA(3,0,2)(1,0,2)[12] intercept : AIC=3407.315, Time=7.76 sec
ARIMA(3,0,2)(1,0,1)[12] intercept : AIC=inf, Time=2.55 sec
ARIMA(2,0,2)(0,0,2)[12] intercept : AIC=3404.139, Time=2.81 sec
ARIMA(3,0,3)(0,0,2)[12] intercept : AIC=3406.898, Time=5.59 sec
ARIMA(2,0,3)(0,0,2)[12] intercept : AIC=3403.631, Time=3.79 sec
ARIMA(3,0,2)(0,0,2)[12] : AIC=inf, Time=5.93 sec

```

Best model: ARIMA(3,0,2)(0,0,2)[12] intercept
Total fit time: 150.111 seconds

In [114]: model_fit(z53139, (3, 0, 2), (0, 0, 2, 12))

```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
    warnings.warn("Maximum Likelihood optimization failed to "

```

SARIMAX Results

Dep. Variable: Price **No. Observations:** 216

Model: SARIMAX(3, 0, 2)x(0, 0, 2, 12) **Log Likelihood:** -1607.097

Date: Fri, 21 May 2021 **AIC:** 3230.193

Time: 14:17:35 **BIC:** 3256.127

Sample: 0 **HQIC:** 3240.700

- 216

Covariance Type: opg

	coef	std err	z	P> z	[0.025	0.975]
ar.L1	1.0557	0.062	16.917	0.000	0.933	1.178
ar.L2	-0.0562	0.095	-0.593	0.553	-0.242	0.130

ar.L3	-0.0016	0.038	-0.043	0.966	-0.075	0.072
ma.L1	1.7481	0.305	5.735	0.000	1.151	2.346
ma.L2	0.6592	0.290	2.271	0.023	0.090	1.228
ma.S.L12	-0.9529	0.122	-7.797	0.000	-1.192	-0.713
ma.S.L24	1.8495	0.183	10.098	0.000	1.491	2.208
sigma2	4.301e+05	4.65e-07	9.24e+11	0.000	4.3e+05	4.3e+05

Ljung-Box (L1) (Q): 24.94 **Jarque-Bera (JB):** 0.16

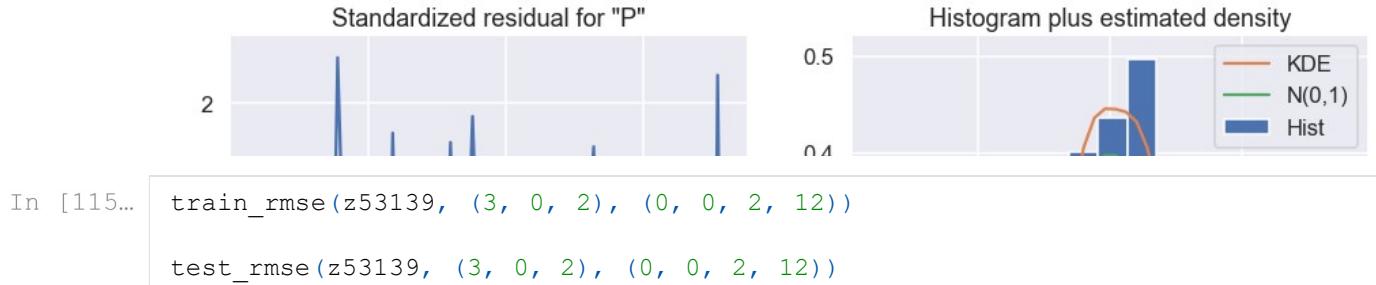
Prob(Q): 0.00 **Prob(JB):** 0.92

Heteroskedasticity (H): 1.47 **Skew:** 0.05

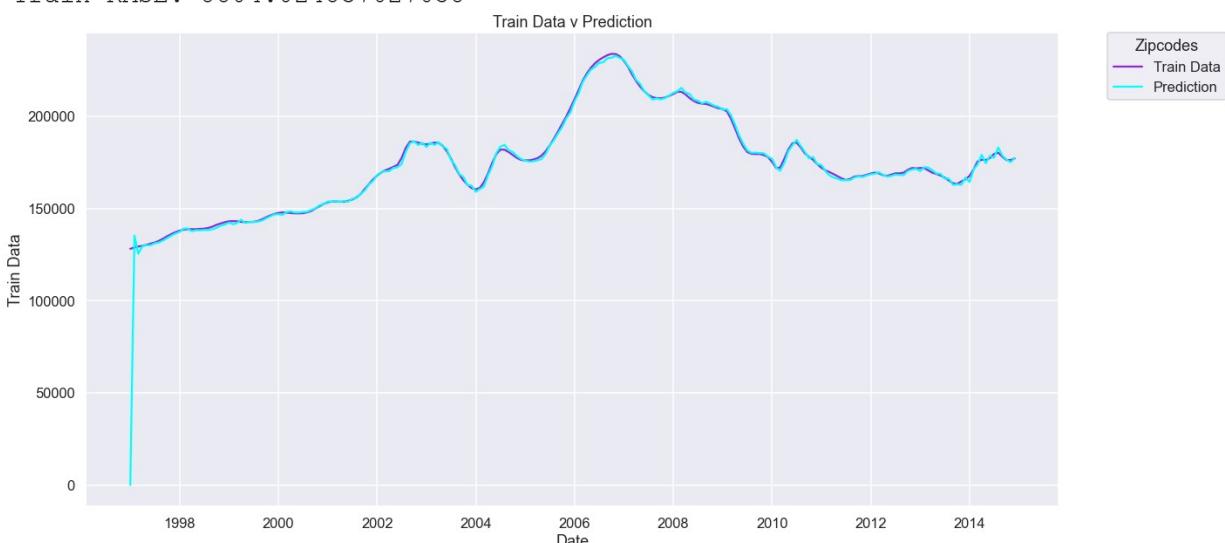
Prob(H) (two-sided): 0.13 **Kurtosis:** 2.89

Warnings:

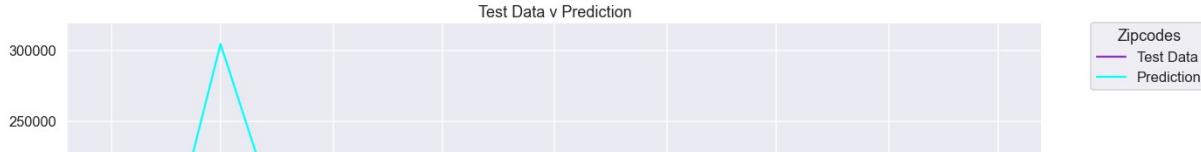
- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 1.07e+28. Standard



```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
Train RMSE: 8804.024837027058
```

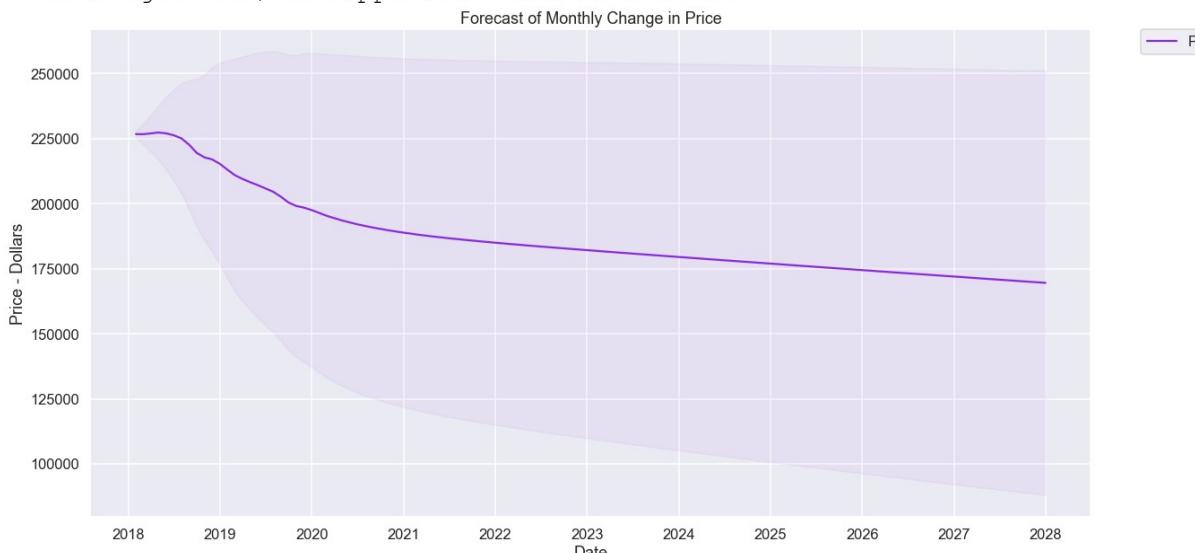


```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
Train RMSE: 37095.10213732872
```



