Dataset

Dataset *Electric Vehicle Title and Registration Activity* diambil dari sumber berikut.
https://catalog.data.gov/dataset/electric-vehicle-title-and-registration-activity

Import Library/Packages, Data, *and Mount* Google Drive

In [ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [ ]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from pandas import read_csv
from pandas import datetime
from pandas import Series
from matplotlib import pyplot
from statsmodels.tsa.stattools import adfuller
import statsmodels.api as sm
!pip install pmdarima
import pmdarima as pm
from statsmodels.tsa.statespace.sarimax import SARIMAX
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_l
```

```
<ipython-input-1-6d4a4b7227a0>:6: FutureWarning: The pandas.datetime class is depr
ecated and will be removed from pandas in a future version. Import from datetime m
odule instead.
  from pandas import datetime
```

```
Collecting pmdarima
  Downloading pmdarima-2.0.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.manylinux_2_28_x86_64.whl (1.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.8/1.8 MB 8.7 MB/s eta 0:00:00
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.10/dist-pack
ages (from pmdarima) (1.3.2)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in /usr/local/lib/
python3.10/dist-packages (from pmdarima) (0.29.36)
Requirement already satisfied: numpy>=1.21.2 in /usr/local/lib/python3.10/dist-pac
kages (from pmdarima) (1.23.5)
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.10/dist-pack
ages (from pmdarima) (1.5.3)
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.10/dis
t-packages (from pmdarima) (1.2.2)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.10/dist-pack
ages (from pmdarima) (1.10.1)
Requirement already satisfied: statsmodels>=0.13.2 in /usr/local/lib/python3.10/di
st-packages (from pmdarima) (0.14.0)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.10/dist-packages
(from pmdarima) (2.0.4)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/pytho
n3.10/dist-packages (from pmdarima) (67.7.2)
Requirement already satisfied: python-dateutil>=2.8.1 in /usr/local/lib/python3.1
0/dist-packages (from pandas>=0.19->pmdarima) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-pack
ages (from pandas>=0.19->pmdarima) (2023.3)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/d
ist-packages (from scikit-learn>=0.22->pmdarima) (3.2.0)
Requirement already satisfied: patsy>=0.5.2 in /usr/local/lib/python3.10/dist-pack
ages (from statsmodels>=0.13.2->pmdarima) (0.5.3)
Requirement already satisfied: packaging>=21.3 in /usr/local/lib/python3.10/dist-p
ackages (from statsmodels>=0.13.2->pmdarima) (23.1)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (fro
m patsy>=0.5.2->statsmodels>=0.13.2->pmdarima) (1.16.0)
Installing collected packages: pmdarima
Successfully installed pmdarima-2.0.3
```

In [ ]:
```
df = pd.read_csv('https://data.wa.gov/api/views/rpr4-cgyd/rows.csv')
```

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

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	O
0	Battery Electric Vehicle (BEV)	1N4AZ0CPXF	121397454	2015	NISSAN	Leaf	Passenger	84	0	Or
1	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or
2	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
3	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
4	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or

5 rows × 35 columns

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 781713 entries, 0 to 781712
Data columns (total 35 columns):
 #   Column                                                     Non-Null Coun
t   Dtype
---  ------                                                     --------------
-   -----
 0  Clean  Alternative Fuel Vehicle Type                       781713 non-nu
ll  object
 1   VIN (1-10)                                                781713 non-nu
ll  object
 2   DOL Vehicle ID                                            781713 non-nu
ll  int64
 3   Model Year                                                781713 non-nu
ll  int64
 4   Make                                                      781713 non-nu
ll  object
 5   Model                                                     781713 non-nu
ll  object
 6   Vehicle Primary Use                                       781713 non-nu
ll  object
 7   Electric Range                                            781713 non-nu
ll  int64
 8   Odometer Reading                                          781713 non-nu
ll  int64
 9   Odometer Code                                             781713 non-nu
ll  object
 10  New or Used Vehicle                                       781713 non-nu
ll  object
 11  Sale Price                                                781713 non-nu
ll  int64
 12  Sale Date                                                 233413 non-nu
ll  object
 13  Base MSRP                                                 781713 non-nu
ll  int64
 14  Transaction Type                                          781713 non-nu
ll  object
 15  DOL Transaction Date                                      781713 non-nu
ll  object
 16  Transaction Year                                          781713 non-nu
ll  int64
 17  County                                                    781595 non-nu
ll  object
 18  City                                                      781560 non-nu
ll  object
 19  State of Residence                                        781712 non-nu
ll  object
 20  Postal Code                                               781583 non-nu
ll  float64
 21  2015 HB 2778 Exemption Eligibility                        781713 non-nu
ll  object
 22  2019 HB 2042 Clean Alternative Fuel Vehicle (CAFV) Eligibility  781713 non-nu
ll  object
 23  Meets 2019 HB 2042 Electric Range Requirement             781713 non-nu
ll  bool
 24  Meets 2019 HB 2042 Sale Date Requirement                  781713 non-nu
ll  bool
 25  Meets 2019 HB 2042 Sale Price/Value Requirement           781713 non-nu
ll  bool
 26  2019 HB 2042: Battery Range Requirement                   289527 non-nu
ll  object
 27  2019 HB 2042: Purchase Date Requirement                   781713 non-nu
ll  object
 28  2019 HB 2042: Sale Price/Value Requirement                781713 non-nu
```

```
ll  object
 29  Electric Vehicle Fee Paid                                781713 non-nu
ll  object
 30  Transportation  Electrification  Fee Paid                690682 non-nu
ll  object
 31  Hybrid  Vehicle  Electrification  Fee Paid               690682 non-nu
ll  object
 32  2020 Census Tract                                        781595 non-nu
ll  float64
 33  Legislative  District                                   778995 non-nu
ll  float64
 34  Electric Utility                                         781595 non-nu
ll  object
dtypes: bool(3), float64(3), int64(7), object(22)
memory usage: 193.1+ MB
```

Preprocessing

Drop Kolom

Kami akan menghapus kolom-kolom yang tidak akan kami gunakan dalam proses analisis data. Kolom-kolom tersebut yaitu `2015 HB 2778 Exemption Eligibility`, `2019 HB 2042 Clean Alternative Fuel Vehicle (CAFV) Eligibility`, `Meets 2019 HB 2042 Electric Range Requirement`, `Meets 2019 HB 2042 Sale Date Requirement`, `Meets 2019 HB 2042 Sale Price/Value Requirement`, `2019 HB 2042: Battery Range Requirement`, `2019 HB 2042: Purchase Date Requirement`, `2019 HB 2042: Sale Price/Value Requirement`, `Electric Vehicle Fee Paid`, `Transportation Electrification Fee Paid`, `Hybrid Vehicle Electrification Fee Paid`, `2020 Census Tract`, `Legislative District`, dan `Electric Utility`.

In [ ]:
```
drop_column = ['2015 HB 2778 Exemption Eligibility', '2019 HB 2042 Clean Alternativ
               'Meets 2019 HB 2042 Electric Range Requirement', 'Meets 2019 HB 2042
               'Meets 2019 HB 2042 Sale Price/Value Requirement', '2019 HB 2042: Ba
               '2019 HB 2042: Purchase Date Requirement', '2019 HB 2042: Sale Price
               'Electric Vehicle Fee Paid', 'Transportation Electrification Fee Pai
               '2020 Census Tract', 'Legislative District', 'Electric Utility']
df.drop(drop_column, axis = 1, inplace = True)
```

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

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	O
0	Battery Electric Vehicle (BEV)	1N4AZ0CPXF	121397454	2015	NISSAN	Leaf	Passenger	84	0	Or
1	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or
2	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
3	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
4	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or

5 rows × 21 columns

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 781713 entries, 0 to 781712
Data columns (total 21 columns):
 #   Column                                Non-Null Count   Dtype  
---                                       ----------------------  -----
 0   Clean Alternative Fuel Vehicle Type   781713 non-null  object 
 1   VIN (1-10)                            781713 non-null  object 
 2   DOL Vehicle ID                        781713 non-null  int64  
 3   Model Year                            781713 non-null  int64  
 4   Make                                  781713 non-null  object 
 5   Model                                 781713 non-null  object 
 6   Vehicle Primary Use                   781713 non-null  object 
 7   Electric Range                        781713 non-null  int64  
 8   Odometer Reading                      781713 non-null  int64  
 9   Odometer Code                         781713 non-null  object 
 10  New or Used Vehicle                   781713 non-null  object 
 11  Sale Price                            781713 non-null  int64  
 12  Sale Date                             233413 non-null  object 
 13  Base MSRP                             781713 non-null  int64  
 14  Transaction Type                      781713 non-null  object 
 15  DOL Transaction Date                  781713 non-null  object 
 16  Transaction Year                      781713 non-null  int64  
 17  County                                781595 non-null  object 
 18  City                                  781560 non-null  object 
 19  State of Residence                    781712 non-null  object 
 20  Postal Code                           781583 non-null  float64
dtypes: float64(1), int64(7), object(13)
memory usage: 125.2+ MB
```

Drop Kolom dengan Informasi Redundan

In [ ]:
```
df[["Sale Date", "DOL Transaction Date", "Transaction Year"]]
```

Out[ ]:

	Sale Date	DOL Transaction Date	Transaction Year
0	NaN	September 27 2022	2022
1	NaN	February 19 2021	2021
2	NaN	March 02 2020	2020
3	NaN	February 19 2021	2021
4	NaN	February 13 2023	2023
...	...	...	...
781708	April 01 2023	April 24 2023	2023
781709	NaN	November 09 2022	2022
781710	July 18 2022	November 09 2022	2022
781711	NaN	April 03 2023	2023
781712	March 15 2023	April 03 2023	2023

781713 rows × 3 columns

In [ ]:
```
df['Sale  Date'].isna().sum()
```

Out[ ]:
```
548300
```

- `Sale Date` : *the day on which the vehicle changed ownership*.
- `DOL Transaction Date` : *the day upon which a transaction was recorded into Department of Licensing's computer system*.
- `Sale Price` : *the amount that was reported to have been paid for a vehicle. A value of zero indicates that the sale price was not available*.
- `Base MSRP` : *This is the lowest Manufacturer's Suggested Retail Price (MSRP) for any version of the model in question*.

Dari hasil di atas, terlihat bahwa kolom `Sale Date` kehilangan banyak informasi. Terdapat perbedaan antara tanggal transaksi yang tercatat dan tanggal penjualan kendaraan yang sebenarnya yaitu sekitar beberapa minggu. Dalam analisis ini, kami akan menggunakan `DOL Transaction Date` dibandingkan `Sale Date`. Kolom `Transaction Year` memberikan informasi yang sama dengan kolom `DOL Transaction Date`. Oleh karena itu, kami akan menghapus kedua kolom tersebut.

Dalam data ini, telah terdapat kolom `Sale Price` (harga jual) kendaraan pada saat transaksi sehingga kolom `Base MSRP` tidak relevan. Jadi, kami akan menghapus kolom tersebut.

In [ ]:
```
drop_column2 = ['Sale Date', 'Transaction Year', 'Base MSRP']
df.drop(drop_column2, axis = 1, inplace = True)
```

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

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	O
0	Battery Electric Vehicle (BEV)	1N4AZ0CPXF	121397454	2015	NISSAN	Leaf	Passenger	84	0	Or
1	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or
2	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
3	Battery Electric Vehicle (BEV)	5YJXCAE43G	119336136	2016	TESLA	Model X	Passenger	200	0	Or
4	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	220	0	Or

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 781713 entries, 0 to 781712
Data columns (total 18 columns):
 #   Column                                Non-Null Count   Dtype  
---                                       ----------------------  -----  
 0   Clean Alternative Fuel Vehicle Type  781713 non-null  object 
 1   VIN (1-10)                           781713 non-null  object 
 2   DOL Vehicle ID                       781713 non-null  int64  
 3   Model Year                           781713 non-null  int64  
 4   Make                                 781713 non-null  object 
 5   Model                                781713 non-null  object 
 6   Vehicle Primary Use                  781713 non-null  object 
 7   Electric Range                       781713 non-null  int64  
 8   Odometer Reading                     781713 non-null  int64  
 9   Odometer Code                        781713 non-null  object 
 10  New or Used Vehicle                  781713 non-null  object 
 11  Sale Price                           781713 non-null  int64  
 12  Transaction Type                     781713 non-null  object 
 13  DOL Transaction Date                 781713 non-null  object 
 14  County                               781595 non-null  object 
 15  City                                 781560 non-null  object 
 16  State of Residence                   781712 non-null  object 
 17  Postal Code                          781583 non-null  float64
dtypes: float64(1), int64(5), object(12)
memory usage: 107.4+ MB
```

Filter Data

- `Transaction Type` : *the category of activity that was performed*.

> ***A car registration*** *is proof that an owner has paid the necessary fees to legally drive the vehicle on public roads, and that the vehicle has been recorded by the state*.
>
> ***A car title*** *establishes the owner of a vehicle, and includes the car's make, model, year and details about its history*.
>
> *Some dealerships offer temporary registration (usually 30 days) and a temporary paper tag when you purchase a new car*.
>
> *Depending on your state, you'll have to renew your car registration every 1-2 years*.

https://www.policygenius.com/auto-insurance/whats-the-difference-between-title-and-registration/

Kami tidak akan menggunakan informasi *registration* untuk analisis ini. Kami akan berfokus pada *title transaction* untuk menghitung jumlah kendaraan listrik yang ada di jalan. Oleh karena itu, kami akan mem-*filter* informasi tersebut dari dataset ini.

In [ ]:
```
df["Transaction Type"].unique()
```

Out[ ]:
```
array(['Registration Renewal', 'Original Registration', 'Original Title',
       'Registration at time of Transfer', 'Transfer Title'], dtype=object)
```

In [ ]:
```
df = df[(df['Transaction Type']=='Original Title') | (df['Transaction Type']=='Tran
```

Preprocessing Informasi Waktu

In [ ]:
```
# Mengubah 'DOL Transaction Date' ke format datetime
df['DOL Transaction Date'] = pd.to_datetime(df['DOL Transaction Date'])
```

Membuat Kolom `m/y` (*Month/Year*)

Kami akan menggunakan informasi dari kolom `m/y` untuk membersihkan duplikat data.

In [ ]:
```
df['m/y'] = df['DOL Transaction Date'].dt.strftime("%m-%Y")
```

Mengubah Index Dataframe

In [ ]:
```
df.set_index('DOL Transaction Date', inplace = True)
df.head()
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Elect Ran
2019-02-21	Battery Electric Vehicle (BEV)	5YJ3E1EB6K	474790578	2019	TESLA	Model 3	Passenger	2
2021-06-18	Battery Electric Vehicle (BEV)	5YJYGDEE0M	157748132	2021	TESLA	Model Y	Passenger	
2019-08-16	Battery Electric Vehicle (BEV)	WVWPP7AUXG	339698565	2016	VOLKSWAGEN	e-Golf	Passenger	
2012-10-12	Plug-in Hybrid Electric Vehicle (PHEV)	1G1RB6E48D	228226729	2013	CHEVROLET	Volt	Passenger	
2022-11-15	Battery Electric Vehicle (BEV)	7SAYGDEE2N	220688121	2022	TESLA	Model Y	Passenger	

Data Duplikat

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

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	Odom C
DOL Transaction Date										

Tidak ada data duplikat yang persis sama.

In [ ]:
```
df[df.duplicated(subset = ['m/y', 'DOL Vehicle ID', 'County'], keep = False)].sort
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range
2021-12-29	Plug-in Hybrid Electric Vehicle (PHEV)	1G1RF6E42D	2661907	2013	CHEVROLET	Volt	Passenger	38
2021-12-08	Plug-in Hybrid Electric Vehicle (PHEV)	1G1RF6E42D	2661907	2013	CHEVROLET	Volt	Passenger	38
2019-12-05	Battery Electric Vehicle (BEV)	5YJ3E1EA0K	2679813	2019	TESLA	Model 3	Passenger	220
2019-12-21	Battery Electric Vehicle (BEV)	5YJ3E1EA0K	2679813	2019	TESLA	Model 3	Passenger	220
2021-04-08	Battery Electric Vehicle (BEV)	5YJ3E1EA6L	2722485	2020	TESLA	Model 3	Passenger	266
...	...	...	...	...	...	...	...	...
2021-03-11	Battery Electric Vehicle (BEV)	1G1FZ6S00K	474952670	2019	CHEVROLET	Bolt EV	Passenger	238
2021-10-04	Plug-in Hybrid Electric Vehicle (PHEV)	LYVBR0DM5J	476000556	2018	VOLVO	XC60	Passenger	17
2021-10-05	Plug-in Hybrid Electric Vehicle (PHEV)	LYVBR0DM5J	476000556	2018	VOLVO	XC60	Passenger	17
2022-09-08	Battery Electric Vehicle (BEV)	5YJ3E1EA3K	478795530	2019	TESLA	Model 3	Passenger	220
2022-09-09	Battery Electric Vehicle (BEV)	5YJ3E1EA3K	478795530	2019	TESLA	Model 3	Passenger	220

138 rows × 18 columns

- `DOL Vehicle ID` : *a unique identification number for each vehicle present in Transactions dataset. Transactions done on the same vehicle will have the same DOL Vehicle ID.*

Dari hasil tersebut terlihat bahwa dataset memiliki 138 baris data duplikat. Jika tidak terdapat informasi informasi kota (*city*) dan kode pos (*postal code*), datanya akan persis sama. Kami akan menyimpan data yang terakhir dari setiap baris dari data duplikat.