```
In [116]: forecast(z53139, (3, 0, 2), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.  
    warnings.warn('An unsupported index was provided and will be'  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals  
    warnings.warn("Maximum Likelihood optimization failed to "  
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.  
    warnings.warn('No supported index is available.'
```

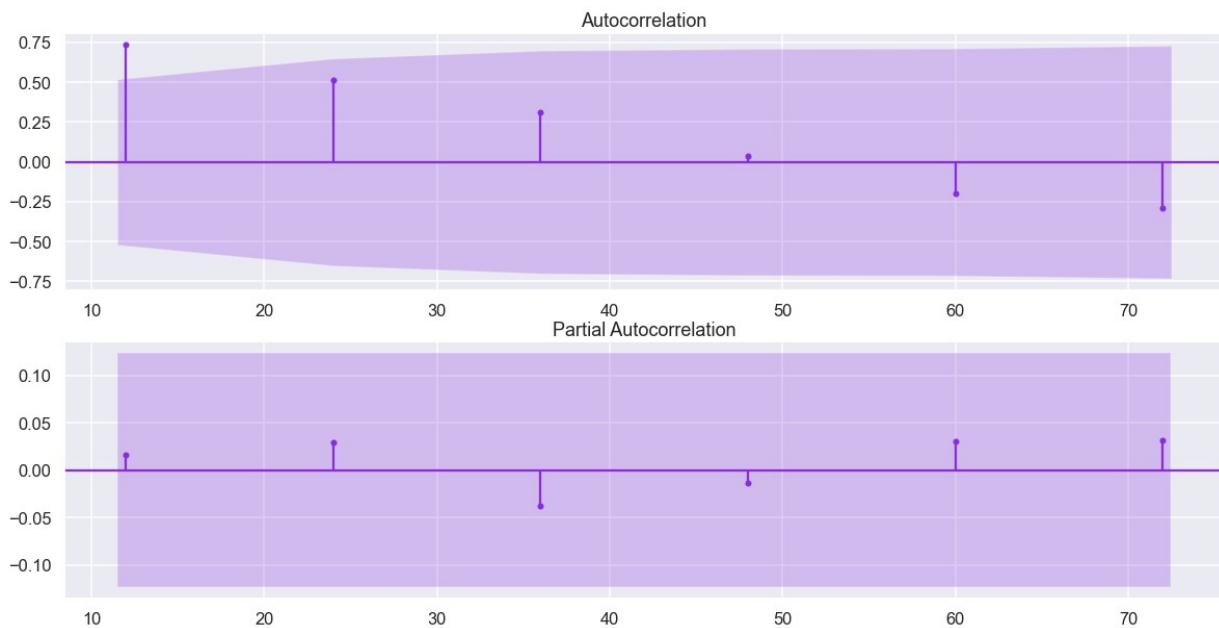


Expected Return - Five-Years: \$53303.75

```
In [117]: zipcode.append('53139')  
year5.append('53303.75')
```

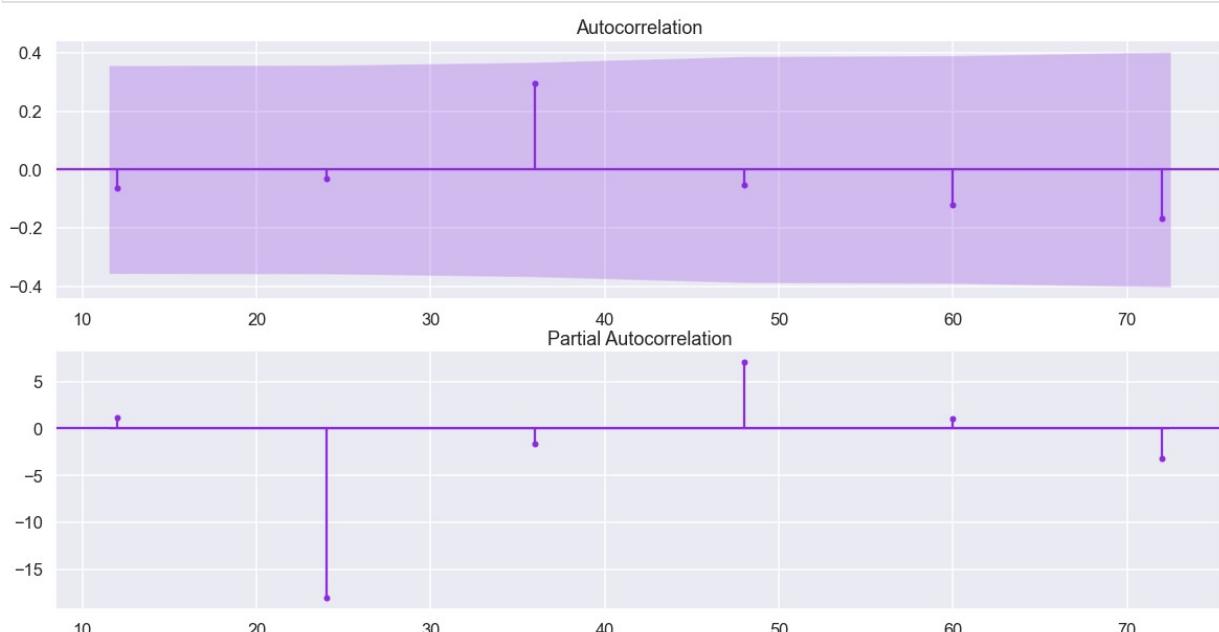
53404

```
In [118]: acf_pacf(z53404)
```



In [119...]

seasonal_acf_pacf(z53404)



In [120...]

params(z53404)

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept : AIC=inf, Time=1.12 sec
ARIMA(0,0,0)(0,0,0)[12] intercept : AIC=4949.739, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept : AIC=3873.320, Time=1.08 sec
ARIMA(0,0,1)(0,0,1)[12] intercept : AIC=inf, Time=0.87 sec
ARIMA(0,0,0)(0,0,0)[12] : AIC=5777.285, Time=0.02 sec
ARIMA(1,0,0)(0,0,0)[12] intercept : AIC=3875.977, Time=0.06 sec
ARIMA(1,0,0)(2,0,0)[12] intercept : AIC=3865.380, Time=7.57 sec
ARIMA(1,0,0)(2,0,1)[12] intercept : AIC=3856.993, Time=1.42 sec
ARIMA(1,0,0)(1,0,1)[12] intercept : AIC=3875.214, Time=0.40 sec
ARIMA(1,0,0)(2,0,2)[12] intercept : AIC=inf, Time=6.37 sec
ARIMA(1,0,0)(1,0,2)[12] intercept : AIC=3859.956, Time=2.51 sec
ARIMA(0,0,0)(2,0,1)[12] intercept : AIC=inf, Time=2.42 sec
ARIMA(2,0,0)(2,0,1)[12] intercept : AIC=3471.648, Time=2.18 sec
ARIMA(2,0,0)(1,0,1)[12] intercept : AIC=3483.294, Time=0.71 sec
ARIMA(2,0,0)(2,0,0)[12] intercept : AIC=3469.088, Time=45.60 sec
```

```

ARIMA(2,0,0)(1,0,0)[12] intercept : AIC=3483.587, Time=2.62 sec
ARIMA(3,0,0)(2,0,0)[12] intercept : AIC=3304.783, Time=16.54 sec
ARIMA(3,0,0)(1,0,0)[12] intercept : AIC=3307.740, Time=4.95 sec
ARIMA(3,0,0)(2,0,1)[12] intercept : AIC=3307.011, Time=2.86 sec
ARIMA(3,0,0)(1,0,1)[12] intercept : AIC=3309.546, Time=0.99 sec
ARIMA(3,0,1)(2,0,0)[12] intercept : AIC=3273.616, Time=4.15 sec
ARIMA(3,0,1)(1,0,0)[12] intercept : AIC=3279.916, Time=1.96 sec
ARIMA(3,0,1)(2,0,1)[12] intercept : AIC=3276.638, Time=5.79 sec
ARIMA(3,0,1)(1,0,1)[12] intercept : AIC=3279.306, Time=2.46 sec
ARIMA(2,0,1)(2,0,0)[12] intercept : AIC=3316.371, Time=1.58 sec
ARIMA(3,0,2)(2,0,0)[12] intercept : AIC=3275.198, Time=4.52 sec
ARIMA(2,0,2)(2,0,0)[12] intercept : AIC=3279.666, Time=3.38 sec
ARIMA(3,0,1)(2,0,0)[12] : AIC=inf, Time=5.28 sec

```

Best model: ARIMA(3,0,1)(2,0,0)[12] intercept
Total fit time: 129.544 seconds

In [121]: model_fit(z53404, (3, 0, 1), (2, 0, 0, 12))

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
```

SARIMAX Results

Dep. Variable:	Price	No. Observations:	216
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Model:	SARIMAX(3, 0, 1)x(2, 0, [], 12)	Log Likelihood	-1464.915
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Date:	Fri, 21 May 2021	AIC	2943.831
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Time:	14:20:12	BIC	2966.523
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Sample:	0	HQIC	2953.024
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- 216

Covariance Type:	opg
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	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	1.8015	0.052	34.607	0.000	1.700	1.904
ar.L2	-0.7813	0.101	-7.733	0.000	-0.979	-0.583
ar.L3	-0.0201	0.059	-0.344	0.731	-0.135	0.095
ma.L1	1.2191	0.049	24.951	0.000	1.123	1.315
ar.S.L12	-0.1401	0.086	-1.636	0.102	-0.308	0.028
ar.S.L24	0.0146	0.099	0.147	0.883	-0.180	0.209
sigma2	2.432e+05	3.86e-07	6.3e+11	0.000	2.43e+05	2.43e+05

Ljung-Box (L1) (Q): 18.71 **Jarque-Bera (JB):** 56.78

Prob(Q):	0.00	Prob(JB):	0.00
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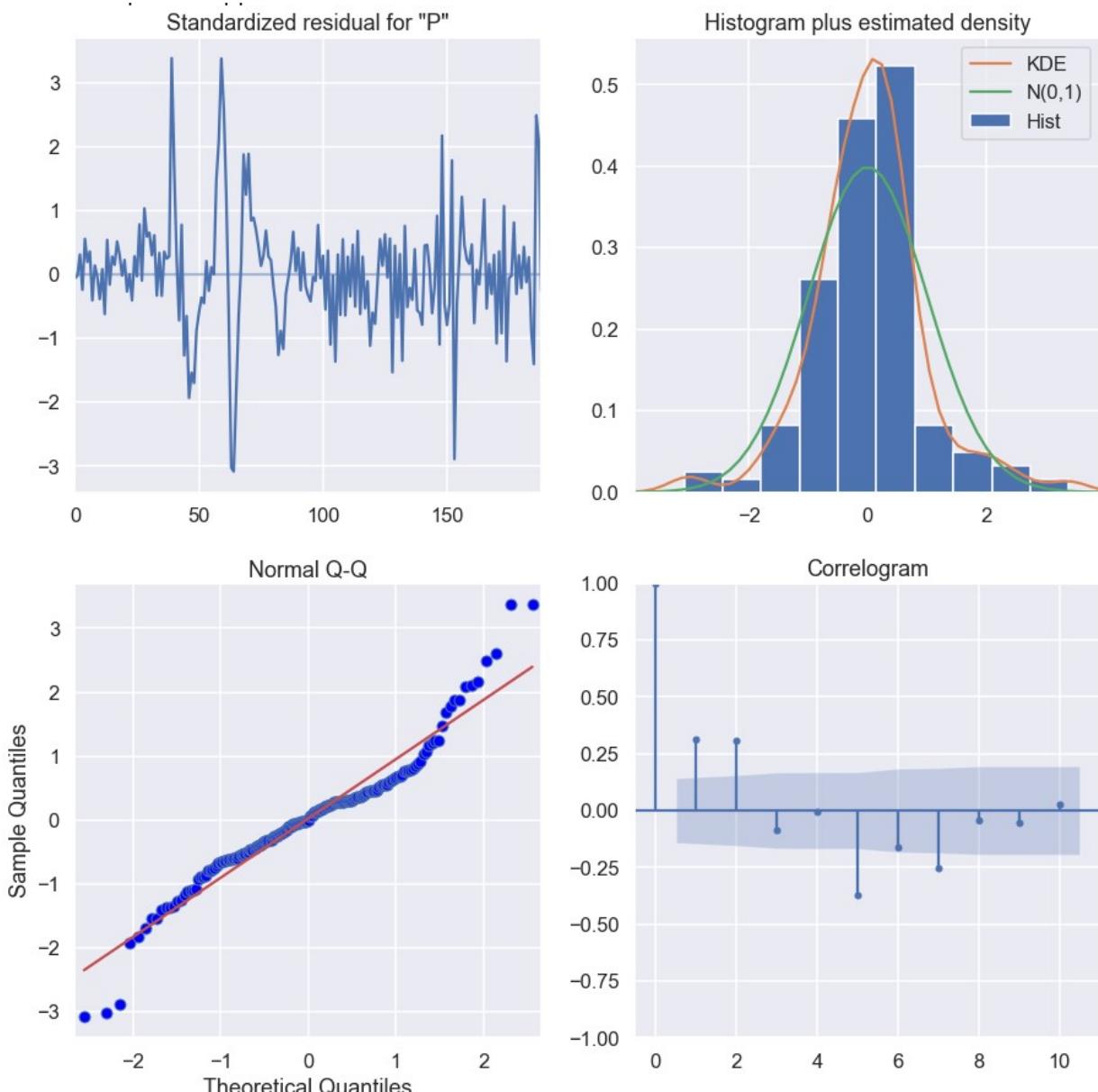
Heteroskedasticity (H):	0.86	Skew:	0.24
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Prob(H) (two-sided): 0.56

Kurtosis: 5.64

Warnings:

- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 1.07e+27. Standard

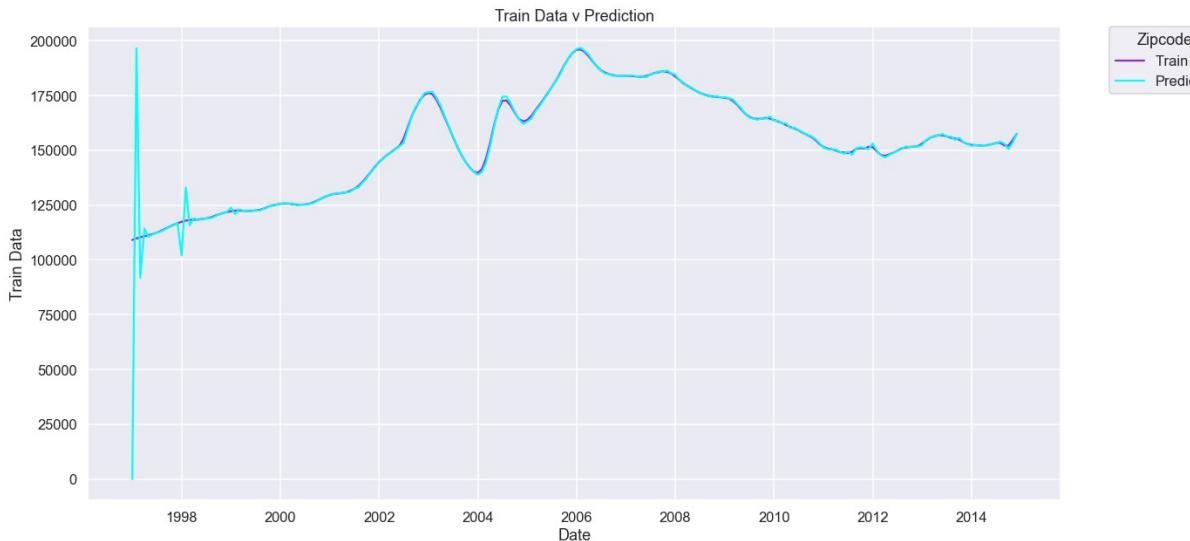


```
In [122]: train_rmse(z53404, (3, 0, 1), (2, 0, 0, 12))
test_rmse(z53404, (3, 0, 1), (2, 0, 0, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will b
```

e ignored when e.g. forecasting.

Train RMSE: 9698.898423227765



```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

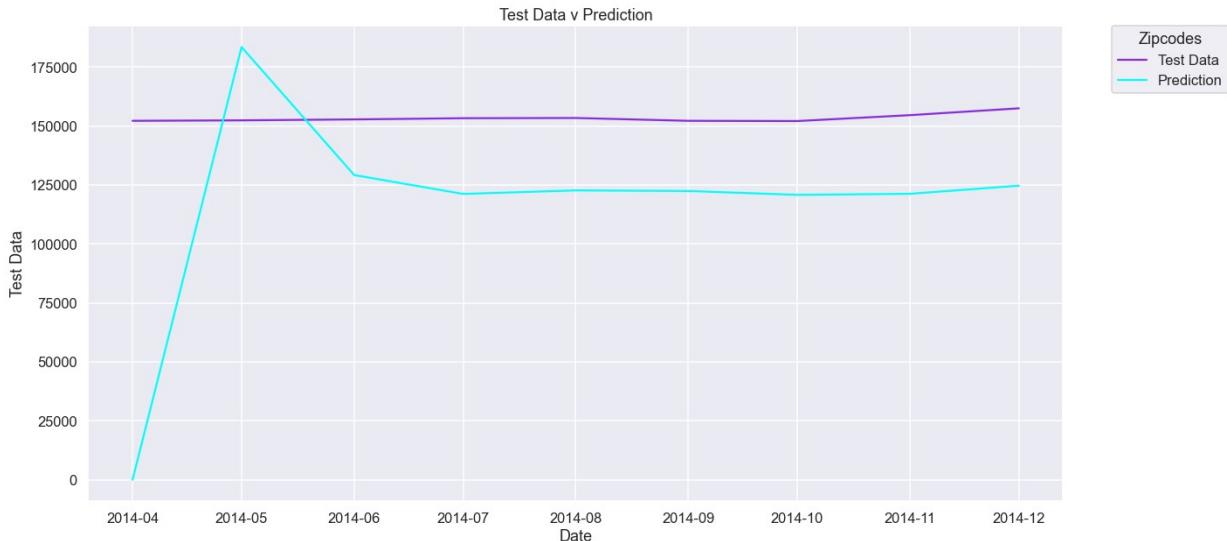
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
```

```
    warnings.warn("Maximum Likelihood optimization failed to "
```

Train RMSE: 32622.554676920907



In [123]: `forecast(z53404, (3, 0, 1), (2, 0, 0, 12))`

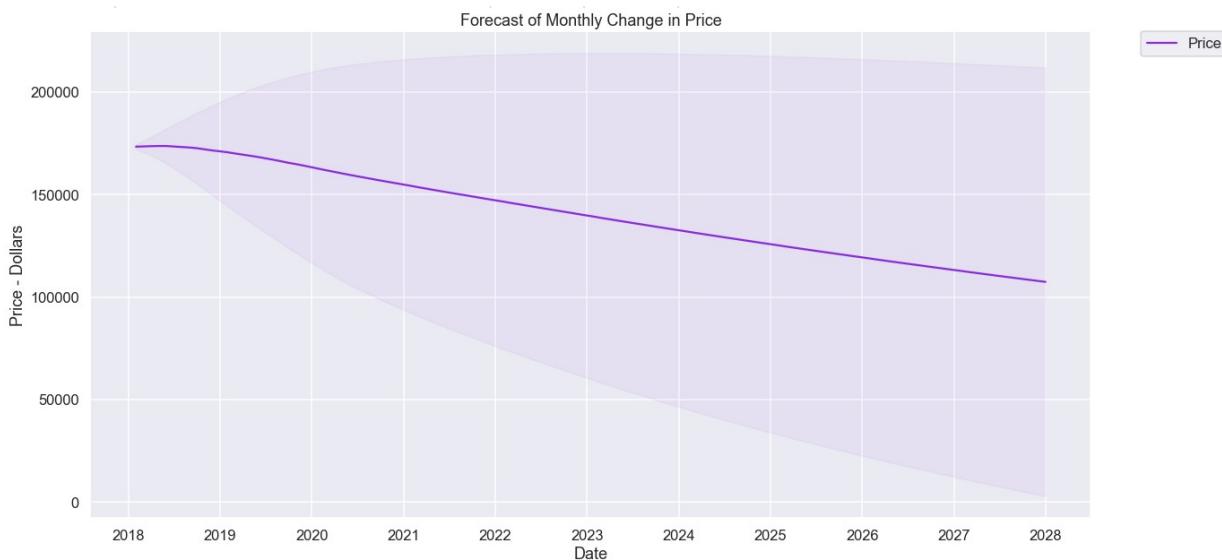
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\mod
el.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to conve
rge. Check mle_retrvals
    warnings.warn("Maximum Likelihood optimization failed to "
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
e\tsa_model.py:376: ValueWarning: No supported index is available. Prediction
results will be given with an integer index beginning at `start`.
```