In [ ]:
```
df.drop_duplicates(subset = ['m/y', 'DOL Vehicle ID', 'County'], keep = 'last', in
```

In [ ]:
```
df[df.duplicated(subset = ['m/y', 'DOL Vehicle ID'], keep = False)].sort_values('D
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Od
2020-01-31	Plug-in Hybrid Electric Vehicle (PHEV)	5UXKT0C56H	4892387	2017	BMW	X5	Passenger	14	
2020-01-06	Plug-in Hybrid Electric Vehicle (PHEV)	5UXKT0C56H	4892387	2017	BMW	X5	Passenger	14	
2019-10-15	Battery Electric Vehicle (BEV)	KNDJP3AE2G	100489049	2016	KIA	Soul	Passenger	93	
2019-10-15	Battery Electric Vehicle (BEV)	KNDJP3AE2G	100489049	2016	KIA	Soul	Passenger	93	
2021-04-15	Plug-in Hybrid Electric Vehicle (PHEV)	WAUUPBFF7H	103084264	2017	AUDI	A3	Passenger	16	
...	...	...	...	...	...	...	...	...	
2023-05-30	Battery Electric Vehicle (BEV)	5YJ3E1EB8J	474750307	2018	TESLA	Model 3	Passenger	215	
2023-03-16	Battery Electric Vehicle (BEV)	SADHD2S14K	475069724	2019	JAGUAR	I-PACE	Passenger	234	
2023-03-24	Battery Electric Vehicle (BEV)	SADHD2S14K	475069724	2019	JAGUAR	I-PACE	Passenger	234	
2019-01-25	Battery Electric Vehicle (BEV)	1N4AZ1CP5J	475454710	2018	NISSAN	Leaf	Passenger	151	
2019-01-31	Battery Electric Vehicle (BEV)	1N4AZ1CP5J	475454710	2018	NISSAN	Leaf	Passenger	151	

84 rows × 18 columns

Kami menemukan terdapat duplikat transaksi yang muncul untuk mobil yang sama dengan informasi yang persis sama kecuali untuk informasi *county*, *city*, dan kode pos (*postal code*). Diasumsikan bahwa transaksi terakhir untuk setiap duplikasi ini adalah transaksi yang akurat, dan transaksi tersebut akan disimpan.

In [ ]:
```
df.drop_duplicates(subset = ['m/y', 'DOL Vehicle ID'], keep = 'last', inplace = Tr
```

In [ ]:
```
# Verifikasi
df[df.duplicated(subset = ['m/y', 'DOL Vehicle ID'], keep = False)].sort_values('D
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	Odom C

Missing Values

In [ ]:
```
df.isna().sum()
```

Out[ ]:
```
Clean Alternative Fuel Vehicle Type     0
VIN (1-10)                              0
DOL Vehicle ID                          0
Model Year                              0
Make                                    0
Model                                   0
Vehicle Primary Use                     0
Electric Range                          0
Odometer Reading                        0
Odometer Code                           0
New or Used Vehicle                     0
Sale Price                              0
Transaction Type                        0
County                                  9
City                                   21
State of Residence                      1
Postal Code                            13
m/y                                     0
dtype: int64
```

In [ ]:
```
df.isnull().sum()/df.shape[0]*100.00
```

Out[ ]:
```
Clean Alternative Fuel Vehicle Type    0.000000
VIN (1-10)                             0.000000
DOL Vehicle ID                         0.000000
Model Year                             0.000000
Make                                   0.000000
Model                                  0.000000
Vehicle Primary Use                    0.000000
Electric Range                         0.000000
Odometer Reading                       0.000000
Odometer Code                          0.000000
New or Used Vehicle                    0.000000
Sale Price                             0.000000
Transaction Type                       0.000000
County                                 0.004253
City                                   0.009923
State of Residence                     0.000473
Postal Code                            0.006143
m/y                                    0.000000
dtype: float64
```

Dari hasil tersebut, terlihat bahwa 4 kolom: `County`, `City`, `State of Residence`, dan `Postal Code` memiliki *missing value*.

In [ ]:
```
df[df['County'].isna()]
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Od R
2014-09-23	Battery Electric Vehicle (BEV)	JN1AZ0CP1B	133789183	2011	NISSAN	Leaf	Passenger	73	
2023-04-12	Battery Electric Vehicle (BEV)	1N4AZ0CP1D	112277063	2013	NISSAN	Leaf	Passenger	75	
2022-11-30	Battery Electric Vehicle (BEV)	7FCTGAAA3N	211400563	2022	RIVIAN	R1T	Truck	0	
2018-02-28	Plug-in Hybrid Electric Vehicle (PHEV)	5UXKT0C38H	111058636	2017	BMW	X5	Passenger	14	
2023-07-03	Battery Electric Vehicle (BEV)	5YJYGDEFXL	115593201	2020	TESLA	Model Y	Passenger	291	
2023-07-05	Plug-in Hybrid Electric Vehicle (PHEV)	KNDCS3LF9P	245797730	2023	KIA	Niro	Passenger	33	
2023-07-31	Battery Electric Vehicle (BEV)	5YJSA1E27G	232897885	2016	TESLA	Model S	Passenger	210	
2023-07-13	Plug-in Hybrid Electric Vehicle (PHEV)	3FA6P0PU2H	348669772	2017	FORD	Fusion	Passenger	21	
2023-07-27	Battery Electric Vehicle (BEV)	5YJSA1E49K	447161816	2019	TESLA	Model S	Passenger	270	

Informasi *county* yang hilang akan dihapus.

In [ ]:
```
df.dropna(subset = ['County'], inplace = True)
```

In [ ]:
```
# Verifikasi
df[df['County'].isna()]
```

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	Odom C
DOL Transaction Date										

Analisis kami akan difokuskan pada negara bagian (*state*) Washington. Oleh karena itu, kami tidak akan menyimpan kendaraan dengan pemilik yang tinggal di luar `WA` (Washington). Selain itu, kami akan menghapus semua *missing value* dari kolom `State of Residence`.

In [ ]:
```
df = df[df['State of Residence']=='WA']
```

In [ ]:
```
df[df['State  of  Residence'].isna()]
```

Out[ ]:

	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	Odom C
DOL Transaction Date										

In [ ]:
```
df[df['City'].isna()]
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primar
2023-03-29	Battery Electric Vehicle (BEV)	1G1FZ6S07P	235316994	2023	CHEVROLET	Bolt EUV	Pass
2016-12-02	Battery Electric Vehicle (BEV)	5YJSA1E45G	174235330	2016	TESLA	Model S	Pass
2022-10-19	Battery Electric Vehicle (BEV)	50EA1GDA1N	220602070	2022	LUCID	Air	Pass
16	Electric	WBY2Z2C58F	149693113	2015	BMW	i8	Pass
	Vehicle (PHEV)						
2020-09-22	Battery Electric Vehicle (BEV)	1G1FY6S05L	125903291	2020	CHEVROLET	Bolt EV	E (State/County/Local/

2020-09-22	Battery Electric Vehicle (BEV)	1G1FY6S00L	124526531	2020	CHEVROLET	Bolt EV	E (State/County/Local/
2020-09-22	Battery Electric Vehicle (BEV)	1G1FY6S0XL	124726094	2020	CHEVROLET	Bolt EV	E (State/County/Local/
2020-09-22	Battery Electric Vehicle (BEV)	1G1FY6S09L	124578051	2020	CHEVROLET	Bolt EV	E (State/County/Local/
2022-04-12	Plug-in Hybrid Electric Vehicle (PHEV)	2C4RC1S75M	144770097	2021	CHRYSLER	Pacifica	Pass
2013-12-06	Battery Electric Vehicle (BEV)	5YJSA1CP7D	4046318	2013	TESLA	Model S	Pass
2014-10-01	Plug-in Hybrid Electric Vehicle (PHEV)	3FA6P0PU0D	175810001	2013	FORD	Fusion	Pass

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primar
2023-05-01	Plug-in Hybrid Electric Vehicle (PHEV)	JTMEB3FV1P	241246617	2023	TOYOTA	RAV4 Prime	Pass

Karena kami hanya memperhatikan kendaraan di tingkat *county*, *missing value* di kolom `City` tidak akan menjadi masalah. Namun, kami akan mengubah *missing value* tersebut dengan 'Unknown' sebagai label sementara.

In [ ]:
```
df['City'].fillna('Unknown', inplace = True)
# Verifikasi
df[df['City'].isna()]
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Odometer Reading	Odom C

In [ ]:
```
df[df['Postal  Code'].isna()]
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range
2020-01-24	Battery Electric Vehicle (BEV)	5YJ3E1EB4L	6301263	2020	TESLA	Model 3	Passenger	322
2017-01-06	Battery Electric Vehicle (BEV)	1N4AZ0CPXD	135986539	2013	NISSAN	Leaf	Passenger	75
2023-07-24	Battery Electric Vehicle (BEV)	1G1FY6S00K	347558116	2019	CHEVROLET	Bolt EV	Passenger	238
2023-03-06	Plug-in Hybrid Electric Vehicle (PHEV)	YV4H60DW7P	233912304	2023	VOLVO	XC60	Passenger	35

Sama seperti sebelumnya, karena kami hanya berfokus pada informasi *county*, kami akan menggantikan *missing value* di kolom `Postal Code` dengan 'Unknown'.

In [ ]:
```
df['Postal Code'].fillna('Unknown', inplace = True)
```

In [ ]:
```
# Verifikasi
df.isna().sum()
```

Out[ ]:
```
Clean Alternative Fuel Vehicle Type    0
VIN (1-10)                             0
DOL Vehicle ID                         0
Model Year                             0
Make                                   0
Model                                  0
Vehicle Primary Use                    0
Electric Range                         0
Odometer Reading                       0
Odometer Code                          0
New or Used Vehicle                    0
Sale Price                             0
Transaction Type                       0
County                                 0
City                                   0
State of Residence                     0
Postal Code                            0
m/y                                    0
dtype: int64
```

Standarisasi Nama pada Kolom `Model`

In [ ]:
```
df['Model'].unique()
```

Out[ ]:
```
array(['Model 3', 'Model Y', 'e-Golf', 'Volt', 'Leaf', 'Niro', 'Model X',
       'Roadster', 'Model S', '500', 'PS2', 'Bolt EV', 'Prius Prime',
       'Soul', 'EV6', 'Pacifica', 'Cayenne', 'C-Max', 'I-PACE', 'Taycan',
       'ID.4', 'GLC-Class', 'X5', 'i4', 'F-150', 'i3', 'Wrangler', 'A3',
       'XC60', 'IONIQ 5', 'RAV4', 'Corsair', 'XC90', 'EQS-Class Sedan',
       'X3', 'R1T', 'Optima', 'Sorento', 'Mustang Mach-E',
       'Prius Plug-in', 'RAV4 Prime', 'Fusion', 'Escape', 'Focus',
       'ARIYA', 'Clarity', 'R1S', 'Lyriq', 'ELR', 'Panamera',
       'e-tron Sportback', 'e-tron', 'iX', 'Kona Electric', '530e',
       'Countryman', '330e', 'EQS-Class SUV', 'Spark', 'Grand Cherokee',
       'Q5 e', 'Transit', 'Ioniq', 'Bolt EUV', 'S60', 'Soul EV',
       'Sportage', 'Outlander', 'e-tron GT', 'Solterra', 'Kona',
       'Hardtop', 'EQ Fortwo', 'i8', 'PRIUS', 'Santa Fe', 'EQB-Class',
       'B-Class', 'G80', 'Crosstrek', 'CT6', 'Sonata', 'Q5',
       'Fortwo Electric Drive', 'NX', 'Ioniq 6', 'XC40', 'GLE-Class',
       'Aviator', 'C40', 'Fortwo', 'Tucson', 'Q4', 'CX-90', 'Air', 'V60',
       'i-MiEV', 'EQE-Class SUV', 'Karma', 'Ranger', 'S-Class', 'bZ4X',
       'RZ 450e', 'Range Rover Sport', 'C-Class', '740e', 'Wheego',
       'City', 'GV60', 'EDV', 'S90', 'A7', 'RS e-tron GT', 'Range Rover',
       '745e', 'Q8', 'GV70', 'EQE-Class Sedan', 'S-10 Pickup', 'A8 e',
       'Transit Connect Electric', 'TONALE', 'Accord', 'Caravan',
       'Flying Spur', '918', '745Le', 'Bentayga', 'Fit', 'Mirai',
       'Bubble Buddy', 'Voyager'], dtype=object)
```

In [ ]:
```
# Sebelum
len(df['Model'].unique())
```

Out[ ]:
```
132
```

In [ ]:
```
df['Model'] = df['Model'].map(lambda model: model.title())
df['Model'].unique()
```

Out[ ]:
```
array(['Model 3', 'Model Y', 'E-Golf', 'Volt', 'Leaf', 'Niro', 'Model X',
       'Roadster', 'Model S', '500', 'Ps2', 'Bolt Ev', 'Prius Prime',
       'Soul', 'Ev6', 'Pacifica', 'Cayenne', 'C-Max', 'I-Pace', 'Taycan',
       'Id.4', 'Glc-Class', 'X5', 'I4', 'F-150', 'I3', 'Wrangler', 'A3',
       'Xc60', 'Ioniq 5', 'Rav4', 'Corsair', 'Xc90', 'Eqs-Class Sedan',
       'X3', 'R1T', 'Optima', 'Sorento', 'Mustang Mach-E',
       'Prius Plug-In', 'Rav4 Prime', 'Fusion', 'Escape', 'Focus',
       'Ariya', 'Clarity', 'R1S', 'Lyriq', 'Elr', 'Panamera',
       'E-Tron Sportback', 'E-Tron', 'Ix', 'Kona Electric', '530E',
       'Countryman', '330E', 'Eqs-Class Suv', 'Spark', 'Grand Cherokee',
       'Q5 E', 'Transit', 'Ioniq', 'Bolt Euv', 'S60', 'Soul Ev',
       'Sportage', 'Outlander', 'E-Tron Gt', 'Solterra', 'Kona',
       'Hardtop', 'Eq Fortwo', 'I8', 'Prius', 'Santa Fe', 'Eqb-Class',
       'B-Class', 'G80', 'Crosstrek', 'Ct6', 'Sonata', 'Q5',
       'Fortwo Electric Drive', 'Nx', 'Ioniq 6', 'Xc40', 'Gle-Class',
       'Aviator', 'C40', 'Fortwo', 'Tucson', 'Q4', 'Cx-90', 'Air', 'V60',
       'I-Miev', 'Eqe-Class Suv', 'Karma', 'Ranger', 'S-Class', 'Bz4X',
       'Rz 450E', 'Range Rover Sport', 'C-Class', '740E', 'Wheego',
       'City', 'Gv60', 'Edv', 'S90', 'A7', 'Rs E-Tron Gt', 'Range Rover',
       '745E', 'Q8', 'Gv70', 'Eqe-Class Sedan', 'S-10 Pickup', 'A8 E',
       'Transit Connect Electric', 'Tonale', 'Accord', 'Caravan',
       'Flying Spur', '918', '745Le', 'Bentayga', 'Fit', 'Mirai',
       'Bubble Buddy', 'Voyager'], dtype=object)
```

In [ ]:
```
df['Clean Alternative Fuel Vehicle Type'].unique()
```

Out[ ]:
```
array(['Battery Electric Vehicle (BEV)',
       'Plug-in Hybrid Electric Vehicle (PHEV)',
       'Hydrogen Powered Vehicle'], dtype=object)
```

Selanjutnya, kami menemukan bahwa model Prius memiliki sebutan tambahan di sebelah nama modelnya yaitu 'Plug-In'. Informasi tersebut sebenarnya tidak terlalu dibutuhkan karena sudah terdapat dalam kolom `Clean Alternative Fuel Vehicle Type`.

In [ ]:
```
df[df['Model']=='Prius  Plug-In'].head()
```

Out[ ]:

DOL Transaction Date	Clean Alternative Fuel Vehicle Type	VIN (1-10)	DOL Vehicle ID	Model Year	Make	Model	Vehicle Primary Use	Electric Range	Od R
2012-06-05	Plug-in Hybrid Electric Vehicle (PHEV)	JTDKN3DP0C	105109784	2012	TOYOTA	Prius Plug-In	Passenger	6	
2015-12-28	Plug-in Hybrid Electric Vehicle (PHEV)	JTDKN3DP2F	228065407	2015	TOYOTA	Prius Plug-In	Passenger	6	
2019-03-29	Plug-in Hybrid Electric Vehicle (PHEV)	JTDKN3DP2F	228065407	2015	TOYOTA	Prius Plug-In	Passenger	6	
2012-05-07	Plug-in Hybrid Electric Vehicle (PHEV)	JTDKN3DP4C	158518748	2012	TOYOTA	Prius Plug-In	Passenger	6	
2019-06-06	Plug-in Hybrid Electric Vehicle (PHEV)	JTDKN3DP3C	148553583	2012	TOYOTA	Prius Plug-In	Passenger	6	

In [ ]:
```
df['Model'].replace('Prius  Plug-In', 'Prius', inplace = True)
```

In [ ]:
```
# Sesudah
len(df['Model'].unique())
```

Out[ ]:
```
131
```

EDA

Mem-*filter Original Title Transaction* berdasarkan *County*

Tujuan dari analisis kami adalah untuk memprediksi jumlah kendaraan listrik baru yang dijalankan di jalan raya untuk setiap *county* dari waktu ke waktu. Oleh karena itu, kami hanya tertarik pada pembelian kendaraan baru dan bukan transaksi kendaraan bekas. Informasi jumlah mobil di jalan dari waktu ke waktu didapatkan dengan menjumlahkan transaksi "Original Title" bulanan untuk setiap *county* secara kumulatif.