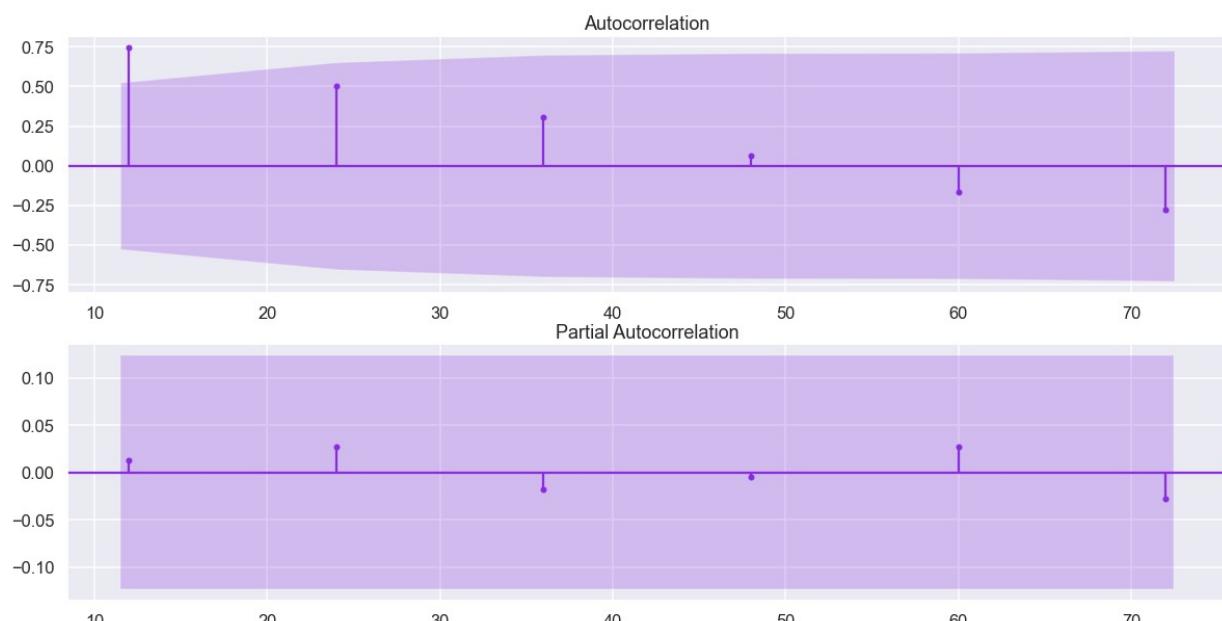


Expected Return - Five-Years: \$29970.68

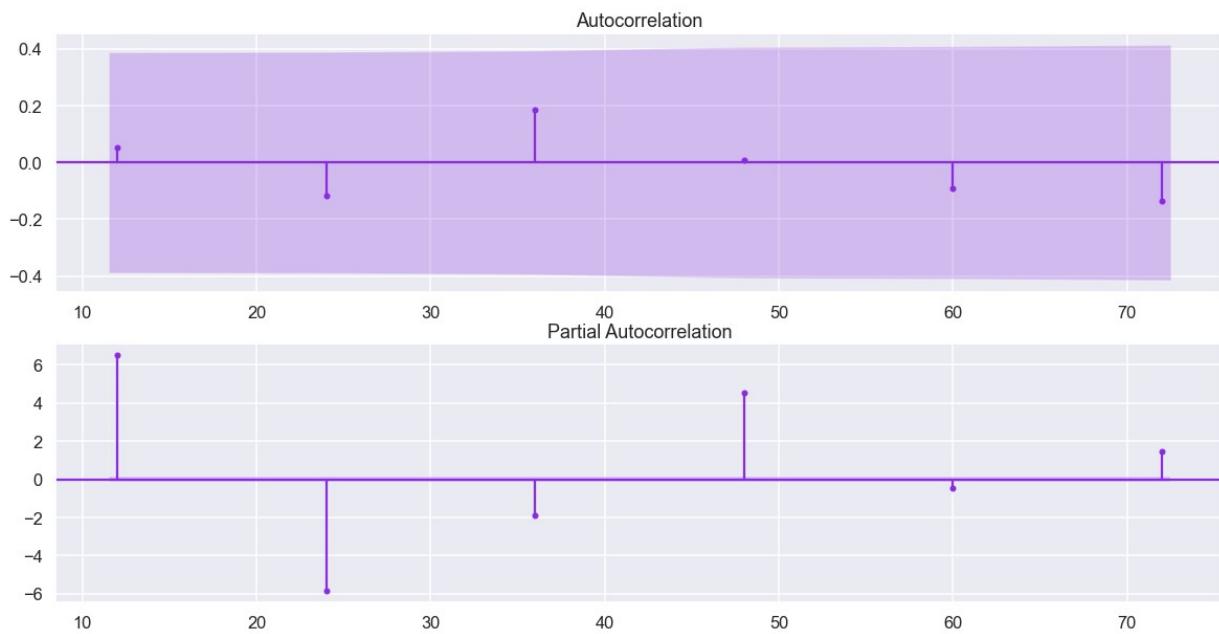
```
In [124]: zipcode.append('53404')
year5.append('29970.68')
```

53405

```
In [125]: acf_pacf(z53405)
```



```
In [126]: seasonal_acf_pacf(z53405)
```



In [127...]

params (z53405)

```
Performing stepwise search to minimize aic
ARIMA(1,0,1) (1,0,1)[12] intercept      : AIC=inf, Time=1.07 sec
ARIMA(0,0,0) (0,0,0)[12] intercept      : AIC=4973.635, Time=0.20 sec
ARIMA(1,0,0) (1,0,0)[12] intercept      : AIC=3862.641, Time=1.57 sec
ARIMA(0,0,1) (0,0,1)[12] intercept      : AIC=inf, Time=0.68 sec
ARIMA(0,0,0) (0,0,0)[12]                : AIC=5795.597, Time=0.02 sec
ARIMA(1,0,0) (0,0,0)[12] intercept      : AIC=inf, Time=0.40 sec
ARIMA(1,0,0) (2,0,0)[12] intercept      : AIC=inf, Time=13.68 sec
ARIMA(1,0,0) (1,0,1)[12] intercept      : AIC=inf, Time=1.32 sec
ARIMA(1,0,0) (0,0,1)[12] intercept      : AIC=3863.844, Time=0.22 sec
ARIMA(1,0,0) (2,0,1)[12] intercept      : AIC=3847.564, Time=1.40 sec
ARIMA(1,0,0) (2,0,2)[12] intercept      : AIC=inf, Time=6.65 sec
ARIMA(1,0,0) (1,0,2)[12] intercept      : AIC=3848.537, Time=2.45 sec
ARIMA(0,0,0) (2,0,1)[12] intercept      : AIC=inf, Time=2.51 sec
ARIMA(2,0,0) (2,0,1)[12] intercept      : AIC=3481.962, Time=3.84 sec
ARIMA(2,0,0) (1,0,1)[12] intercept      : AIC=3496.577, Time=0.78 sec
ARIMA(2,0,0) (2,0,0)[12] intercept      : AIC=3482.738, Time=23.88 sec
ARIMA(2,0,0) (2,0,2)[12] intercept      : AIC=inf, Time=7.07 sec
ARIMA(2,0,0) (1,0,0)[12] intercept      : AIC=3494.602, Time=2.12 sec
ARIMA(2,0,0) (1,0,2)[12] intercept      : AIC=3479.580, Time=5.39 sec
ARIMA(2,0,0) (0,0,2)[12] intercept      : AIC=inf, Time=3.24 sec
ARIMA(2,0,0) (0,0,1)[12] intercept      : AIC=3494.553, Time=0.64 sec
ARIMA(3,0,0) (1,0,2)[12] intercept      : AIC=3366.451, Time=4.74 sec
ARIMA(3,0,0) (0,0,2)[12] intercept      : AIC=3358.935, Time=3.85 sec
ARIMA(3,0,0) (0,0,1)[12] intercept      : AIC=3370.296, Time=0.55 sec
ARIMA(3,0,0) (1,0,1)[12] intercept      : AIC=3370.486, Time=1.54 sec
ARIMA(3,0,1) (0,0,2)[12] intercept      : AIC=3329.474, Time=4.52 sec
ARIMA(3,0,1) (0,0,1)[12] intercept      : AIC=3336.768, Time=1.49 sec
ARIMA(3,0,1) (1,0,2)[12] intercept      : AIC=inf, Time=6.76 sec
ARIMA(3,0,1) (1,0,1)[12] intercept      : AIC=inf, Time=1.95 sec
ARIMA(2,0,1) (0,0,2)[12] intercept      : AIC=3350.648, Time=2.41 sec
ARIMA(3,0,2) (0,0,2)[12] intercept      : AIC=3312.928, Time=5.11 sec
ARIMA(3,0,2) (0,0,1)[12] intercept      : AIC=3316.869, Time=2.00 sec
ARIMA(3,0,2) (1,0,2)[12] intercept      : AIC=inf, Time=7.47 sec
ARIMA(3,0,2) (1,0,1)[12] intercept      : AIC=3314.925, Time=2.52 sec
ARIMA(2,0,2) (0,0,2)[12] intercept      : AIC=3316.738, Time=3.14 sec
ARIMA(3,0,3) (0,0,2)[12] intercept      : AIC=3314.682, Time=5.53 sec
ARIMA(2,0,3) (0,0,2)[12] intercept      : AIC=3315.459, Time=3.67 sec
ARIMA(3,0,2) (0,0,2)[12]                : AIC=3352.592, Time=4.47 sec
```