In [ ]:
```
county_dict = {}
for county in list(df['County'].unique()):
    county_dict[county] = df[(df['County']==county) & (df['Transaction Type']=='Or
# resample('M'): month
```

In [ ]:
```
df_cumsum = pd.DataFrame(county_dict)
df_cumsum
```

Out[ ]:

DOL Transaction Date	King	Yakima	Clark	Jefferson	Island	Kitsap	Thurston	Snohomish	Cowlitz	C
2010-02-28	NaN	NaN	NaN	NaN	NaN	1	NaN	NaN	NaN	
2010-03-31	1.0	NaN	1.0	NaN	NaN	1	NaN	NaN	NaN	
2010-04-30	2.0	NaN	1.0	NaN	NaN	1	NaN	NaN	NaN	
2010-05-31	2.0	NaN	1.0	NaN	NaN	1	1.0	1.0	NaN	
2010-06-30	3.0	NaN	1.0	NaN	NaN	1	1.0	1.0	NaN	
...	...	...	...	...	...	...	...	...	...	
2023-03-31	84444.0	720.0	9305.0	741.0	1476.0	4899	4970.0	16573.0	792.0	
2023-04-30	87162.0	737.0	9589.0	758.0	1510.0	5025	5114.0	17084.0	813.0	
2023-05-31	89772.0	764.0	9896.0	783.0	1546.0	5151	5260.0	17718.0	842.0	
2023-06-30	92748.0	789.0	10232.0	800.0	1588.0	5297	5420.0	18353.0	871.0	
2023-07-31	95356.0	805.0	10531.0	818.0	1634.0	5410	5548.0	19042.0	887.0	

162 rows × 39 columns

In [ ]:
```
# Mengisi missing value dengan 0
df_cumsum.fillna(0, inplace = True)
```

In [ ]:
```
df_cumsum
```

Out[ ]:

DOL Transaction Date	King	Snohomish	Pierce	Clark	Thurston	Kitsap	Spokane	Whatcom	Benton
2010-02-28	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0
2010-03-31	1.0	0.0	0.0	1.0	0.0	1	0.0	0.0	0.0
2010-04-30	2.0	0.0	0.0	1.0	0.0	1	1.0	1.0	0.0
2010-05-31	2.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0
2010-06-30	3.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0
...	...	...	...	...	...	...	...	...	...
2023-03-31	84444.0	16573.0	11279.0	9305.0	4970.0	4899	3609.0	3224.0	1755.0
2023-04-30	87162.0	17084.0	11689.0	9589.0	5114.0	5025	3712.0	3302.0	1819.0
2023-05-31	89772.0	17718.0	12118.0	9896.0	5260.0	5151	3830.0	3399.0	1865.0
2023-06-30	92748.0	18353.0	12493.0	10232.0	5420.0	5297	3963.0	3501.0	1914.0
2023-07-31	95356.0	19042.0	12875.0	10531.0	5548.0	5410	4071.0	3603.0	1960.0

162 rows × 10 columns

Kendaraan Listrik yang Dijalankan di Negara Bagian Washington

In [ ]:
```
df_cumsum['State Total'] = df_cumsum.sum(axis = 1)
df_cumsum.head()
```

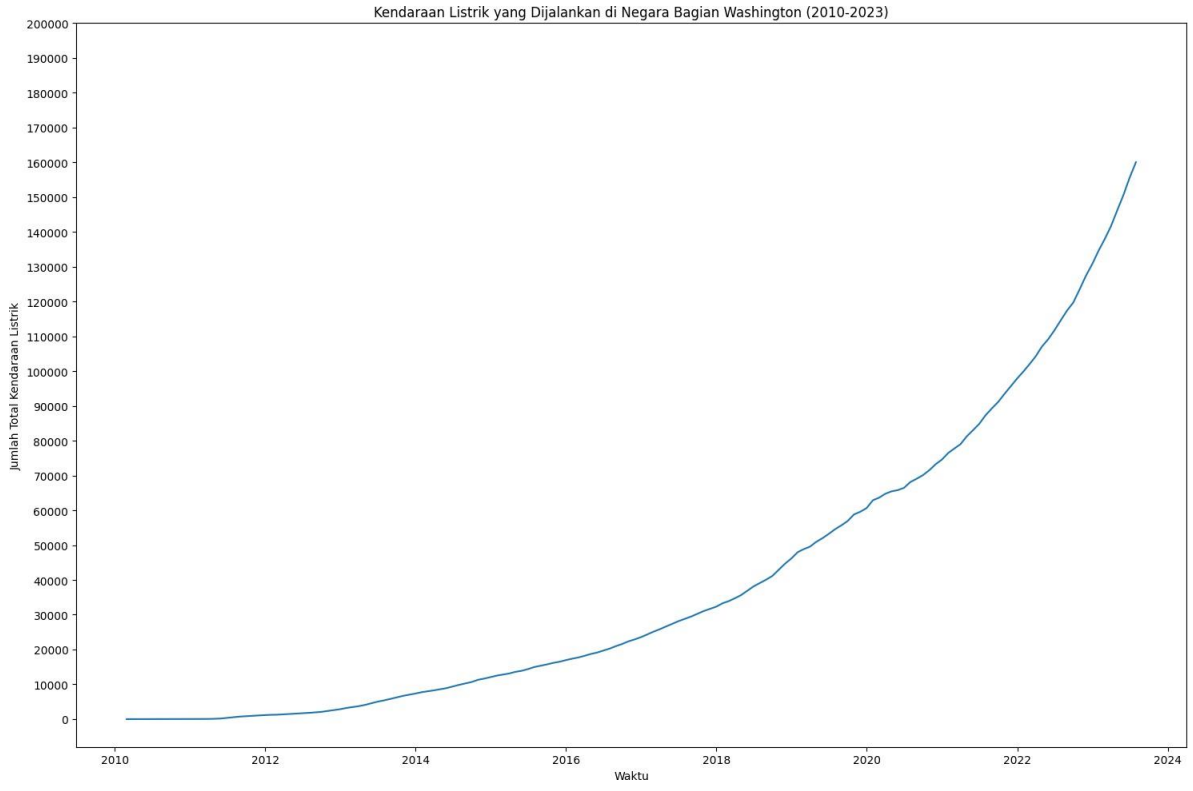
Out[ ]:

DOL Transaction Date	King	Snohomish	Pierce	Clark	Thurston	Kitsap	Spokane	Whatcom	Benton	Islan
2010-02-28	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	0
2010-03-31	1.0	0.0	0.0	1.0	0.0	1	0.0	0.0	0.0	0
2010-04-30	2.0	0.0	0.0	1.0	0.0	1	1.0	1.0	0.0	0
2010-05-31	2.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0	0
2010-06-30	3.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0	0

In [ ]:
```
df_cumsum = df_cumsum.reset_index()
```

In [ ]:
```
# Menyimpan df_cumsum untuk pembuatan dashboard
df_cumsum.to_csv('jumlah_kendaraan.csv', index = False)
```

In [ ]:
```
fig, ax = plt.subplots(figsize = (15, 10))
sns.lineplot(x = 'DOL Transaction Date', y = 'State Total', data = df_cumsum, ax =
ax.set_xlabel('Waktu')
ax.set_ylabel('Jumlah Total Kendaraan Listrik')
ax.set_title('Kendaraan Listrik yang Dijalankan di Negara Bagian Washington (2010-2
ax.set_yticks(range(0, 210000, 10000))
plt.tight_layout()
```



Terlihat bahwa jumlah kendaraan listrik yang dijalankan di negara bagian Washington telah meningkat secara eksponensial selama 3 tahun terakhir. Hal tersebut menegaskan bahwa terdapat peluang yang besar untuk menginvestasikan perusahaan pengisian kendaraan listrik di negara bagian Washington karena memiliki tren meningkat tinggi dari tahun ke tahunnya.

Catatan: Karena data diawali dengan tahun 2010, maka perhitungan dimulai dengan 0 pada tahun 2010. Namun, bukan berarti bahwa tidak ada kendaraan listrik di jalan raya pada tahun 2010. Kami hanya mengambil tahun 2010 sebagai titik awal perhitungan.

Kendaraan Listrik yang Dijalankan Sepanjang Waktu menurut *County*

Karena waktu yang terbatas, kami akan membatasi analisis kami pada 10 *county* teratas yang memiliki pembelian kendaraan listrik terbanyak dimana *county* tertinggi akan kami modelkan dengan detail sedangkan yang lainnya tidak akan kami modelkan secara detail karena hanya akan digunakan untuk pembuatan dashboard.

In [ ]:
```
df['County'].value_counts()
```

Out[ ]:
```
King            113658
Snohomish        24021
Pierce           16988
Clark            12063
Thurston          7112
Kitsap            7083
Spokane           5157
Whatcom           5033
Benton            2500
Island            2126
Skagit            2126
Clallam           1184
Jefferson         1126
Cowlitz           1034
San Juan          1030
Chelan            1024
Yakima            1022
Mason              938
Lewis              766
Franklin           689
Grays Harbor       657
Grant              563
Kittitas           520
Walla Walla        478
Douglas            370
Whitman            317
Klickitat          306
Stevens            245
Pacific            228
Okanogan           215
Skamania           215
Asotin              92
Adams               64
Pend Oreille        61
Wahkiakum           51
Lincoln             45
Ferry               33
Columbia            26
Garfield             4
Name: County, dtype: int64
```

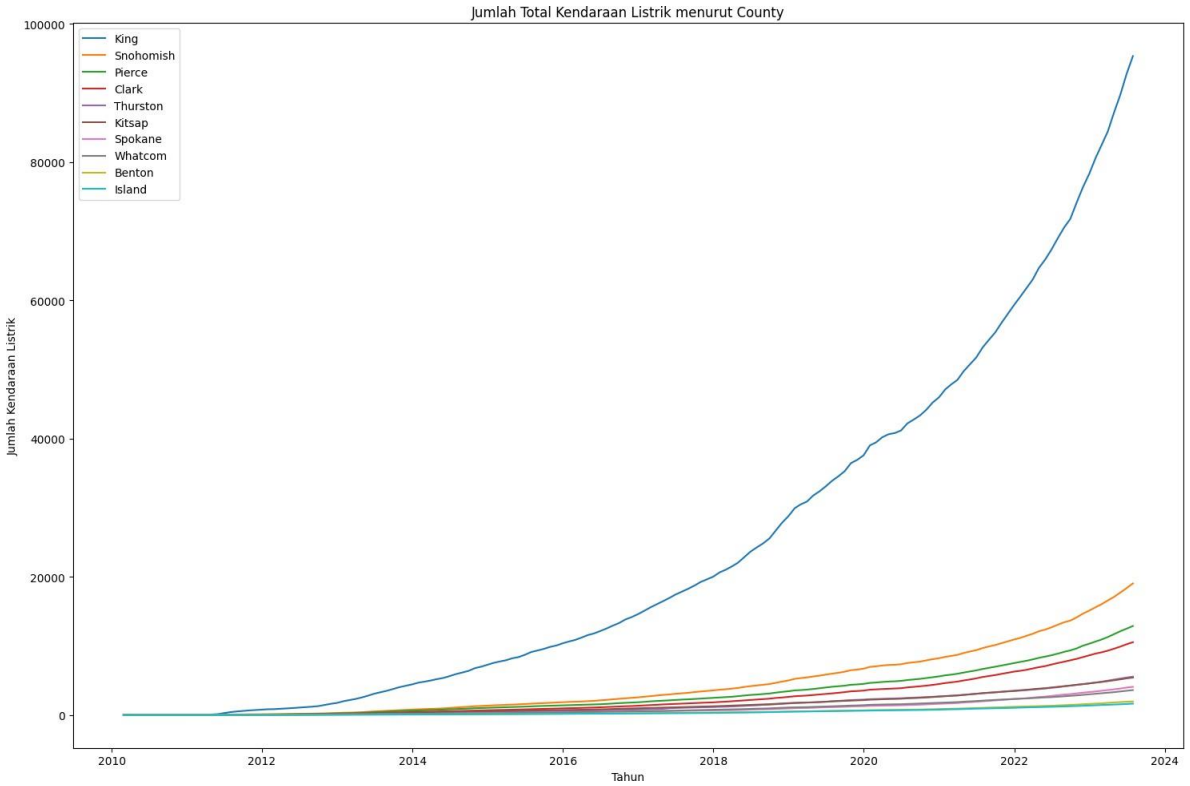
In [ ]:
```
top_10_county = ['King', 'Snohomish', 'Pierce', 'Clark', 'Thurston', 'Kitsap', 'Sp
```

In [ ]:
```
# Mem-filter top 10
df_cumsum = df_cumsum.loc[:, ['DOL Transaction Date', *top_10_county]]
df_cumsum.head()
```

Out[ ]:

	DOL Transaction Date	King	Snohomish	Pierce	Clark	Thurston	Kitsap	Spokane	Whatcom	Benton	I
0	2010-02-28	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	
1	2010-03-31	1.0	0.0	0.0	1.0	0.0	1	0.0	0.0	0.0	
2	2010-04-30	2.0	0.0	0.0	1.0	0.0	1	1.0	1.0	0.0	
3	2010-05-31	2.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0	
4	2010-06-30	3.0	1.0	0.0	1.0	1.0	1	1.0	1.0	0.0	

In [ ]:
```
fig, ax = plt.subplots(figsize = (15, 10))
for county in top_10_county:
    sns.lineplot(x = 'DOL Transaction Date', y = county, data = df_cumsum, ax = ax
ax.set_xlabel('Tahun')
ax.set_ylabel('Jumlah  Kendaraan  Listrik')
ax.set_title('Jumlah  Total  Kendaraan  Listrik  menurut  County')
ax.legend()
plt.tight_layout()
```



Terlihat bahwa dari 10 *county* dengan pembelian kendaraan listrik terbanyak, *county* King meningkat jauh lebih cepat dibandingkan dengan *county* yang lainnya.

> *King County is located in the U.S. state of Washington. The population was 2,269,675 in the 2020 census, making it the most populous county in Washington, and the 13th-most populous in the United States. The county seat is Seattle,also the state's most populous city.*

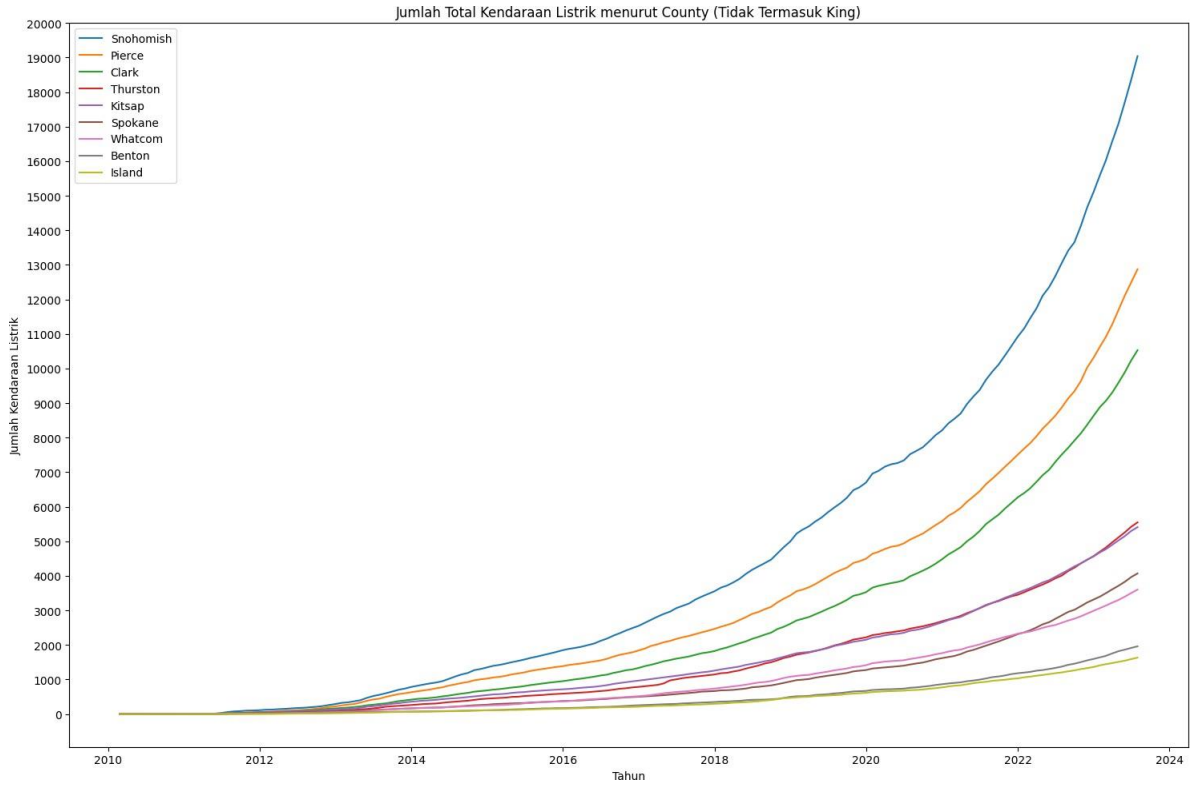
Dikutip dari https://en.wikipedia.org/wiki/King_County,_Washington

Banyaknya pembilian kendaraan listrik di *county* King mungkin disebabkan oleh *county* tersebut merupakan *county* dengan populasi terbanyak di negara bagian (*state*) Washington.

Kendaraan Listrik yang Dijalankan Seiring Waktu (Kecuali King County)

In [ ]:
```
top_10_county.remove('King')

fig, ax = plt.subplots(figsize = (15, 10))
for county in top_10_county:
    sns.lineplot(x = 'DOL Transaction Date', y = county, data = df_cumsum, ax = ax
ax.set_xlabel('Tahun')
ax.set_ylabel('Jumlah  Kendaraan  Listrik')
ax.set_title('Jumlah Total Kendaraan Listrik menurut County (Tidak Termasuk King)')
```

```
ax.set_yticks(range(0, 21000, 1000))
ax.legend()
plt.tight_layout()
```



Setelah *county* King dikeluarkan, terlihat bahwa *county* Snohomish menempati pembelian kendaraan listrik terbanyak diikuti oleh Pierce dan Clark.

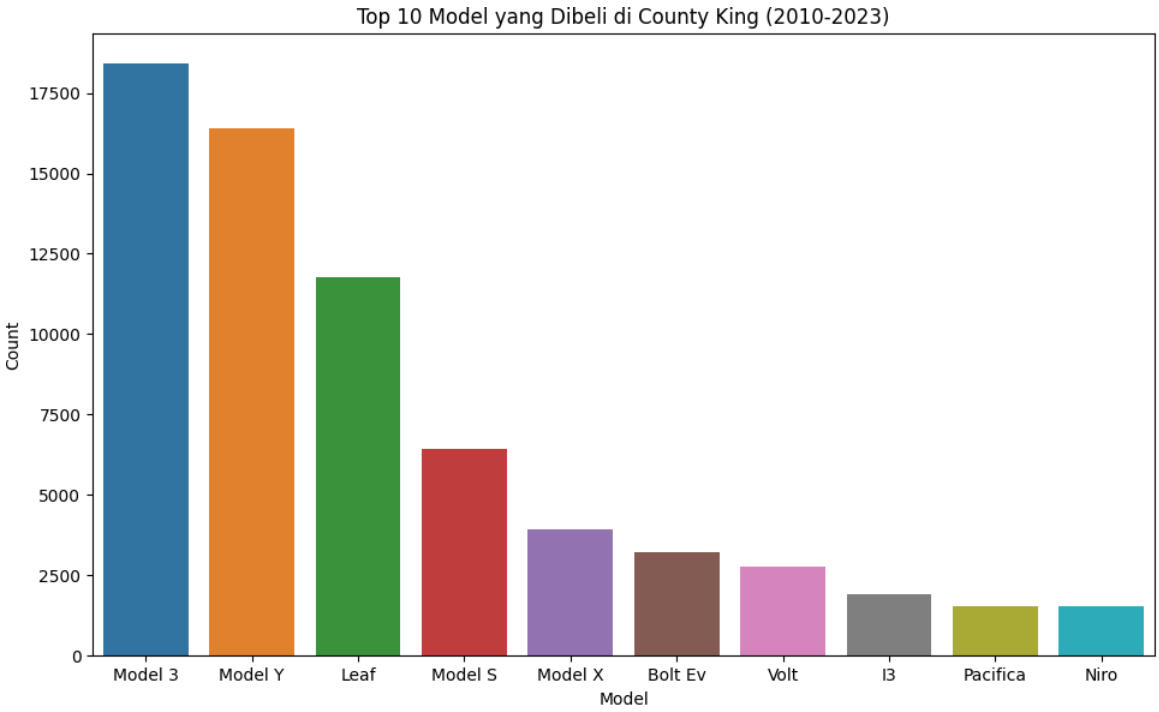
In [ ]:
```
top_10_county.insert(0, 'King')
```

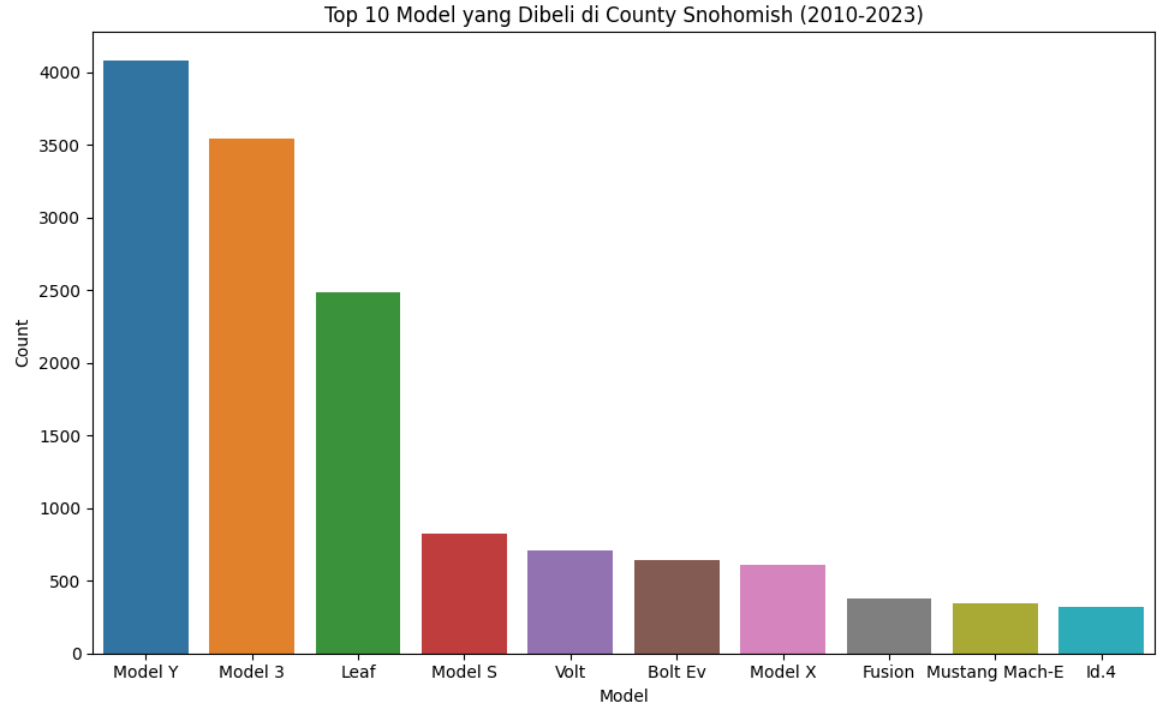
Model Mobil yang Paling Banyak Dibeli menurut *County*

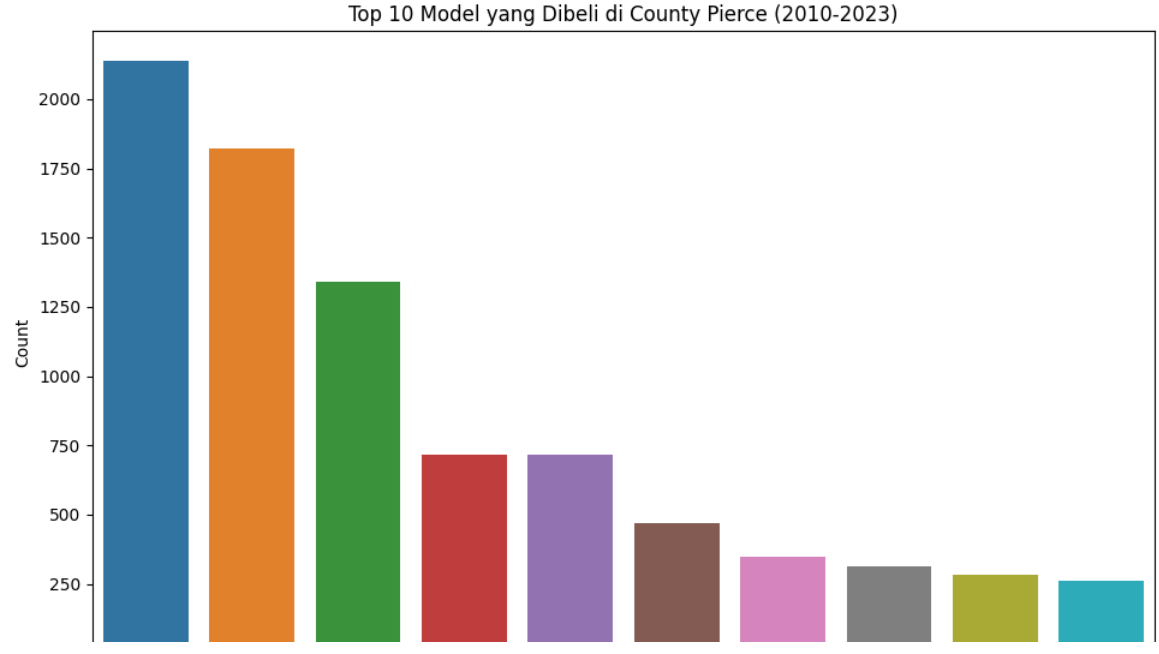
Informasi penting lainnya yang mungkin relevan untuk perusahaan pengisian daya listrik adalah model kendaraan listrik yang paling banyak dibeli di masing-masing *county*. Informasi tersebut dapat digunakan untuk menentukan faktor tambahan, seperti

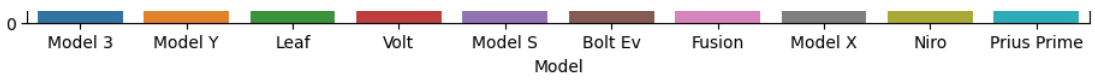
- apakah akan menyertakan adaptor untuk jenis konektor yang berbeda
- jarak pengisi daya berdasarkan ukuran kendaraan.

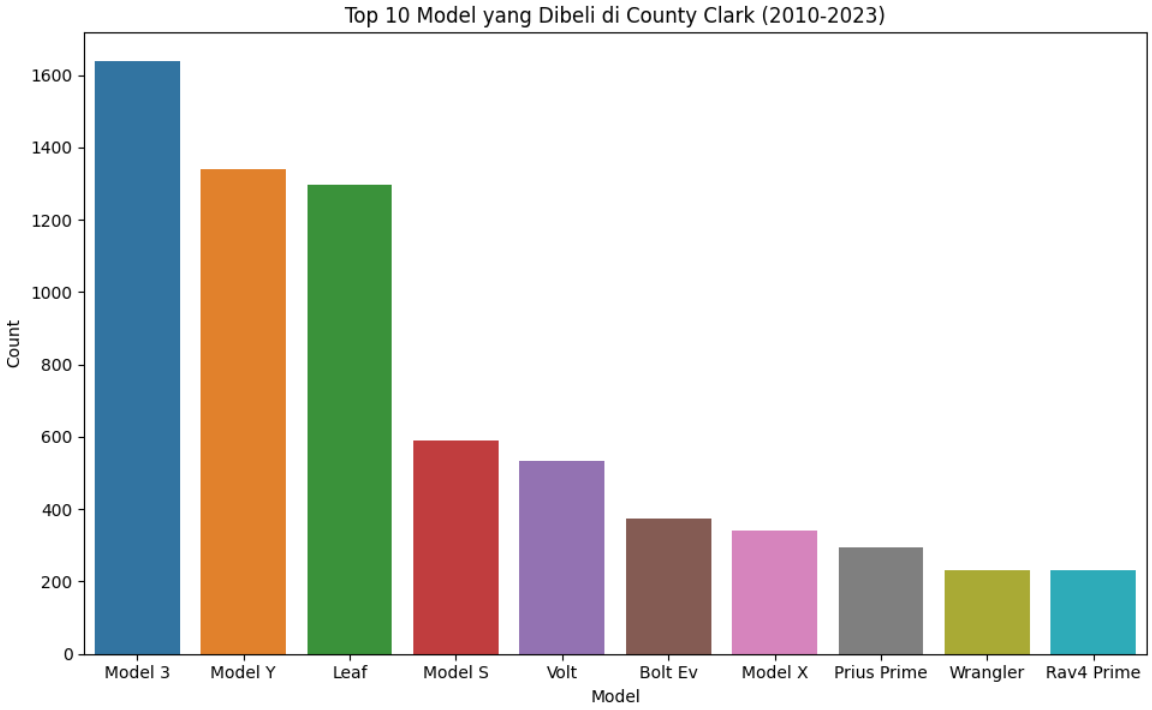
In [ ]:
```
top_n = 10
county_list = top_10_county
fig, ax = plt.subplots(figsize = (10, 60), nrows = len(county_list))

for i, county in enumerate(county_list):
  df_county = df[(df['County']==county) & (df['Transaction Type']=='Original Title'
  model_count_df = pd.DataFrame(df_county['Model'].value_counts()).reset_index()
  model_count_df.columns = ['Model', 'Count']
  sns.barplot(x = 'Model', y = 'Count', data = model_count_df.head(top_n), ax = ax
  ax[i].set_title(f'Top {top_n} Model yang Dibeli di County {county} (2010-2023)')
  plt.tight_layout();
```

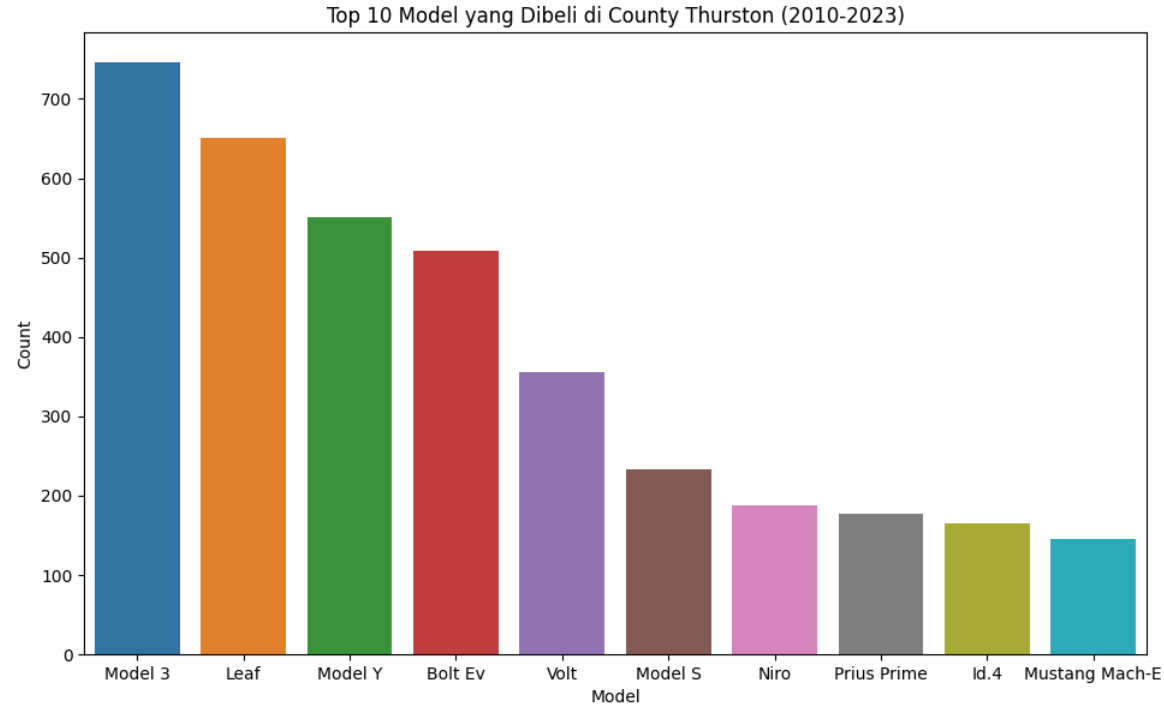

Top 10 Model yang Dibeli di County King (2010-2023)
Count
Model
Model 3
Model Y
Leaf
Model S
Model X
Bolt Ev
Volt
I3
Pacifica
Niro

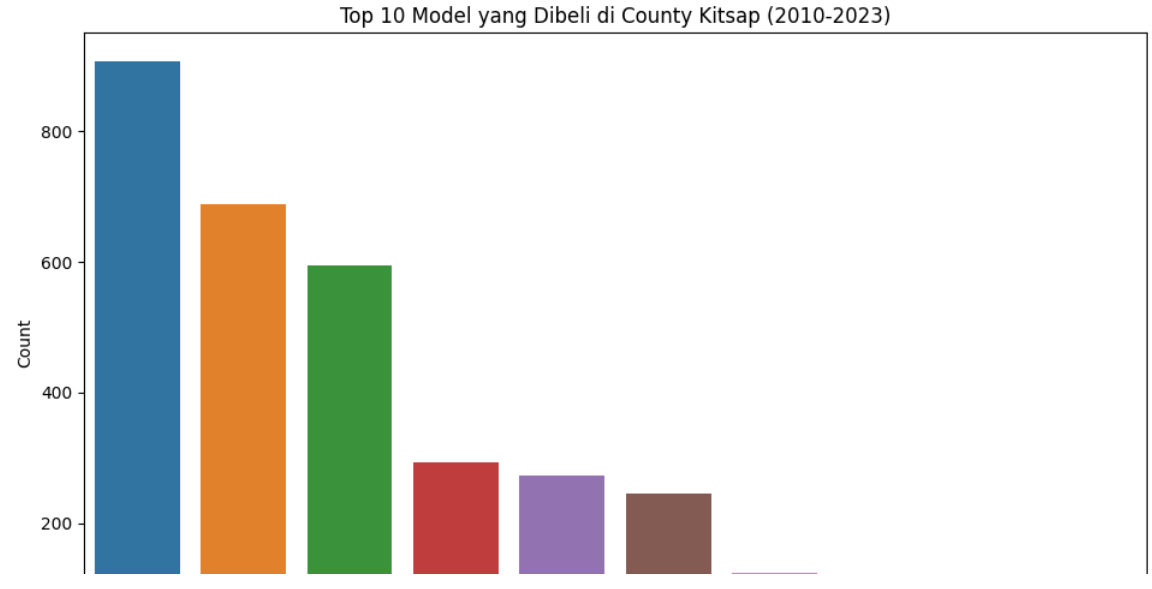

Top 10 Model yang Dibeli di County Snohomish (2010-2023)
Count
Model
Model Y
Model 3
Leaf
Model S
Volt
Bolt Ev
Model X
Fusion
Mustang Mach-E
Id.4


Top 10 Model yang Dibeli di County Pierce (2010-2023)
Count


0
Model 3
Model Y
Leaf
Volt
Model S
Bolt Ev
Fusion
Model X
Niro
Prius Prime
Model


Top 10 Model yang Dibeli di County Clark (2010-2023)
Count
0
200
400
600
800
1000
1200
1400
1600
Model 3
Model Y
Leaf
Model S
Volt
Bolt Ev
Model X
Prius Prime
Wrangler
Rav4 Prime
Model


Top 10 Model yang Dibeli di County Thurston (2010-2023)
Count
0
100
200
300
400
500
600
700
Model 3
Leaf
Model Y
Bolt Ev
Volt
Model S
Niro
Prius Prime
Id.4
Mustang Mach-E
Model


Top 10 Model yang Dibeli di County Kitsap (2010-2023)
Count
200
400
600
800

In [ ]:
```
df[df['Model']=='Model  3']['Make'].unique()
```

Out[ ]:
```
array(['TESLA'], dtype=object)
```

In [ ]:
```
df[df['Model']=='Model  Y']['Make'].unique()
```

Out[ ]:
```
array(['TESLA'], dtype=object)
```

In [ ]:
```
df[df['Model']=='Leaf']['Make'].unique()
```

Out[ ]:
```
array(['NISSAN'], dtype=object)
```

Nissan Leaf, Tesla Model 3, dan Tesla Model Y *mostly* merupakan top 3 kendaraan listrik yang paling banyak dibeli di masing-masing *county* tersebut.

Pemodelan

In [ ]:
```
df_cumsum = df_cumsum.set_index('DOL Transaction Date').resample('M').asfreq()
```

In [ ]:
```
df_cumsum.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 162 entries, 2010-02-28 to 2023-07-31
Freq: M
Data columns (total 10 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   King       162 non-null    float64
 1   Snohomish  162 non-null    float64
 2   Pierce     162 non-null    float64
 3   Clark      162 non-null    float64
 4   Thurston   162 non-null    float64
 5   Kitsap     162 non-null    int64
 6   Spokane    162 non-null    float64
 7   Whatcom    162 non-null    float64
 8   Benton     162 non-null    float64
 9   Island     162 non-null    float64
dtypes: float64(9), int64(1)
memory usage: 13.9 KB
```

Pemisahan Data untuk Setiap *County*

Kami akan membuat model runtun waktu untuk sepuluh *county* teratas. Namun, hanya top 1 yaitu *county* King yang akan kami modelkan secara detail. Oleh karena itu, dataset akan dipisahkan sesuai *county*-nya.