Best model: ARIMA(3, 0, 2)(0, 0, 2)[12] intercept

```
In [128]: model_fit(z53405, (3, 0, 2), (0, 0, 2, 12))
```

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

warnings.warn('An unsupported index was provided and will be')

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.

warnings.warn('An unsupported index was provided and will be')

C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals

warnings.warn("Maximum Likelihood optimization failed to ")

SARIMAX Results

Dep. Variable:	Price	No. Observations:	216
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Model:	SARIMAX(3, 0, 2)x(0, 0, 2, 12)	Log Likelihood	-1676.348
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Date:	Fri, 21 May 2021	AIC	3368.697
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Time:	14:22:58	BIC	3394.631
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Sample:	0	HQIC	3379.203
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- 216

Covariance Type:	opg
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	coef	std err	z	P> z 	[0.025	0.975]
ar.L1	0.9387	0.098	9.586	0.000	0.747	1.131
ar.L2	0.2155	0.110	1.965	0.049	0.001	0.430
ar.L3	-0.1539	0.034	-4.558	0.000	-0.220	-0.088
ma.L1	0.6412	0.155	4.147	0.000	0.338	0.944
ma.L2	-0.2510	0.153	-1.643	0.100	-0.550	0.048
ma.S.L12	2.1697	0.441	4.925	0.000	1.306	3.033
ma.S.L24	4.3223	0.346	12.505	0.000	3.645	5.000
sigma2	2.655e+05	3.4e-06	7.82e+10	0.000	2.65e+05	2.65e+05

Ljung-Box (L1) (Q):	107.11	Jarque-Bera (JB):	152.90
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Prob(Q):	0.00	Prob(JB):	0.00
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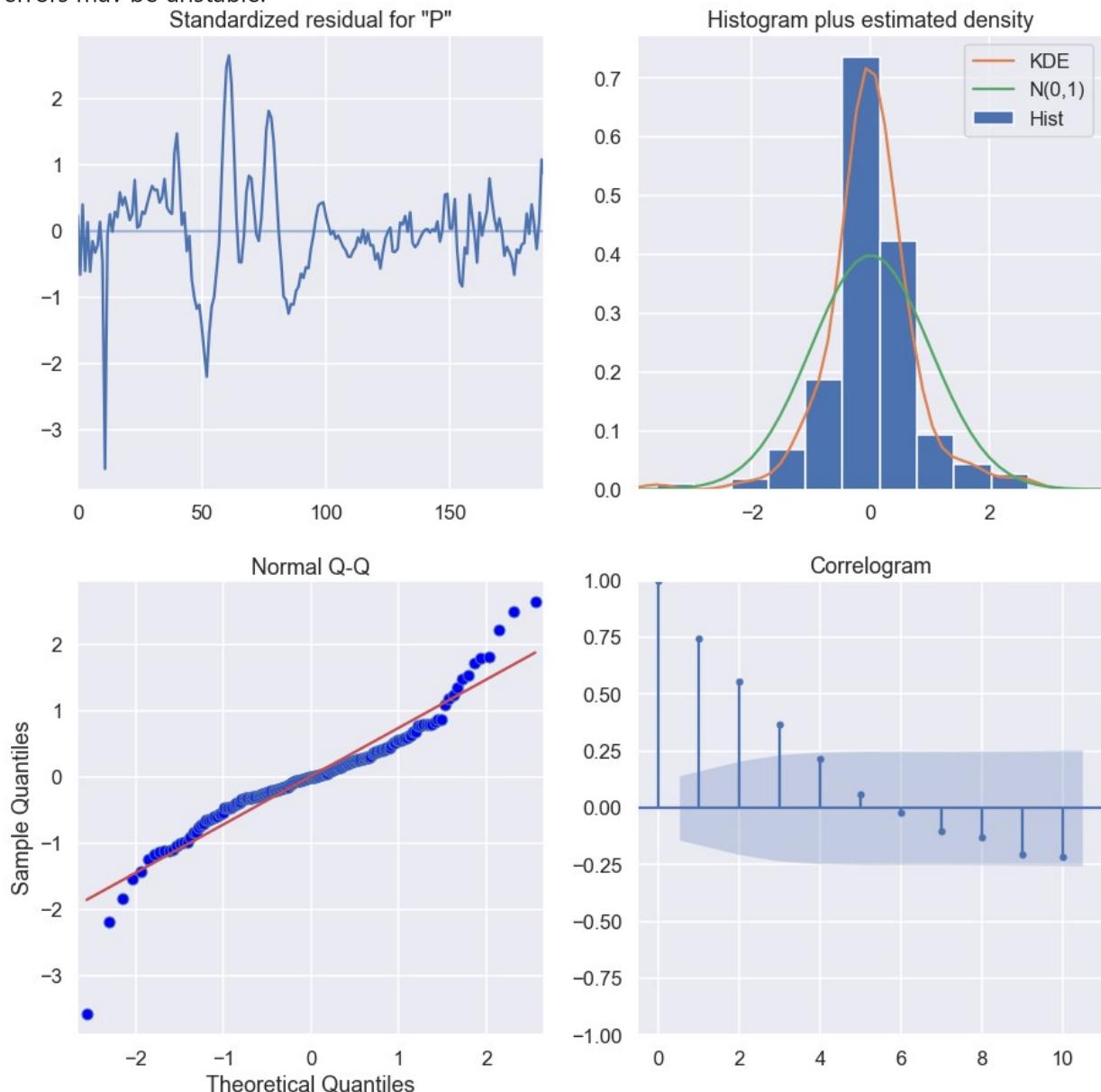
Heteroskedasticity (H):	0.12	Skew:	-0.10
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Prob(H) (two-sided):	0.00	Kurtosis:	7.40
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Warnings:

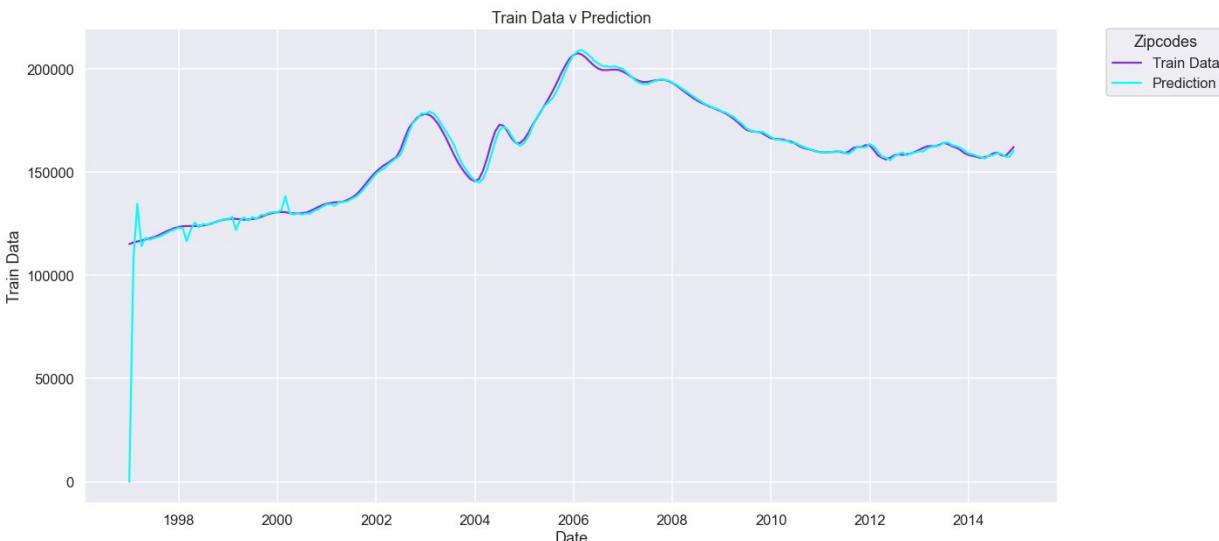
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

[2] Covariance matrix is singular or near-singular, with condition number 2.51e+26. Standard errors may be unstable.



```
In [129]: train_rmse(z53405, (3, 0, 2), (0, 0, 2, 12))
test_rmse(z53405, (3, 0, 2), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be')
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
    warnings.warn("Maximum Likelihood optimization failed to "
Train RMSE: 8124.255559465486
```



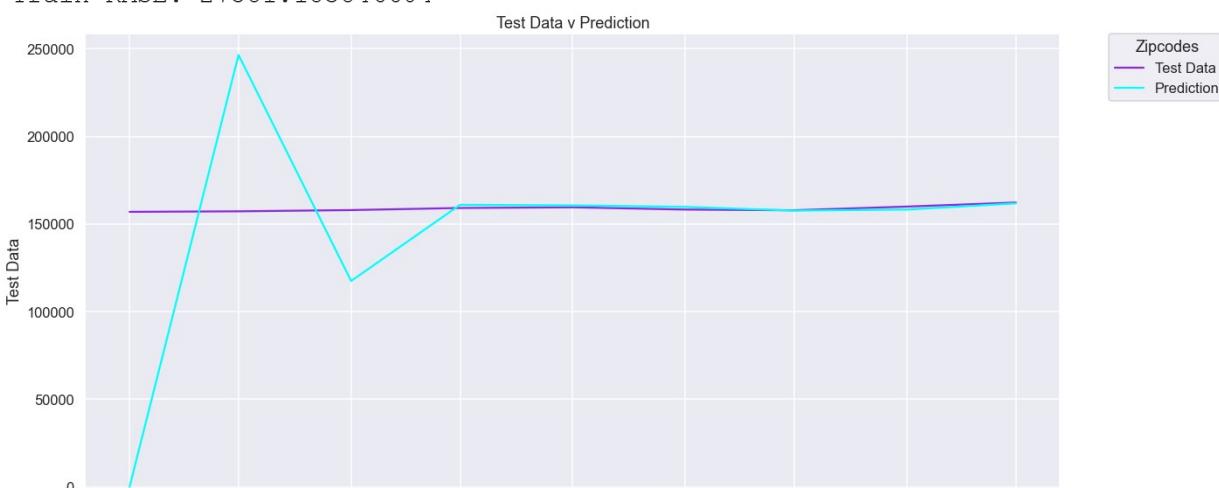
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
Train RMSE: 27581.183846604
```