In [ ]:
```
def separate_data_by_county(county, df):
  df_county = pd.DataFrame(df.loc[:, county])
  df_county.columns = ["Jumlah EV"]
  df_county.head()
  return df_county
```

In [ ]:
```
county_information = {}
for county in top_10_county:
```

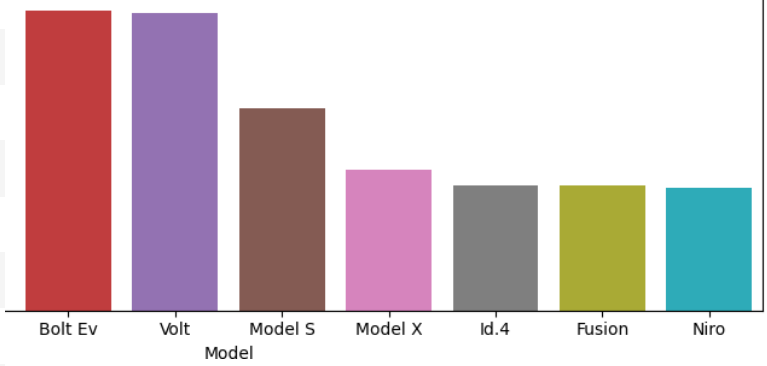
```
    county_information[county] = {}
    county_information[county]['df'] = separate_data_by_county(county, df_cumsum)
```

In [ ]:
```
county_dfs = {}
for county in top_10_county:
    county_dfs[county] = separate_data_by_county(county, df_cumsum)
```

In [ ]:
```
county_dfs['King']
```

Out[ ]:

DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	1.0
2010-04-30	2.0
2010-05-31	2.0
2010-06-30	3.0
...	...
2023-03-31	84444.0
2023-04-30	87162.0
2023-05-31	89772.0
2023-06-30	92748.0
2023-07-31	95356.0



162 rows × 1 columns

Membuat Fungsi

Fungsi untuk Mengevaluasi Model

In [ ]:
```
def  evaluate_model(model):
  display(model.summary())
  model.plot_diagnostics()
  plt.tight_layout()
```

Fungsi untuk *Differencing*

In [ ]:
```
def difference(dataset, interval = 1):
  diff = list()
  for i in range(interval, len(dataset)):
    value = dataset[i] - dataset[i - interval]
    diff.append(value)
  return Series(diff)
```

Fungsi untuk Uji Stasioneritas dengan Melihat Mean, Standar Deviasi, ACF, dan PACF

In [ ]:
```
def  test_stationarity(timeseries):
  # Determing rolling statistics
  rolmean = timeseries.rolling(window = 12).mean()
  rolstd = timeseries.rolling(window = 12).std()

  # Plot rolling statistics:
  fig = plt.figure(figsize = (12, 8))
  orig = plt.plot(timeseries, color = 'blue', label = 'Original')
  mean = plt.plot(rolmean, color = 'red', label = 'Rolling Mean')
  std = plt.plot(rolstd, color = 'black', label = 'Rolling Std')
  plt.legend(loc = 'best')
  plt.title('Rolling Mean & Standard Deviation')
  plt.show()

  # Plot ACF and PACF
  fig = plt.figure(figsize = (12, 8))
  ax1 = fig.add_subplot(211)
  fig = sm.graphics.tsa.plot_acf(timeseries, lags = 36, ax = ax1)
  ax2 = fig.add_subplot(212)
  fig = sm.graphics.tsa.plot_pacf(timeseries, lags = 36, ax = ax2)

  # Perform Dickey-Fuller test:
  print('Results of Dickey-Fuller Test:')
  dftest = adfuller(timeseries, autolag = 'AIC')
  dfoutput = pd.Series(dftest[0:4], index = ['Test Statistic', 'p-value', '#Lags U
  for key, value in dftest[4].items():
    dfoutput['Critical Value (%s)'%key] = value
  print(dfoutput)
  print("")
  if dfoutput['p-value']<0.05:
    print("H_0 berhasil ditolak, yang berarti data sudah stasioner")
  elif dfoutput['p-value']>=0.05:
    print("H_0 tidak berhasil ditolak, yang berarti data belum stasioner")
```

Fungsi untuk Split Train dan Test Data

In [ ]:
```
def train_test_split_ts (df, train_size, test_size):
  train_end_idx = int(round(len(df)*train_size, 0))
  train_set = df.iloc[0:train_end_idx, 0]
  test_set = df.iloc[train_end_idx:, 0]
  return train_set, test_set
```

In [ ]:
```
def plot_train_test_split(train_data, test_data, county):
  train_data.plot(label = 'Data Train')
  test_data.plot(label = 'Data Test')
  ax=plt.gca()
  ax.set_xlabel('Tahun')
  ax.set_ylabel('Jumlah Kendaraan Listrik')
  ax.set_title(f'Jumlah Kendaraan Listrik yang Dijalankan di County {county}')
  ax.legend()
```

Fungsi untuk *Forecastsing*

In [ ]:
```
def get_forecast(model, train_data, test_data, county_name, plot = True):
  # Membuat dataframe dengan informasi forecasting
  forecast_df = model.get_forecast(steps = len(test_data)).conf_int()
  forecast_df.columns = ['Lower Confidence Interval', 'Upper Confidence Interval']
  forecast_df['Forecasts'] = model.get_forecast(steps=len(test_data)).predicted_mea
  # Plot
  if plot==True:
```

```
    with plt.style.context('seaborn-whitegrid'):
      fig, ax = plt.subplots(figsize = (15, 10))
      sns.lineplot(data = train_data, color = 'black', ax = ax)
      sns.lineplot(data = forecast_df, x = forecast_df.index, y = 'Forecasts',
                   color = 'blue', ax = ax, label = 'Data Forecast', ls = '--')
      sns.lineplot(data=test_data, color = 'purple', ax = ax, label = 'Actual Data
      ax.fill_between(forecast_df.index, y1 = forecast_df['Lower Confidence Interva
                      y2 = forecast_df['Upper Confidence Interval'], color = 'green
                      label = 'Confidence Interval')
      ax.set_xlabel('Year')
      ax.set_title(f'Data Test dan Forecast Jumlah Kendaraan Listrik di County {cou
      ax.legend(loc = 2)
      plt.show()
  print("")
  mape=mean_absolute_percentage_error(test_data, forecast_df['Forecasts'])
  print(f"Mean Absolute Percentage Error: {mape}")
  print("")
  mse=mean_squared_error(test_data, forecast_df['Forecasts'])
  print(f"Mean Squared Error: {mse}")
  print("")
  print(f"Root Mean Squared Error: {mse**0.5}")
  print("")
  r2=r2_score(test_data, forecast_df['Forecasts'])
  print(f"R-squared: {r2}")
  return forecast_df
```

Fungsi untuk Memprediksi Masa Depan

In [ ]:

```
def get_prediction(model, df, test_data, county_name, plot = True):
    # Membuat dataframe dengan informasi prediksi
    prediction_df = model.get_forecast(steps = 36).conf_int()
    prediction_df.columns = ['Lower Confidence Interval', 'Upper Confidence Interva
    prediction_df['Predictions'] = model.get_forecast(steps = 36).predicted_mean

    # Get the last result of the prediction, lower CI, and upper CI
    last_prediction = prediction_df.iloc[-1]['Predictions']
    last_lower_ci = prediction_df.iloc[-1]['Lower Confidence Interval']
    last_upper_ci = prediction_df.iloc[-1]['Upper Confidence Interval']

    # Plot
    if plot==True:
        with plt.style.context('seaborn-whitegrid'):
            fig, ax = plt.subplots(figsize = (15, 10))
            sns.lineplot(data = df, ax = ax)
            sns.lineplot(data = prediction_df, x = prediction_df.index, y = 'Predi
                         color = 'orange', ax = ax, label = 'Predicted Data', ls =
            ax.fill_between(prediction_df.index, y1 = prediction_df['Lower Confiden
                            y2 = prediction_df['Upper Confidence Interval'], color
                            label = 'Confidence Interval')
            ax.set_xlabel('Tahun')
            ax.set_ylabel('Jumlah Kendaraan Listrik')
            ax.set_title(f'Prediksi Jumlah Kendaraan Listrik di {county_name} untuk

            # Annotate the last result of the prediction
            x = prediction_df.index[-1]
            y_pred = last_prediction
            y_lower = last_lower_ci
            y_upper = last_upper_ci
            ax.annotate(f'Last Prediction: {y_pred:.0f}', xy=(x, y_pred), xytext=(
            ax.annotate(f'Last Lower CI: {y_lower:.0f}', xy=(x, y_lower), xytext=(
            ax.annotate(f'Last Upper CI: {y_upper:.0f}', xy=(x, y_upper), xytext=(

            #Move the legend
```

```
            ax.legend(loc='upper  center')

            plt.show()
        return  prediction_df
```

County King

Inisialisasi Dataset

In [ ]:
```
county_dfs['King']
```

Out[ ]:

DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	1.0
2010-04-30	2.0
2010-05-31	2.0
2010-06-30	3.0
...	...
2023-03-31	84444.0
2023-04-30	87162.0
2023-05-31	89772.0
2023-06-30	92748.0
2023-07-31	95356.0

162 rows × 1 columns

In [ ]:
```
king  =  county_dfs['King'].copy()
king.reset_index(inplace=True)
mask = king['DOL Transaction Date'] >= '2020-01-31'
king = king[mask]

king.set_index('DOL Transaction Date', inplace = True)
```

Statistika Deskriptif

In [ ]:
```
king.describe()
```

Out[ ]:

	Jumlah EV
count	43.000000
mean	59844.813953
std	16520.856140
min	39015.000000
25%	45578.500000
50%	56750.000000
75%	71166.500000
max	95356.000000

In [ ]:
```
county_information['King']['df'].describe()
```

Out[ ]:

	Jumlah EV
count	162.000000
mean	23826.679012
std	25086.881837
min	0.000000
25%	3138.250000
50%	13995.500000
75%	40000.250000
max	95356.000000

Visualisasi

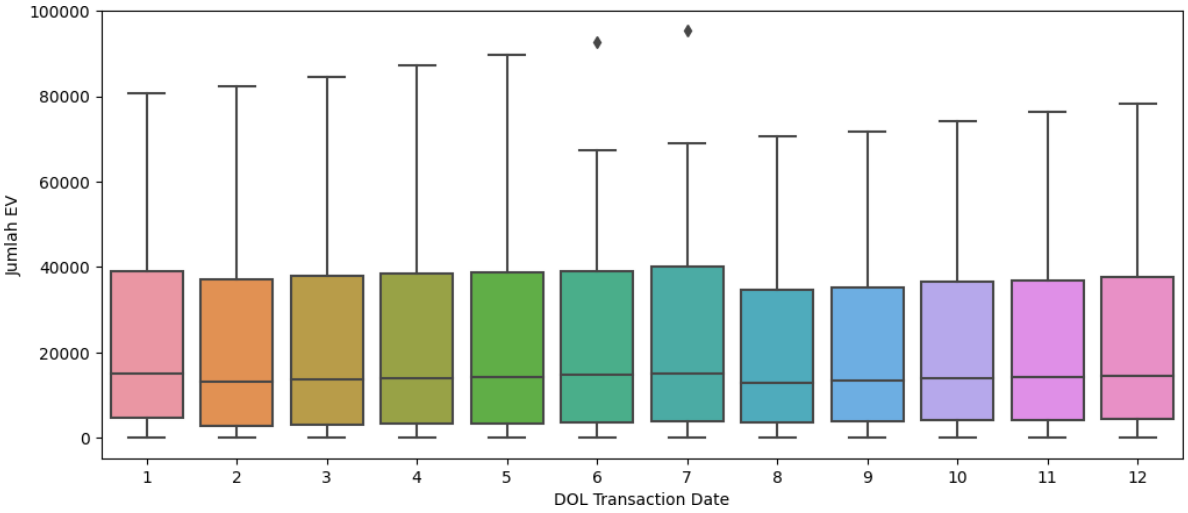
In [ ]:
```
import plotly.express as px
fig = px.line(county_information['King']['df'], y = 'Jumlah EV', title = "Jumlah K
fig.show()
```

In [ ]:
```
import plotly.express as px
fig = px.line(king, y = 'Jumlah EV', title = "Jumlah Kendaraan Listrik di County K
fig.show()
```

Cek Tren dan *Seasonality*

In [ ]:
```
#2010 - 2023
fig, ax = plt.subplots(figsize = (12, 5))
sns.boxplot(x  =  county_information['King']['df'].index.month,
            y = county_information['King']['df']['Jumlah EV'], ax = ax)
```

Out[ ]:
```
<Axes: xlabel='DOL Transaction Date', ylabel='Jumlah EV'>
```

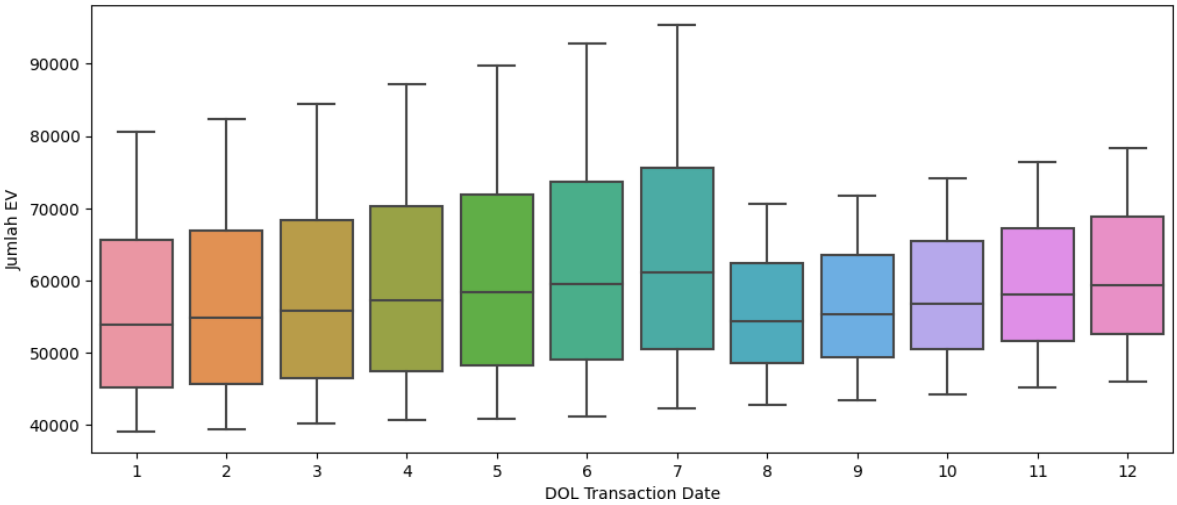


In [ ]:
```
#2020 - 2023
fig, ax = plt.subplots(figsize = (12, 5))
```

```
sns.boxplot(x = king.index.month,
            y = king['Jumlah EV'], ax = ax)
```

Out[ ]:

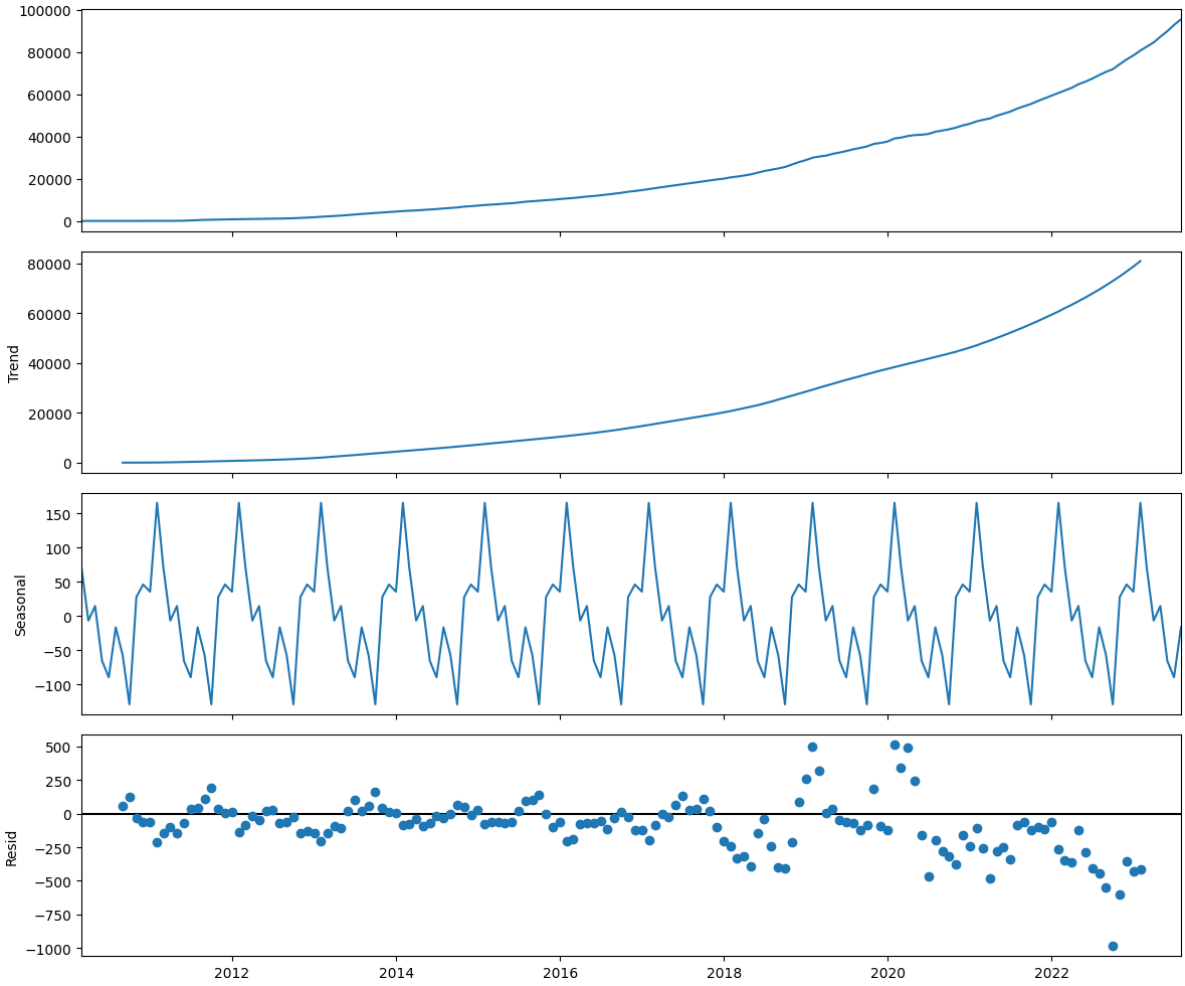
```
<Axes: xlabel='DOL Transaction Date', ylabel='Jumlah EV'>
```

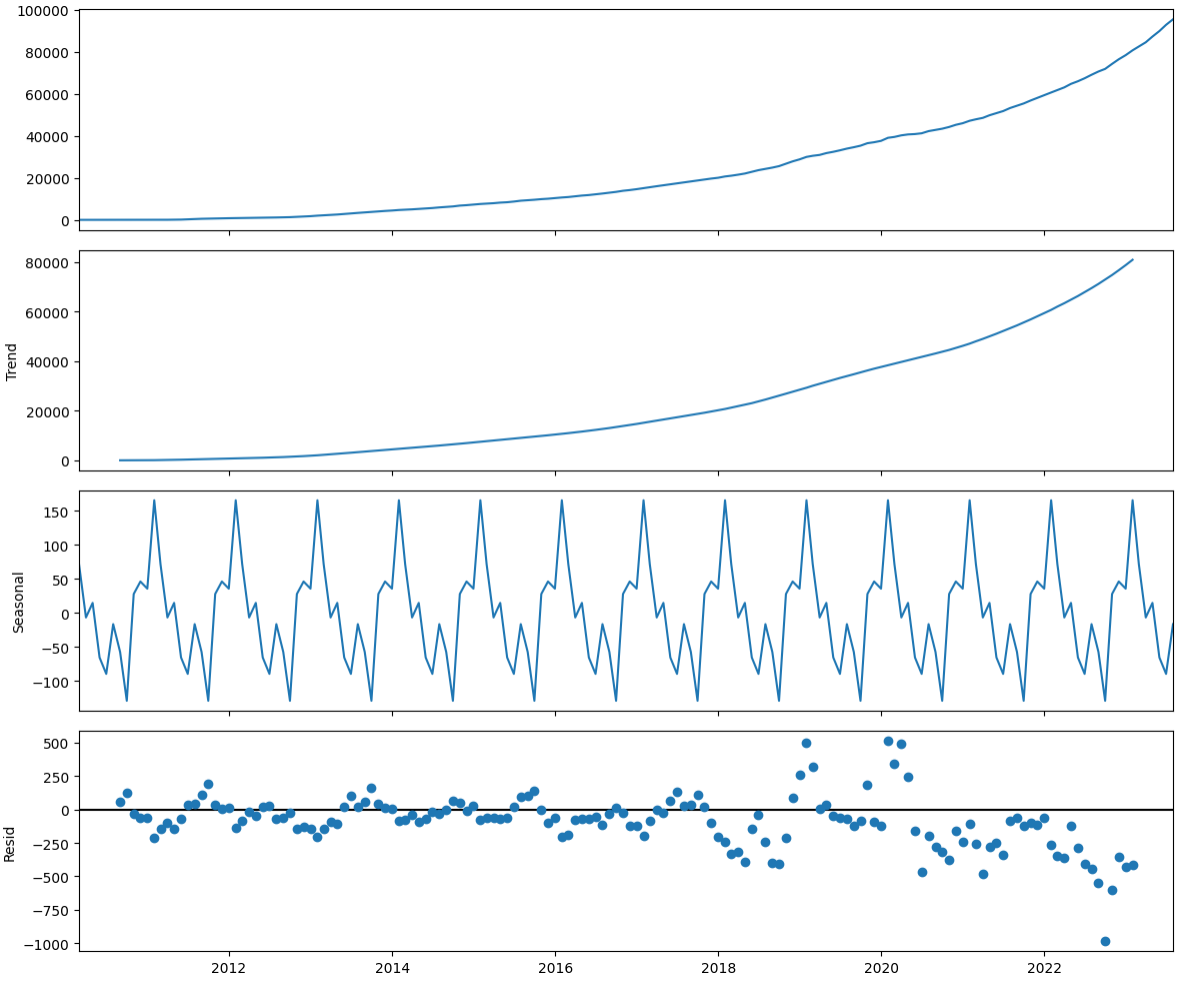


In [ ]:

```
#2010 - 2023
import statsmodels.tsa.api as tsa

plt.rcParams['figure.figsize'] = (12, 10)
decomp = tsa.seasonal_decompose(county_information['King']['df'])
decomp.plot()
```

Out[ ]:

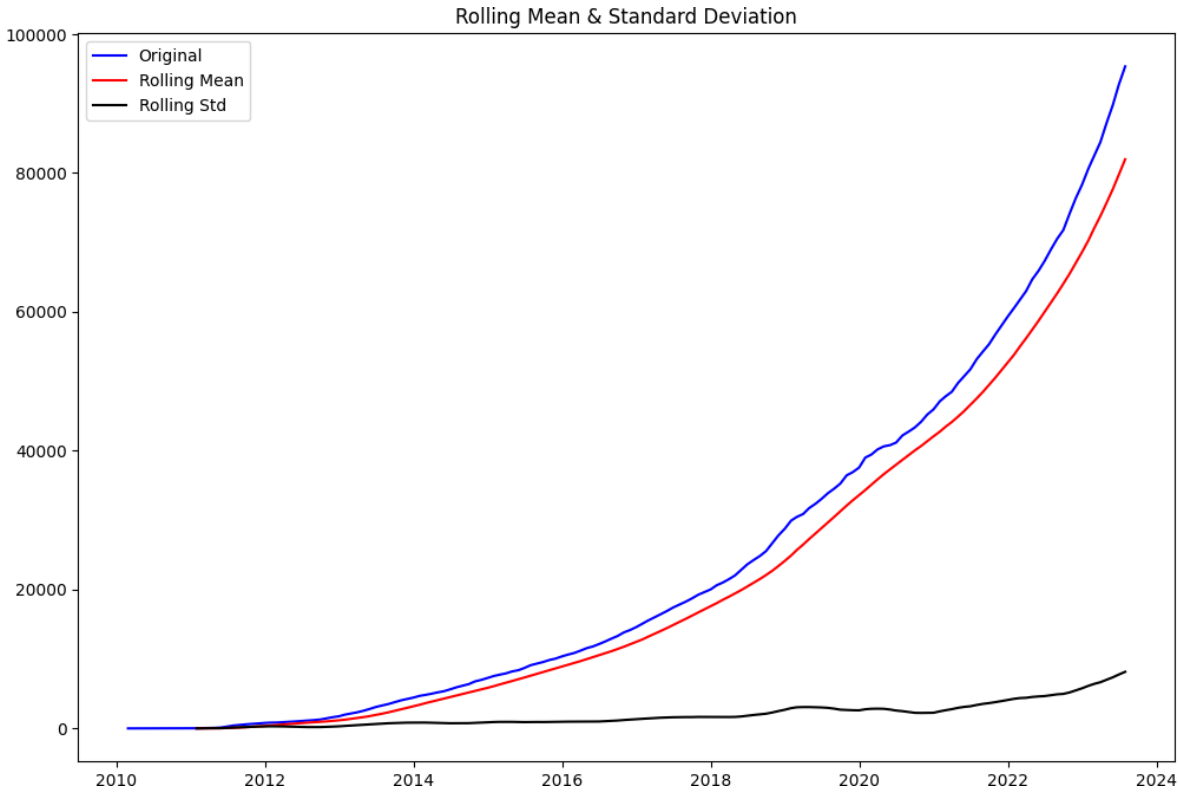




Dari hasil tersebut, terlihat bahwa jumlah kendaraan listrik di *county* King mengalami tren peningkatan. Selain itu, terdapat komponen *seasonality* pada data tersebut.

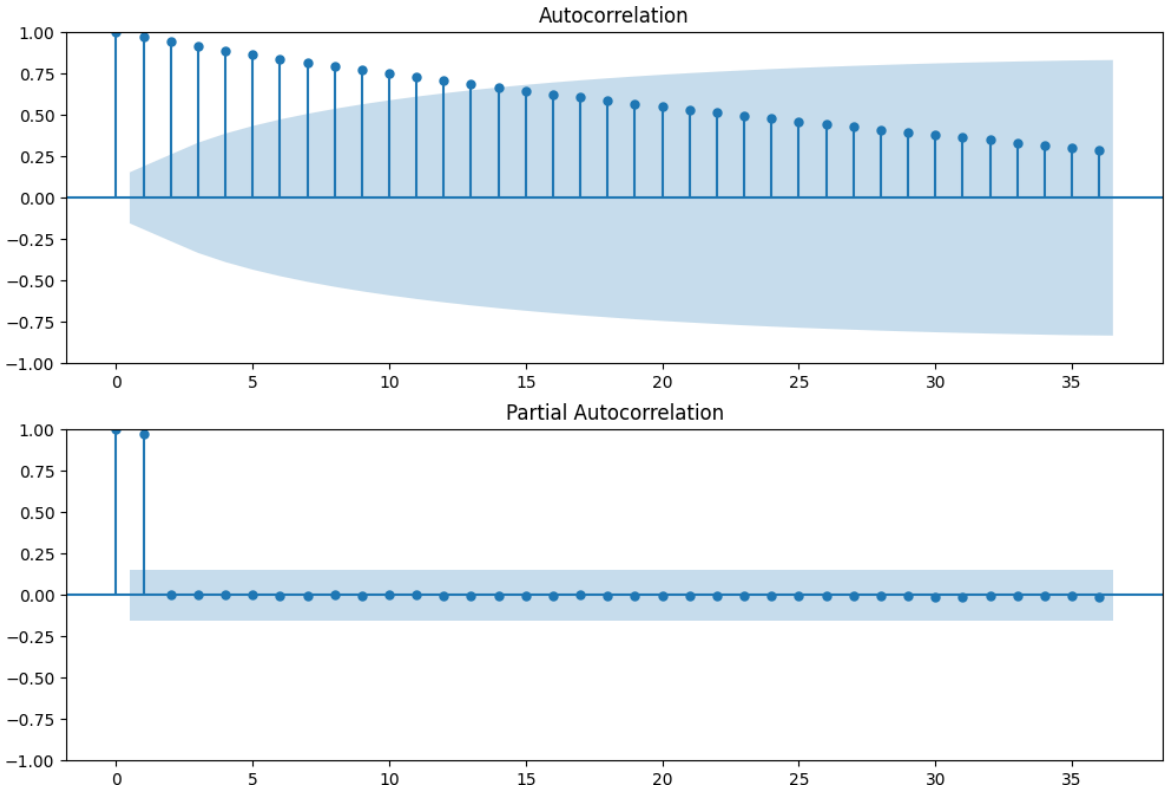
Uji Stasioneritas

In [ ]:
```
#2010 - 2023
test_stationarity(county_information['King']['df']['Jumlah  EV'])
```




```
Results of Dickey-Fuller Test:
Test Statistic                   1.718537
p-value                          0.998173
#Lags Used                       7.000000
Number of Observations Used    154.000000
Critical Value (1%)             -3.473543
Critical Value (5%)             -2.880498
Critical Value (10%)            -2.576878
dtype: float64
```

H_0 tidak berhasil ditolak, yang berarti data belum stasioner



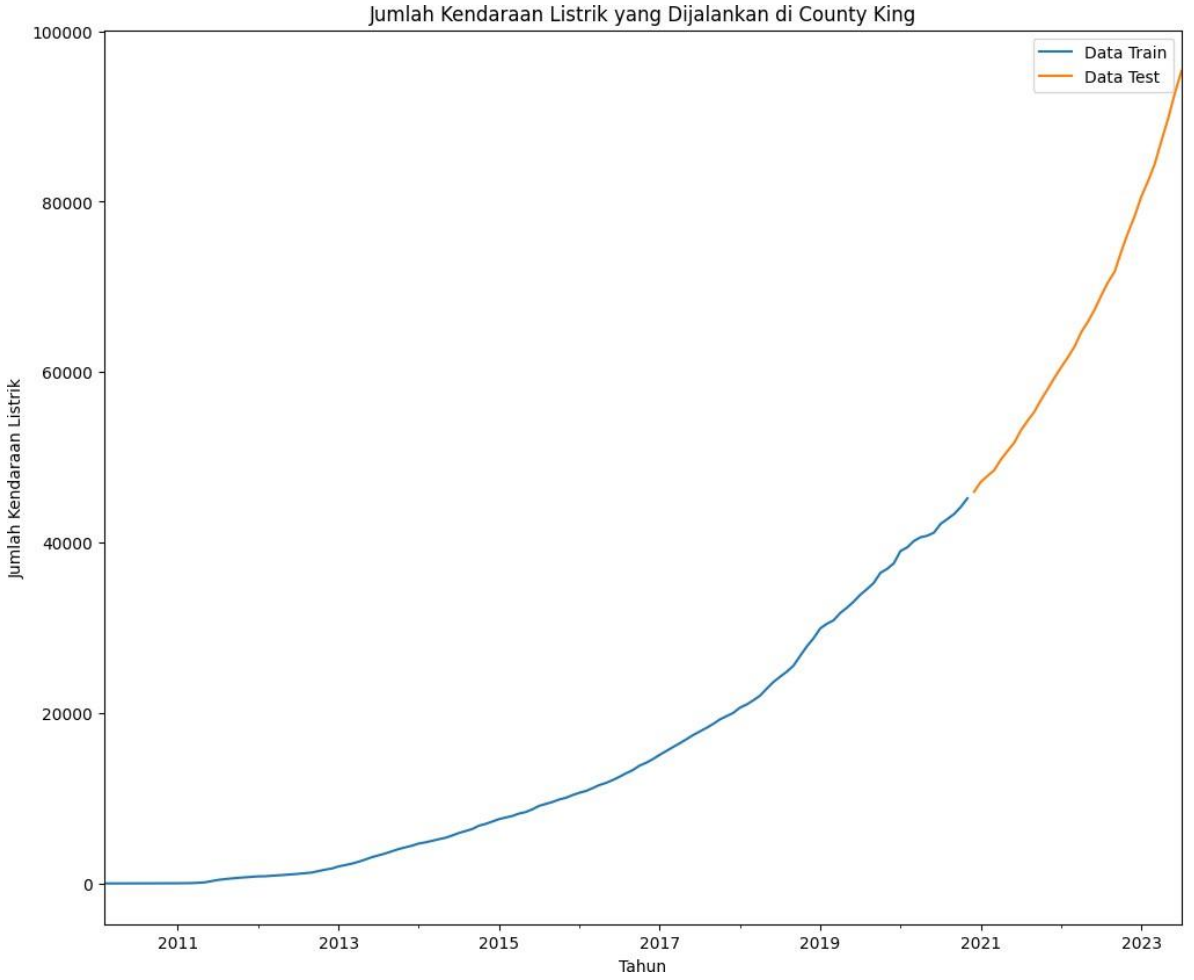
Dari hasil tersebut, terlihat bahwa runtun waktu tersebut tidak stasioner. Oleh karena itu, perlu ditambahkan orde *differencing* pada penentuan model selanjutnya.

Data *Splitting*

Data akan di-*split* dengan rasio 80/20 (Train/Test).

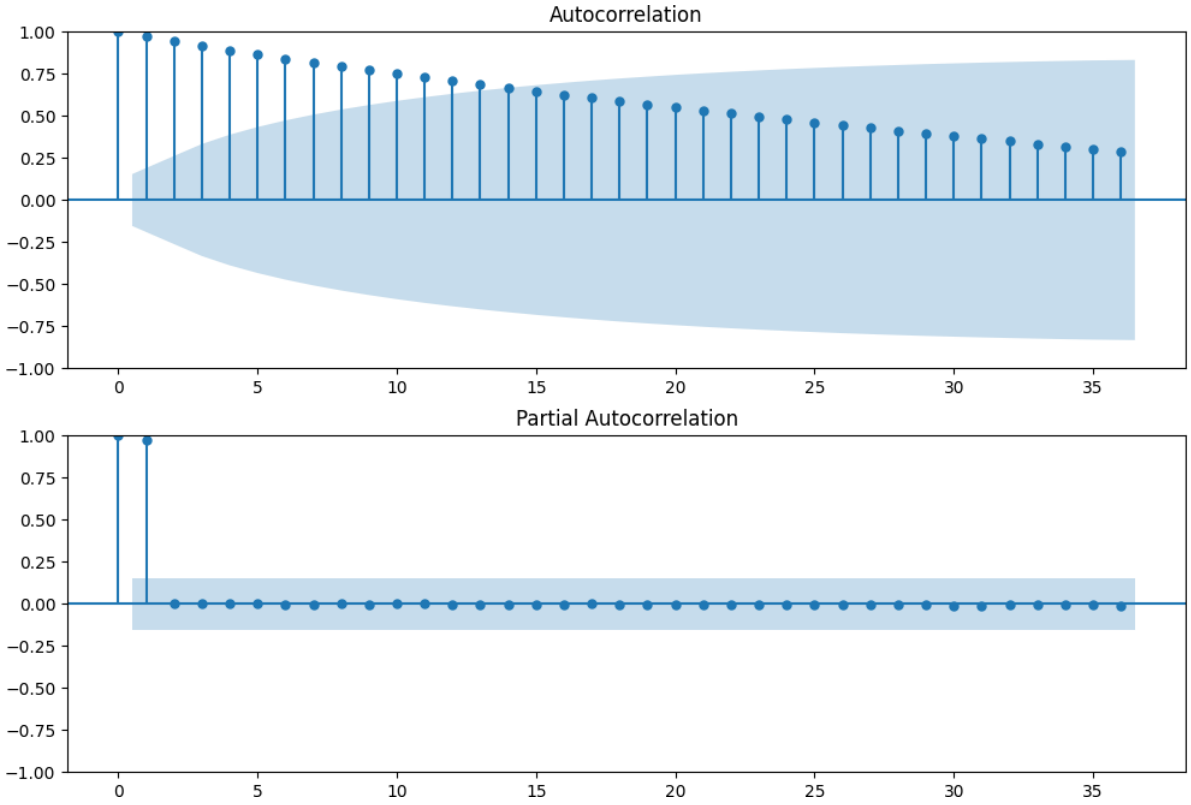
In [ ]:
```
train_king, test_king = train_test_split_ts(county_information['King']['df'], 0.80,
```

In [ ]:
```
plot_train_test_split(train_king, test_king, 'King')
```



Model Identification

In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['King']['df'], lags = 36, ax = a
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['King']['df'], lags = 36, ax =
```



Untuk mendapatkan model yang dapat memprediksi nilai masa depan secara akurat, perlu untuk mengoptimalkan nilai p, d, q model dan memvalidasinya. Kami akan menggunakan bantuan fungsi `auto_arima` dari library `pmdarima`.

In [ ]:
```
auto_model = pm.auto_arima(train_king, start_p = 0, start_d = 0, start_q = 0, max_
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)x(1, 0, 1, 12)	**Log Likelihood**	-827.715
Date:	Fri, 25 Aug 2023	**AIC**	1663.430
Time:	17:26:51	**BIC**	1674.838
Sample:	02-28-2010	**HQIC**	1668.065
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7502	0.037	-20.342	0.000	-0.822	-0.678
ar.S.L12	0.8149	0.243	3.356	0.001	0.339	1.291
ma.S.L12	-0.5481	0.276	-1.988	0.047	-1.088	-0.008
sigma2	2.35e+04	1783.212	13.177	0.000	2e+04	2.7e+04

Ljung-Box (L1) (Q):	0.48	**Jarque-Bera (JB):**	114.15
Prob(Q):	0.49	**Prob(JB):**	0.00
Heteroskedasticity (H):	33.45	**Skew:**	0.14
Prob(H) (two-sided):	0.00	**Kurtosis:**	7.62

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

Parameter terbaik (berdasarkan skor AIC) adalah $(0, 2, 1)$ untuk orde reguler ARIMA dan ($1, 0, 1, 12$) untuk orde *seasonal*. Jadi, model runtun waktu yang baik untuk *county* King yaitu $\mathrm{ARIMA}(0, 2, 1)(1, 0, 1)_{12}$.