```
In [130...]
```

```
forecast(z53405, (3, 0, 2), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
    warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
```

```
    warnings.warn("Maximum Likelihood optimization failed to "
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.
```

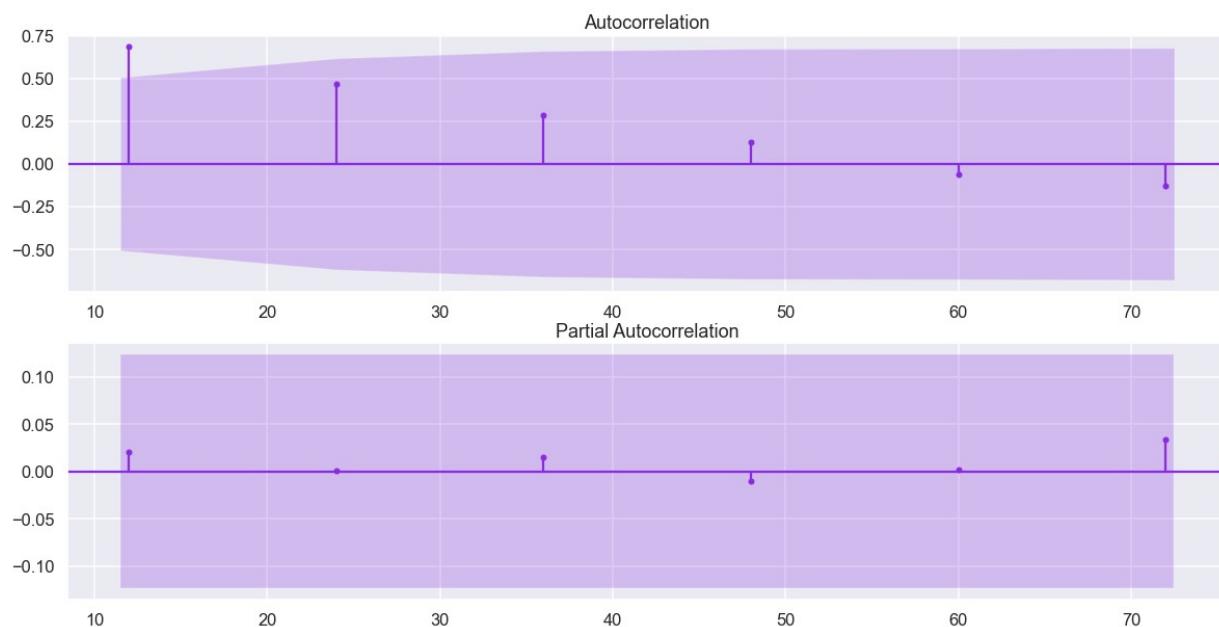
```
    warnings.warn('No supported index is available.'
```



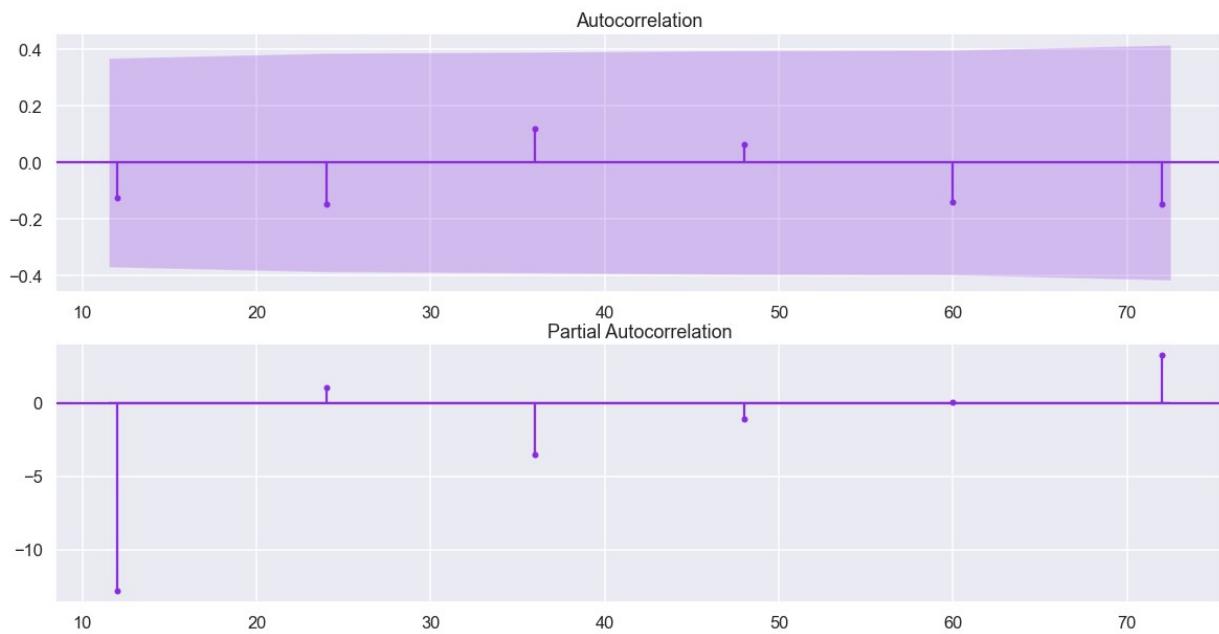
```
In [131]: zipcode.append('53405')
year5.append('53410.31')
```

53185

```
In [132]: acf_pacf(z53185)
```



```
In [133]: seasonal_acf_pacf(z53185)
```



In [134...]

params (z53185)

```
Performing stepwise search to minimize aic
ARIMA(1,0,1)(1,0,1)[12] intercept      : AIC=inf, Time=1.56 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=5063.001, Time=0.02 sec
ARIMA(1,0,0)(1,0,0)[12] intercept      : AIC=4003.968, Time=1.36 sec
ARIMA(0,0,1)(0,0,1)[12] intercept      : AIC=inf, Time=0.80 sec
ARIMA(0,0,0)(0,0,0)[12] intercept      : AIC=5907.976, Time=0.02 sec
ARIMA(1,0,0)(0,0,0)[12] intercept      : AIC=4005.386, Time=0.05 sec
ARIMA(1,0,0)(2,0,0)[12] intercept      : AIC=3997.531, Time=11.45 sec
ARIMA(1,0,0)(2,0,1)[12] intercept      : AIC=3996.882, Time=1.29 sec
ARIMA(1,0,0)(1,0,1)[12] intercept      : AIC=inf, Time=1.38 sec
ARIMA(1,0,0)(2,0,2)[12] intercept      : AIC=inf, Time=4.02 sec
ARIMA(1,0,0)(1,0,2)[12] intercept      : AIC=3998.152, Time=1.18 sec
ARIMA(0,0,0)(2,0,1)[12] intercept      : AIC=inf, Time=3.52 sec
ARIMA(2,0,0)(2,0,1)[12] intercept      : AIC=3594.040, Time=2.20 sec
ARIMA(2,0,0)(1,0,1)[12] intercept      : AIC=3604.052, Time=0.86 sec
ARIMA(2,0,0)(2,0,0)[12] intercept      : AIC=3594.685, Time=8.94 sec
ARIMA(2,0,0)(2,0,2)[12] intercept      : AIC=inf, Time=4.78 sec
ARIMA(2,0,0)(1,0,0)[12] intercept      : AIC=3602.110, Time=2.46 sec
ARIMA(2,0,0)(1,0,2)[12] intercept      : AIC=3591.917, Time=1.93 sec
ARIMA(2,0,0)(0,0,2)[12] intercept      : AIC=inf, Time=3.54 sec
ARIMA(2,0,0)(0,0,1)[12] intercept      : AIC=3602.162, Time=0.30 sec
ARIMA(3,0,0)(1,0,2)[12] intercept      : AIC=3445.620, Time=2.42 sec
ARIMA(3,0,0)(0,0,2)[12] intercept      : AIC=3443.942, Time=1.63 sec
ARIMA(3,0,0)(0,0,1)[12] intercept      : AIC=3450.847, Time=0.49 sec
ARIMA(3,0,0)(1,0,1)[12] intercept      : AIC=inf, Time=2.41 sec
ARIMA(3,0,1)(0,0,2)[12] intercept      : AIC=3416.993, Time=4.65 sec
ARIMA(3,0,1)(0,0,1)[12] intercept      : AIC=3422.865, Time=1.92 sec
ARIMA(3,0,1)(1,0,2)[12] intercept      : AIC=3417.891, Time=5.68 sec
ARIMA(3,0,1)(1,0,1)[12] intercept      : AIC=inf, Time=2.16 sec
ARIMA(2,0,1)(0,0,2)[12] intercept      : AIC=inf, Time=3.66 sec
ARIMA(3,0,2)(0,0,2)[12] intercept      : AIC=3406.611, Time=4.52 sec
ARIMA(3,0,2)(0,0,1)[12] intercept      : AIC=3418.895, Time=1.03 sec
ARIMA(3,0,2)(1,0,2)[12] intercept      : AIC=3407.576, Time=5.90 sec
ARIMA(3,0,2)(1,0,1)[12] intercept      : AIC=inf, Time=2.58 sec
ARIMA(2,0,2)(0,0,2)[12] intercept      : AIC=3407.379, Time=3.86 sec
ARIMA(3,0,3)(0,0,2)[12] intercept      : AIC=3400.746, Time=6.24 sec
ARIMA(3,0,3)(0,0,1)[12] intercept      : AIC=3419.364, Time=1.26 sec
ARIMA(3,0,3)(1,0,2)[12] intercept      : AIC=inf, Time=6.87 sec
ARIMA(3,0,3)(1,0,1)[12] intercept      : AIC=inf, Time=2.86 sec
ARIMA(2,0,3)(0,0,2)[12] intercept      : AIC=3408.372, Time=4.27 sec
```