Model Validation **untuk Data Test**

In [ ]:
```
model = SARIMAX(train_king, order = (0, 2, 1), seasonal_order = (1, 0, 1, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

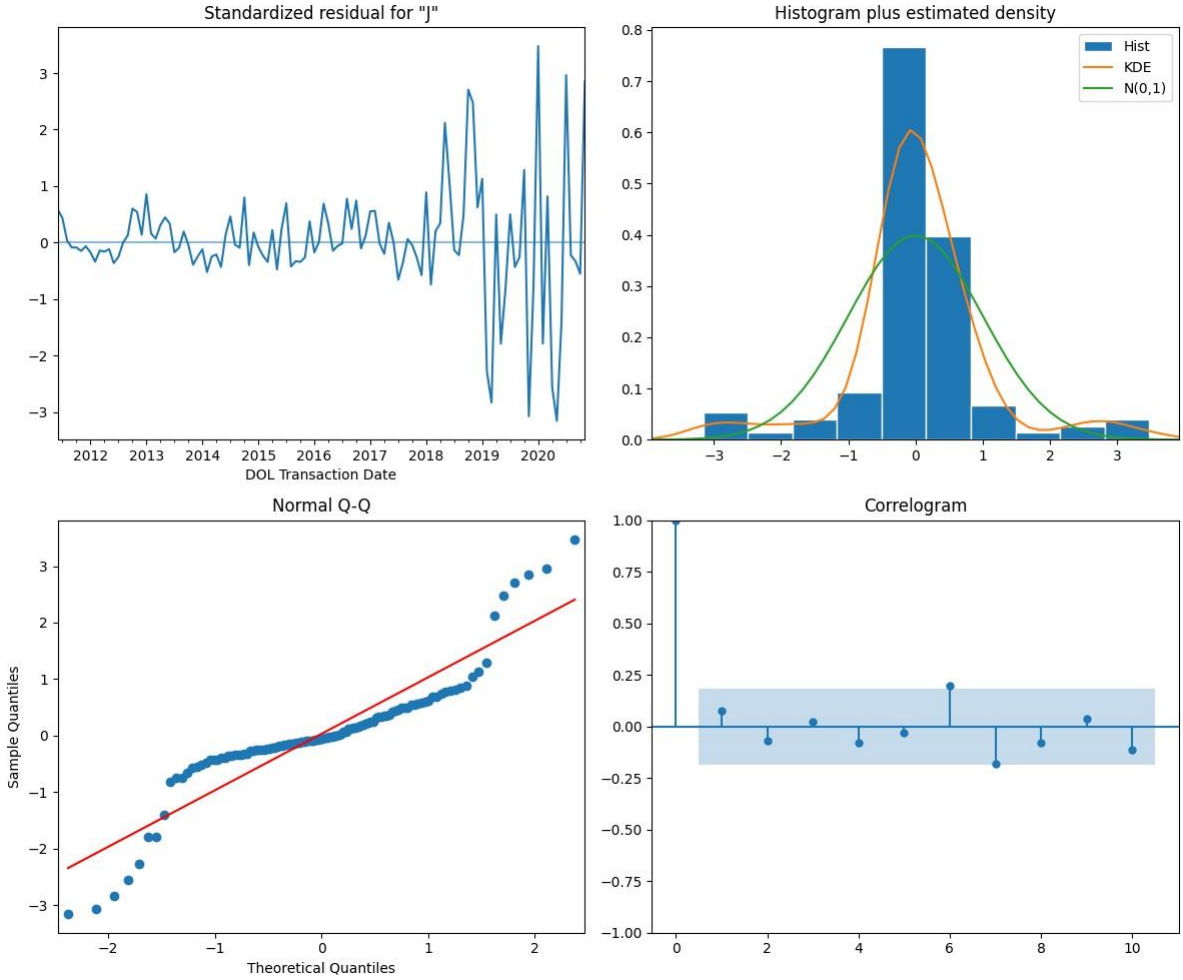
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)x(1, 0, 1, 12)	**Log Likelihood**	-742.716
Date:	Fri, 25 Aug 2023	**AIC**	1493.431
Time:	17:27:35	**BIC**	1504.376
Sample:	02-28-2010	**HQIC**	1497.873
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7422	0.044	-16.950	0.000	-0.828	-0.656
ar.S.L12	0.8741	0.195	4.486	0.000	0.492	1.256
ma.S.L12	-0.4603	0.207	-2.227	0.026	-0.865	-0.055
sigma2	2.611e+04	2184.860	11.949	0.000	2.18e+04	3.04e+04

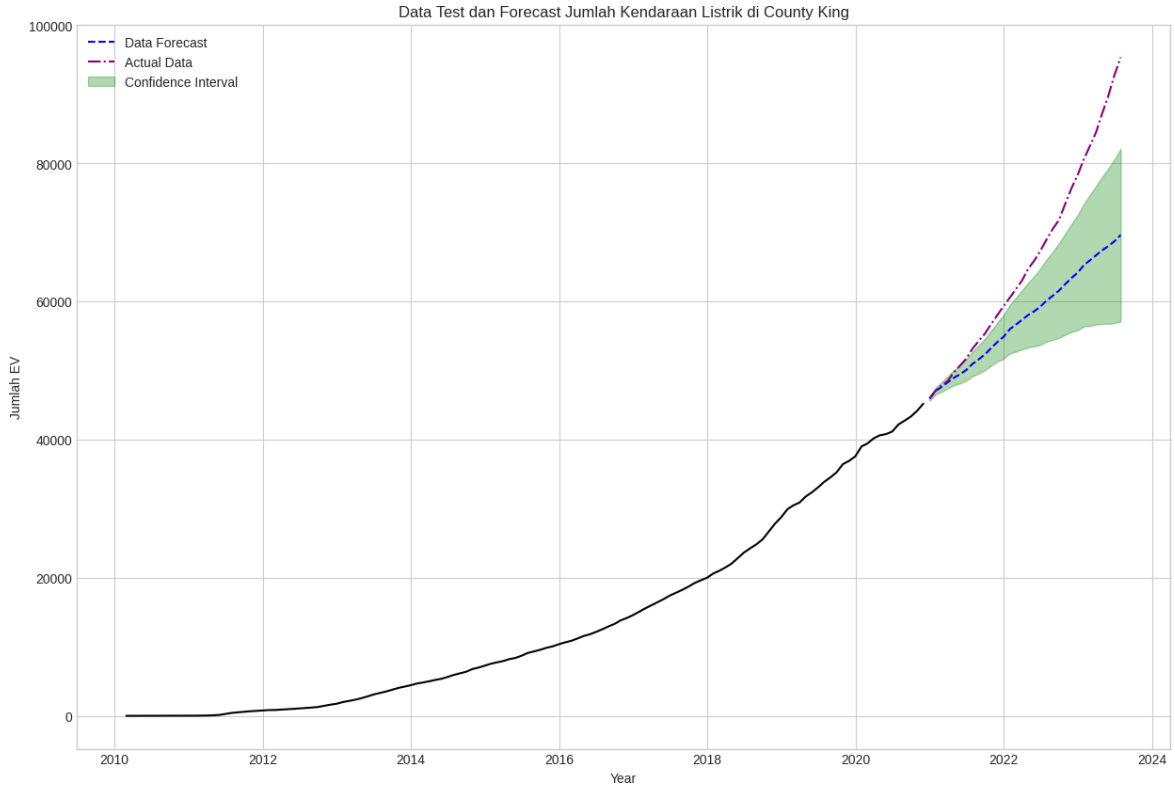
Ljung-Box (L1) (Q):	0.70	**Jarque-Bera (JB):**	64.51
Prob(Q):	0.40	**Prob(JB):**	0.00
Heteroskedasticity (H):	26.52	**Skew:**	0.06
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.68

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



Terlihat bahwa residual relatif tidak "mirip" dengan distribusi normal. Namun, $p - value$ dari koefisien menunjukkan bahwa koefisien-koefisien tersebut signifikan secara statistik.

In [ ]:
```
df_king_forecast = get_forecast(model, train_king, test_king, 'King', plot = True)
```

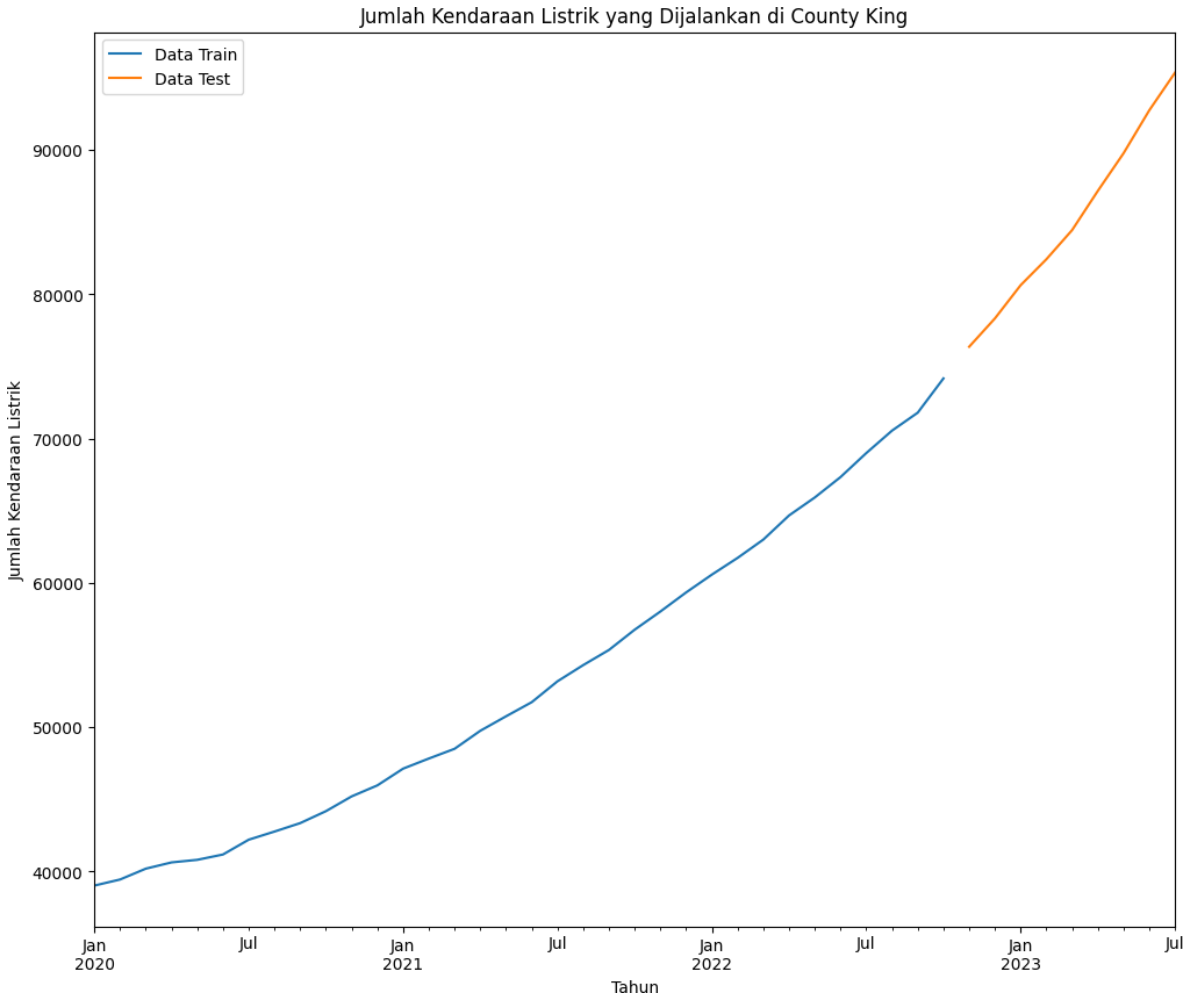


```
Mean Absolute Percentage Error: 0.11022962003362075

Mean Squared Error: 125719125.55856653

Root Mean Squared Error: 11212.45403819193

R-squared:  0.38743620310250126
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_king, test_king = train_test_split_ts(king, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_king, test_king, 'King')
```



In [ ]:
```
auto_model = pm.auto_arima(train_king, start_p = 0, start_d = 0, start_q = 0, max_
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(1, 2, 0)x(1, 0, 0, 12)	**Log Likelihood**	-229.221
Date:	Fri, 25 Aug 2023	**AIC**	464.443
Time:	17:35:40	**BIC**	468.840
Sample:	01-31-2020	**HQIC**	465.900
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.1976	0.101	-1.962	0.050	-0.395	-0.000
ar.S.L12	0.2443	0.094	2.595	0.009	0.060	0.429
sigma2	7.939e+04	1.42e+04	5.600	0.000	5.16e+04	1.07e+05

Ljung-Box (L1) (Q):	1.89	**Jarque-Bera (JB):**	8.31
Prob(Q):	0.17	**Prob(JB):**	0.02
Heteroskedasticity (H):	1.38	**Skew:**	1.10
Prob(H) (two-sided):	0.60	**Kurtosis:**	4.20

Warnings:

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

In [ ]:
```
model = SARIMAX(train_king, order = (1, 2, 0), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

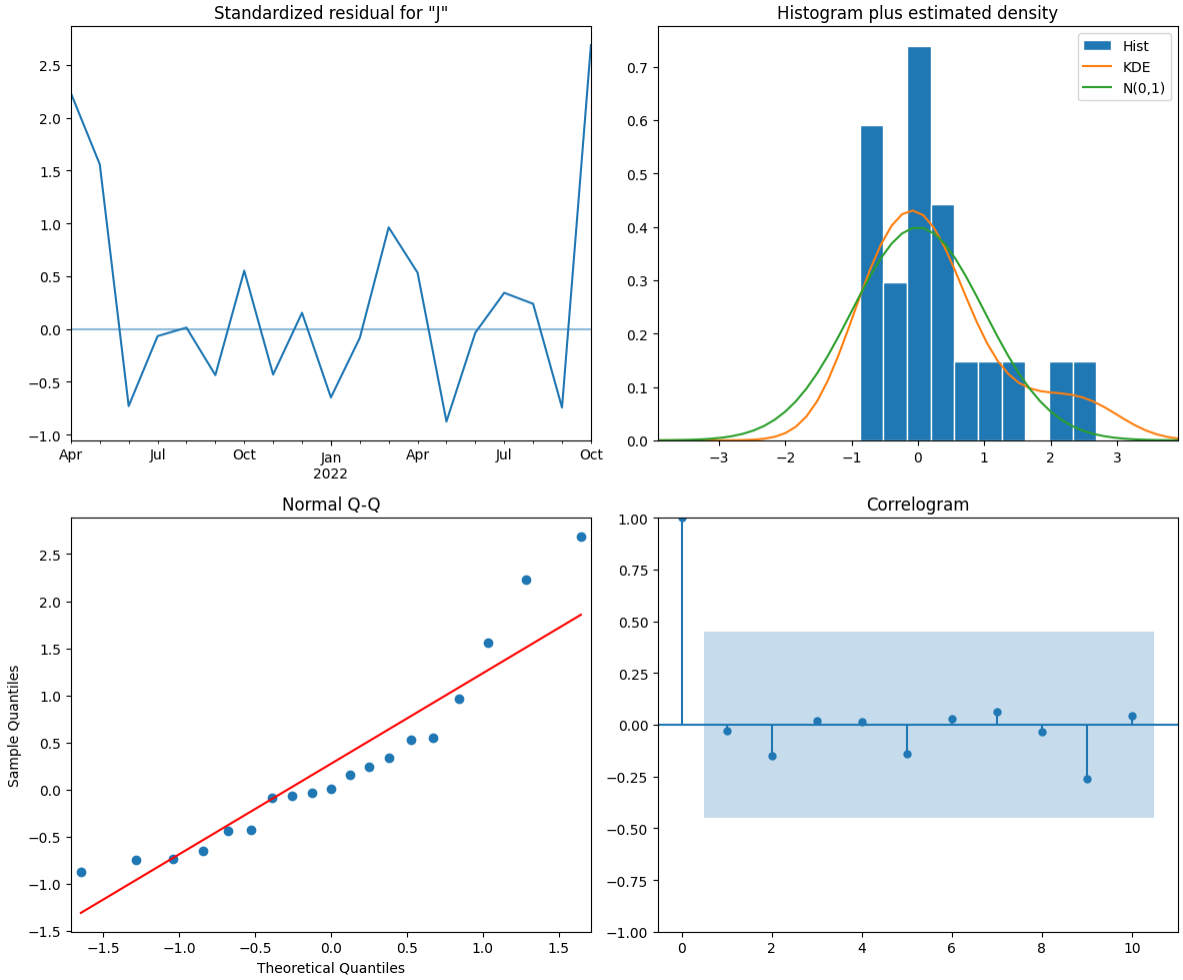
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(1, 2, 0)x(1, 0, 0, 12)	**Log Likelihood**	-133.629
Date:	Fri, 25 Aug 2023	**AIC**	273.258
Time:	17:35:44	**BIC**	276.091
Sample:	01-31-2020	**HQIC**	273.738
	- 10-31-2022		
Covariance Type:	opg		

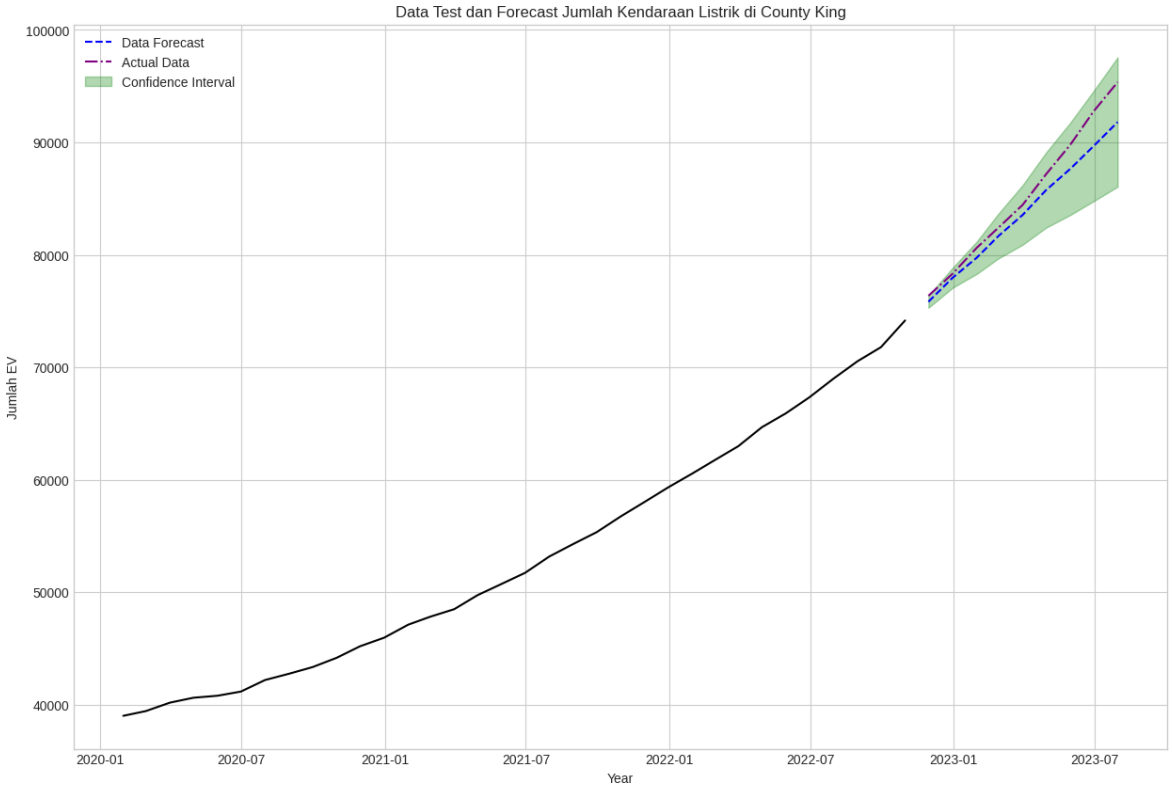
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6814	0.269	-2.532	0.011	-1.209	-0.154
ar.S.L12	0.5977	0.307	1.950	0.051	-0.003	1.199
sigma2	7.523e+04	2e+04	3.768	0.000	3.61e+04	1.14e+05

Ljung-Box (L1) (Q):	0.02	**Jarque-Bera (JB):**	4.10
Prob(Q):	0.90	**Prob(JB):**	0.13
Heteroskedasticity (H):	1.07	**Skew:**	1.11
Prob(H) (two-sided):	0.94	**Kurtosis:**	3.48

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



In [ ]:
```
df_king_forecast = get_forecast(model, train_king, test_king, 'King', plot = True)
```