```
ARIMA(3, 0, 3)(0, 0, 2)[12] : AIC=3408.500, Time=4.72 sec
```

```
Best model: ARIMA(3, 0, 3)(0, 0, 2)[12] intercept
```

```
In [135]: model_fit(z53185, (3, 0, 3), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be')
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be')
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
```

```
warnings.warn("Maximum Likelihood optimization failed to ")
```

SARIMAX Results

Dep. Variable:	Price	No. Observations:	216
-----------------------	-------	--------------------------	-----

Model:	SARIMAX(3, 0, 3)x(0, 0, [1, 2], 12)	Log Likelihood	-1747.042
---------------	-------------------------------------	-----------------------	-----------

Date:	Fri, 21 May 2021	AIC	3512.084
--------------	------------------	------------	----------

Time:	14:25:39	BIC	3541.212
--------------	----------	------------	----------

Sample:	0	HQIC	3523.886
----------------	---	-------------	----------

- 216

Covariance Type:	opg
-------------------------	-----

	coef	std err	z	P> z	[0.025	0.975]
ar.L1	1.1390	0.036	31.678	0.000	1.069	1.209
ar.L2	-0.0272	0.052	-0.517	0.605	-0.130	0.076
ar.L3	-0.1098	0.041	-2.675	0.007	-0.190	-0.029
ma.L1	-0.0602	0.205	-0.294	0.769	-0.461	0.341
ma.L2	0.2946	0.249	1.182	0.237	-0.194	0.783
ma.L3	-0.1188	0.195	-0.610	0.542	-0.501	0.263
ma.S.L12	-4.4676	0.358	-12.479	0.000	-5.169	-3.766
ma.S.L24	4.1911	0.398	10.520	0.000	3.410	4.972
sigma2	4.073e+05	3.5e-06	1.16e+11	0.000	4.07e+05	4.07e+05

Ljung-Box (L1) (Q):	141.79	Jarque-Bera (JB):	5.60
----------------------------	--------	--------------------------	------

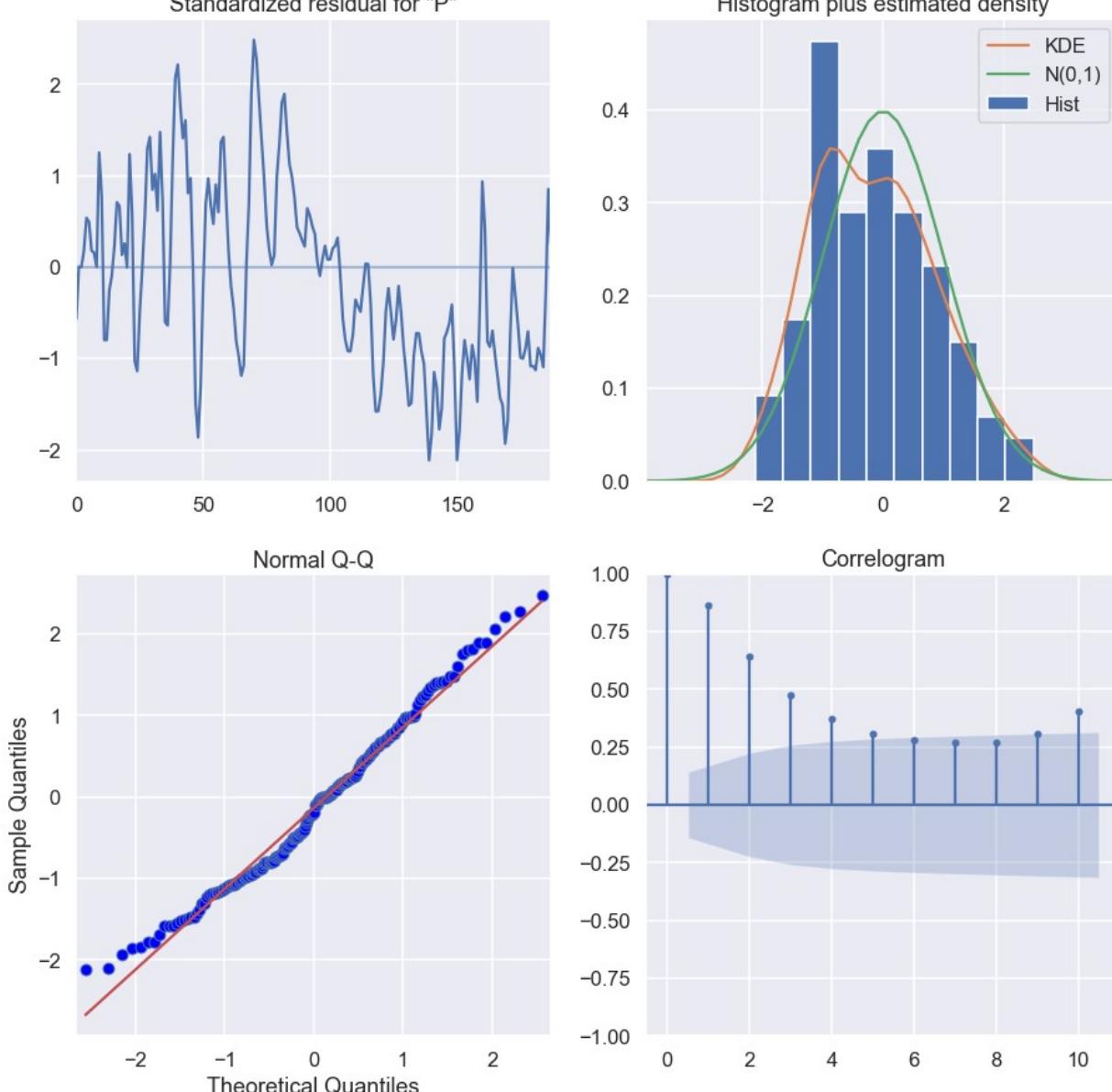
Prob(Q):	0.00	Prob(JB):	0.06
-----------------	------	------------------	------

Heteroskedasticity (H):	1.42	Skew:	0.33
--------------------------------	------	--------------	------

Prob(H) (two-sided):	0.17	Kurtosis:	2.48
-----------------------------	------	------------------	------

Warnings:

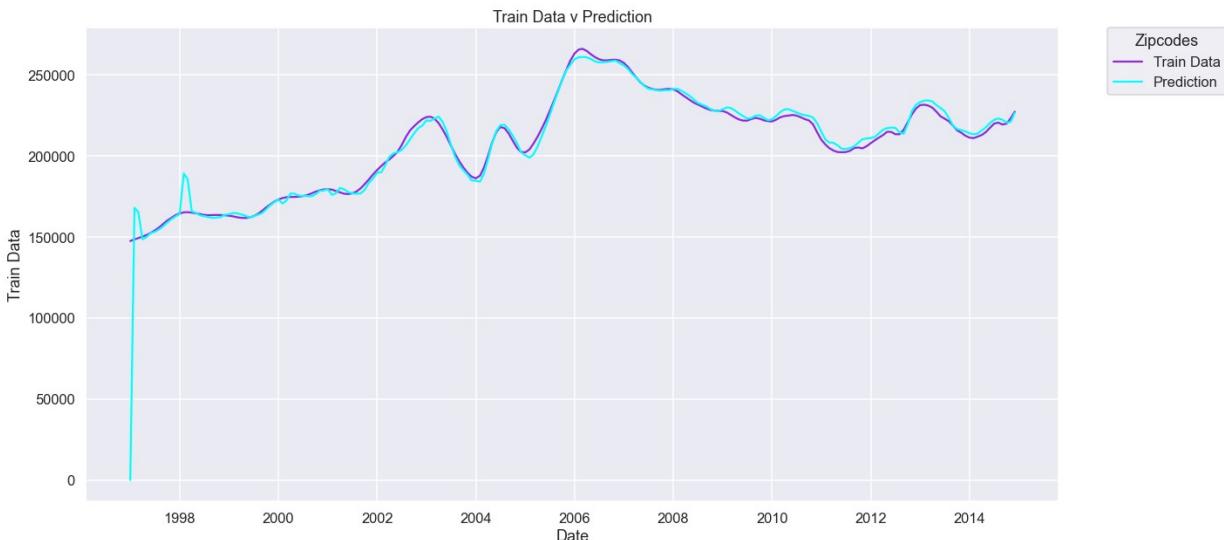
- [1] Covariance matrix calculated using the outer product of gradients (complex-step).
- [2] Covariance matrix is singular or near-singular, with condition number 2.01e+26. Standard



```
In [136]: train_rmse(z53185, (3, 0, 3), (0, 0, 2, 12))
test_rmse(z53185, (3, 0, 3), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
    warnings.warn('An unsupported index was provided and will be'
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
```

```
warnings.warn("Maximum Likelihood optimization failed to "
Train RMSE: 10702.267384141802
```



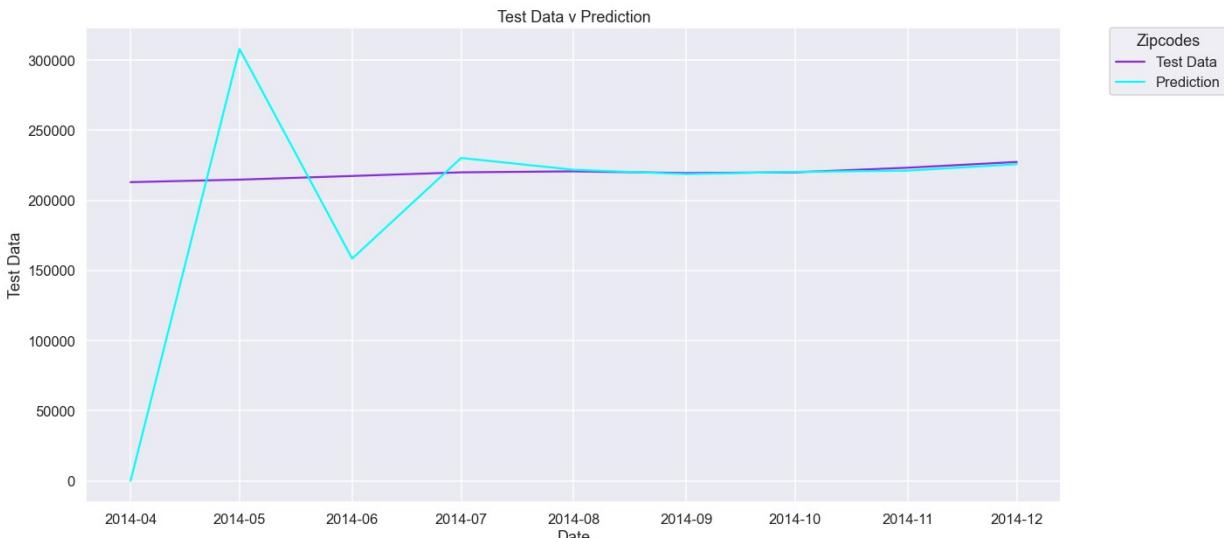
```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
```

```
Train RMSE: 35778.506508328115
```



```
In [137]: forecast(z53185, (3, 0, 3), (0, 0, 2, 12))
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

```
warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\base\tsa_model.py:578: ValueWarning: An unsupported index was provided and will be ignored when e.g. forecasting.
```

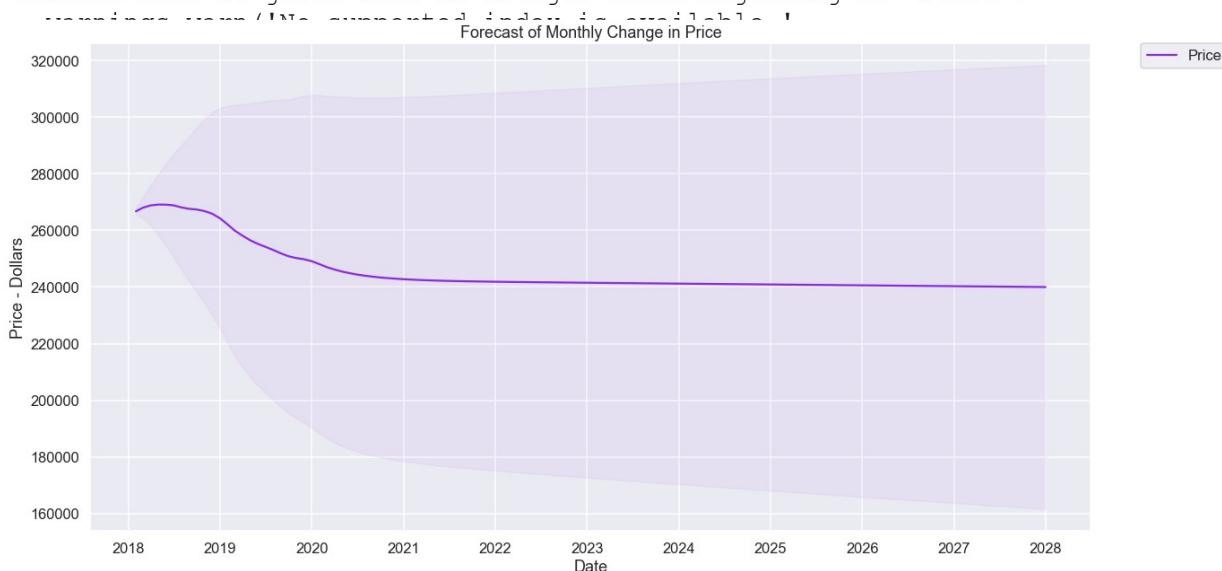
```
warnings.warn('An unsupported index was provided and will be'
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retrvals
```

```
warnings.warn("Maximum Likelihood optimization failed to "
```

```
C:\Users\westi\anaconda3\envs\learn-env\lib\site-packages\statsmodels\tsa\bas
```

e\tsa_model.py:376: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.



Expected Return - Five-Years: \$92993.81

```
In [138]: zipcode.append('53185')
year5.append('92993.81')
```

Complile Results

In [139...]

```
# Create a dataframe of the top5 zipcodes and
# the difference in the forecasted 5-year price
# from starting price

forecast_data = {'Zipcode' : zipcode,
                 'Year-Five Expected Return' : year5}

forecast_df = pd.DataFrame(forecast_data)

forecast_df = forecast_df[0:5]

final_state = pd.Series(['WI',
                        'WI',
                        'WI',
                        'WI',
                        'WI'])

final_county = pd.Series(['Racine',
                          'Kenosha',
                          'Kenosha',
                          'Kenosha',
                          'Racine'])

final_city = pd.Series(['Waterford',
                       'Twin Lakes',
                       'Kenosha',
                       'Kenosha',
                       'Eagle Lake'])

forecast_df['State'] = final_state.values
forecast_df['County'] = final_county.values
forecast_df['City'] = final_city.values

forecast_df = forecast_df[['State',
                           'County',
                           'City',
                           'Zipcode',
                           'Year-Five Expected Return']]

final_zipcodes = chi_mke.loc[chi_mke['Zipcode'].isin(['53185',
                                                       '53181',
                                                       '53144',
                                                       '53142',
                                                       '53139'])]

final_zipcodes = (final_zipcodes[final_zipcodes['Date']
                                 == pd.to_datetime('1997-04-01 00:00:00')])

final_zipcodes.drop(['Date', 'Price'],
                    axis = 1,
                    inplace = True)

forecast_df['Year-Five Expected Return'] = forecast_df['Year-Five Expected Return']

forecast_df.sort_values(by = 'Year-Five Expected Return',
                        ascending = False, inplace = True)
```

Conclusions

Parameters and Evaluation Metric - Review

Risk

The Chiwaukee Group would like to manage their risk profile, with risk evaluated as the Coefficient of Variance, the ratio of the standard deviation to the mean, with an upper-limit set at 50%

Historical Return on Investment

The Chiwaukee Group would like to invest in proven areas with a high historical Return on Investment, filtering to include the top 25%

Expected Future Return

Final recommendations will be provided based on future return forecasts produced through Time Series modeling

Top-Five Zicodes

```
In [140]: print('Top-Five Zipcodes and the difference in their forecasted 5-year price :')
forecast_df
```

Top-Five Zipcodes and the difference in their forecasted 5-year price from the starting price

```
Out[140]:
```

	State	County	City	Zipcode	Year-Five Expected Return
0	WI	Racine	Waterford	60047	149388.39
4	WI	Racine	Eagle Lake	53181	50350.55
3	WI	Kenosha	Kenosha	53158	44133.74
2	WI	Kenosha	Kenosha	53144	39968.79
1	WI	Kenosha	Twin Lakes	53142	38127.55

```
In [141]: forecast_df.to_csv(r'C:\Users\westi\Documents\GitHub\the_chiwauke_group\data\
```

Recommendations

- Invest in the area 15-25miles West of I94, North of the IL-border
- Invest in the area within 5miles I94 in Kenosha County

Detailed Observations

Invest in in the area 15-25miles West of I94, North of the IL-border

Three of the top-five zipcodes, including the top-two,are located sequentially, fifteen-to-twenty-five-miles West of Interstate-94, from the north-most border of Racine County south to the Illinois border

Based on projections that Chicago and Milwaukee will continue to merge into a singular megaregion, it was anticipated that the area directly between, East of Interstate-94 to Lake Michigan, containing cities Kenosha, Racine, and Oak Creek would have been one of the areas on the rise

Follow-Up Questions

- Is the attraction to this area potentially associated with higher rated school system further separated from the cities? (Racine and Milwaukee cities have historically ranked among the worst school systems in the US)
- Are the higher forecasted returns potentially being driven by specific, smaller geographic areas, weighting the average for the zipcode? (Nearby Lake Geneva has historically one of wealthiest areas in the Midwest)
- Is the growth of the area even connected with commuting access to Milwaukee and/or Chicago? Are people looking for an area separated from the cities but still within commuting distance or is the growth of this area being driven by completed disassociated factors?

Invest in the area within 5miles I94 in Kenosha County

The final two of the top-five-zipcodes were more predictably the area directly surrounding the major business developments along Interstate-94 in Kenosha.

This area would also have the most direct access to Interstate-94 and the Hiawatha Train service stop for commuter access (both Milwaukee and Chicago are approximately forty-five-minutes drive)(the Hiawatha train stop in Sturtevant, Wisconsin is two-miles from Interstate-94 in Racine County, approximately ten-totwenty-minutes drive from this area)

Follow-Up Questions

- What type of competition exists for the development residential projects in this area?
- What types of residences are in-demand in this area? What type of socioeconomic profile is being drawn to the area by the business development?
- Are people moving to this area for distribution center and manufacturing jobs or for commuter access to Milwaukee and/or Chicago?

Discard interest in Illinois

All five of the top-five zipcodes are all located in Wisconsin, not Lake County in Illinois

Follow-Up Questions

- How big a factor is the significant discrepancy between state tax-rates in Wisconsin compared to Illinois?

Next Steps

- Additional research can be performed regarding factors such as:
 - Tax Rates
 - Interest Rates
 - School District Ratings
 - Crime Rates
 - Median Household Incomes
- Additional modeling types can be utilized in the analysis of further data types
- Polling can be performed with current residents, with specific emphasis on people who moved to the area recently, to gather further data regarding personal driving factors potentially not captured by available statistics
- Further research can be performed narrowing the geographic range within the top zipcodes to attempt to discover more specifically which areas The Chiwaukee Group should look to invest in