```
Mean Absolute Percentage Error: 0.01696402915975527

Mean Squared Error: 3470399.5655562785

Root Mean Squared Error: 1862.900846947115

R-squared:  0.9079994808680997
```

Prediksi Masa Depan

Fit Model

In [ ]:
```
model = SARIMAX(king['Jumlah EV'], order = (1, 2, 0), seasonal_order = (1, 0, 0, 1
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/ts
ueWarning:

No frequency information was provided, so inferred frequency

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/ts
ueWarning:

No frequency information was provided, so inferred frequency
```

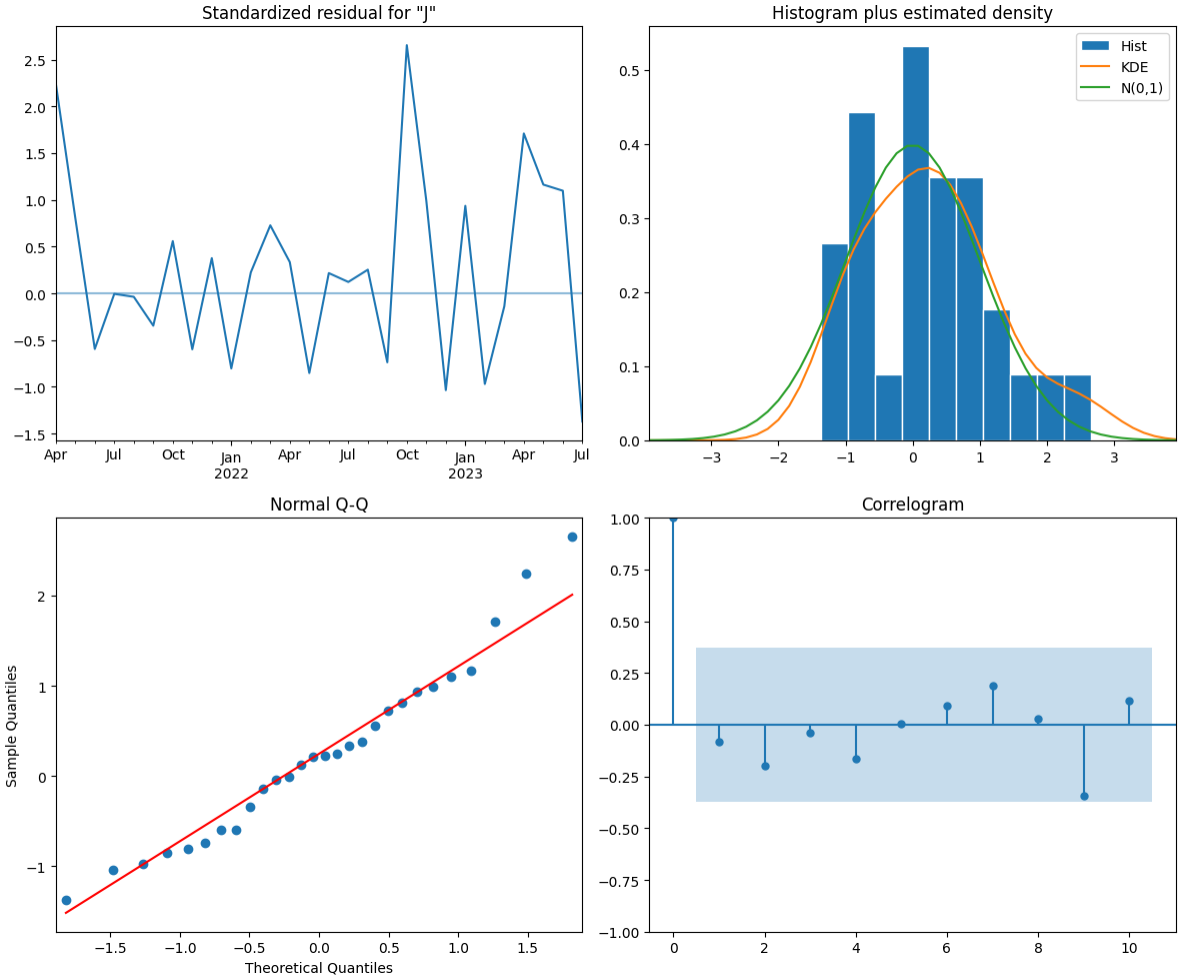
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(1, 2, 0)x(1, 0, 0, 12)	**Log Likelihood**	-199.424
Date:	Fri, 25 Aug 2023	**AIC**	404.847
Time:	16:47:55	**BIC**	408.844
Sample:	01-31-2020	**HQIC**	406.069
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.4269	0.199	-2.148	0.032	-0.817	-0.037
ar.S.L12	0.6217	0.226	2.756	0.006	0.180	1.064
sigma2	8.992e+04	2.58e+04	3.482	0.000	3.93e+04	1.41e+05

Ljung-Box (L1) (Q):	0.22	**Jarque-Bera (JB):**	1.49
Prob(Q):	0.64	**Prob(JB):**	0.47
Heteroskedasticity (H):	1.61	**Skew:**	0.56
Prob(H) (two-sided):	0.49	**Kurtosis:**	2.94

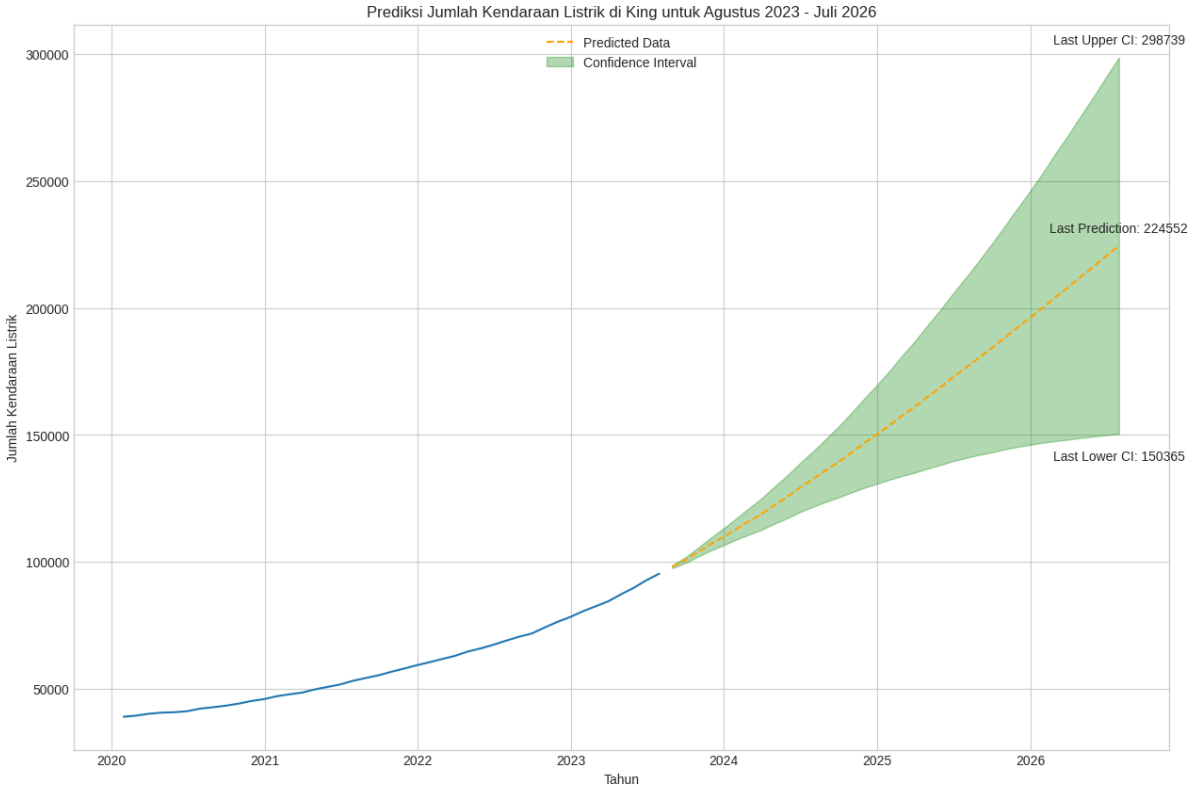
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).



Sama seperti sebelumnya, residual tersebut relatif tidak "mirip" dengan distribusi normal. Namun, $p - value$ dari koefisien juga menunjukkan bahwa koefisien-koefisien tersebut signifikan secara statistik.

Plot

In [ ]:
```
df_king_preds = get_prediction(model, king['Jumlah EV'], test_king, 'King', plot =
```



Dengan model ini, diprediksi bahwa jumlah kendaraan listrik di *county* King akan terus meningkat hampir secara linier berdasarkan nilai rata-rata. Namun, jika dilihat berdasarkan interval kepercayaan, jumlah kendaraan listrik meningkat secara eksponensial.

Saving Prediction

In [ ]:
```
county_information['King']['Predictions'] = df_king_preds
```

County Snohomish

Inisialisasi Dataset

In [ ]:
```
county_dfs['Snohomish']
```

Out[ ]:

DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	0.0
2010-05-31	1.0
2010-06-30	1.0
...	...
2023-03-31	16573.0
2023-04-30	17084.0
2023-05-31	17718.0
2023-06-30	18353.0
2023-07-31	19042.0

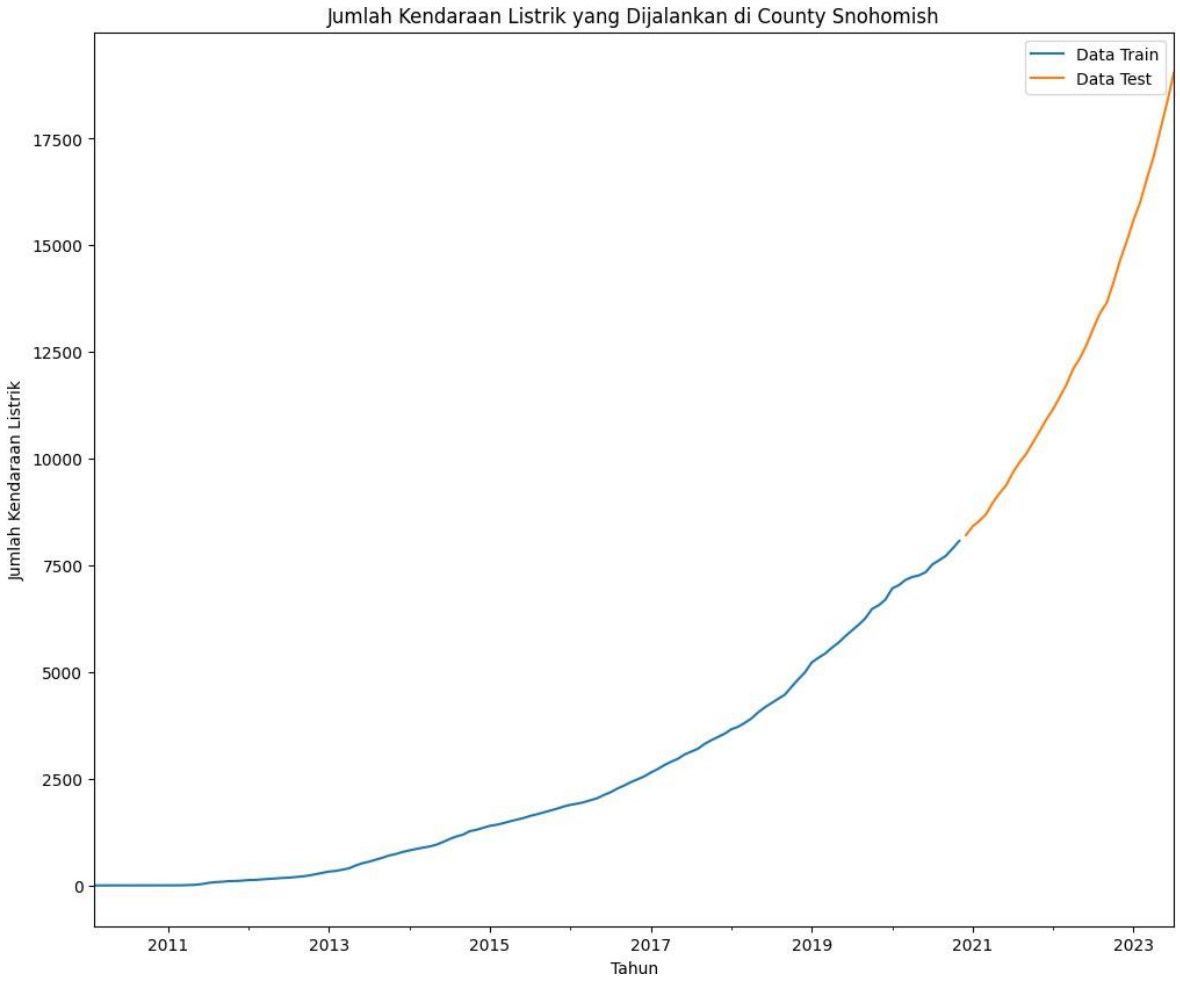
162 rows × 1 columns

In [ ]:
```
snohomish = county_dfs['Snohomish'].copy()
snohomish.reset_index(inplace=True)
mask = snohomish['DOL Transaction Date'] >= '2020-01-31'
snohomish = snohomish[mask]

snohomish.set_index('DOL Transaction Date', inplace = True)
```

Data Splitting

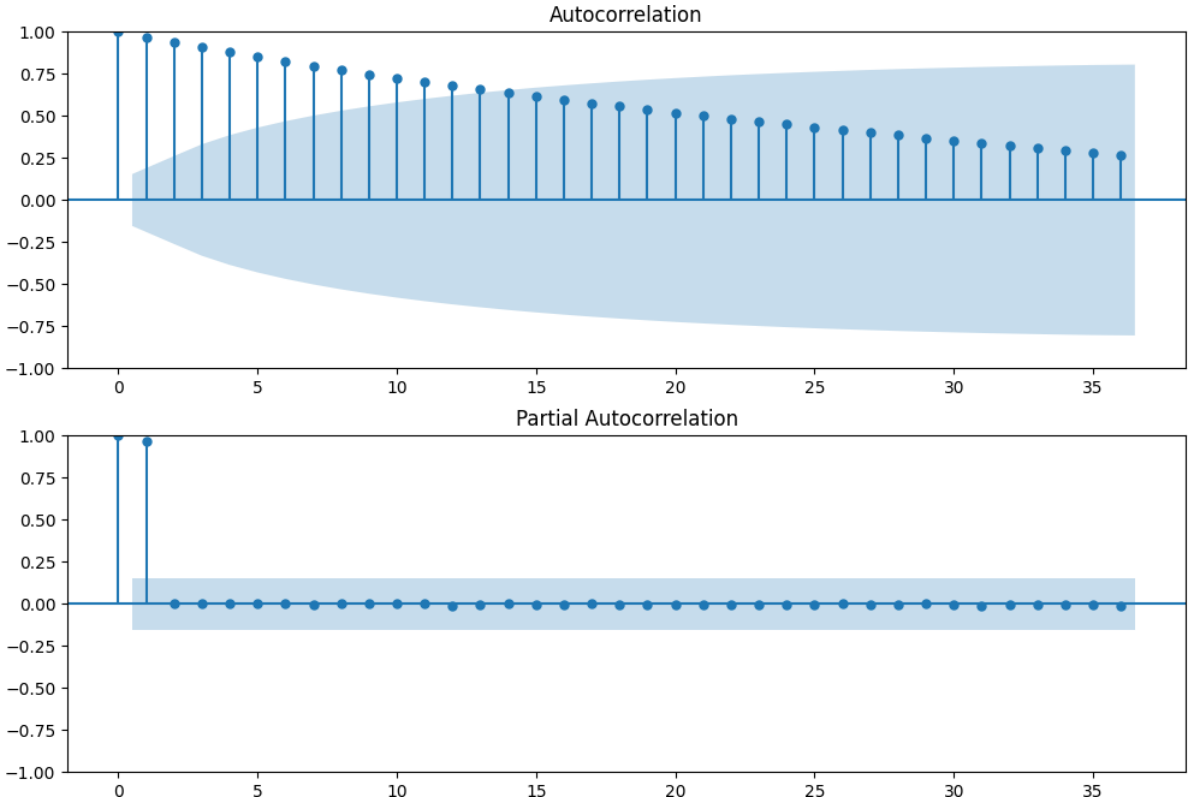
In [ ]:
```
train_snohomish, test_snohomish = train_test_split_ts(county_information['Snohomish
```

In [ ]:
```
plot_train_test_split(train_snohomish, test_snohomish, 'Snohomish')
```



Model Identification

In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['Snohomish']['df'], lags = 36, a
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['Snohomish']['df'], lags = 36,
```



In [ ]:
```
auto_model = pm.auto_arima(train_snohomish, start_p = 0, start_d = 0, start_q = 0,
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(0, 2, 2)x(0, 0, 2, 12)	**Log Likelihood**	-604.750
Date:	Fri, 25 Aug 2023	**AIC**	1219.500
Time:	18:19:07	**BIC**	1233.760
Sample:	02-28-2010	**HQIC**	1225.294
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.6160	0.060	-10.330	0.000	-0.733	-0.499
ma.L2	-0.1889	0.067	-2.841	0.004	-0.319	-0.059
ma.S.L12	0.3548	0.072	4.952	0.000	0.214	0.495
ma.S.L24	0.4668	0.134	3.496	0.000	0.205	0.728
sigma2	701.4465	63.859	10.984	0.000	576.285	826.609

Ljung-Box (L1) (Q):	0.09	**Jarque-Bera (JB):**	71.75
Prob(Q):	0.77	**Prob(JB):**	0.00
Heteroskedasticity (H):	20.98	**Skew:**	-0.30
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.62

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

Model Validation **untuk Data Test**

In [ ]:
```
model = SARIMAX(train_snohomish, order = (0, 2, 2), seasonal_order = (0, 0, 2, 12)
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

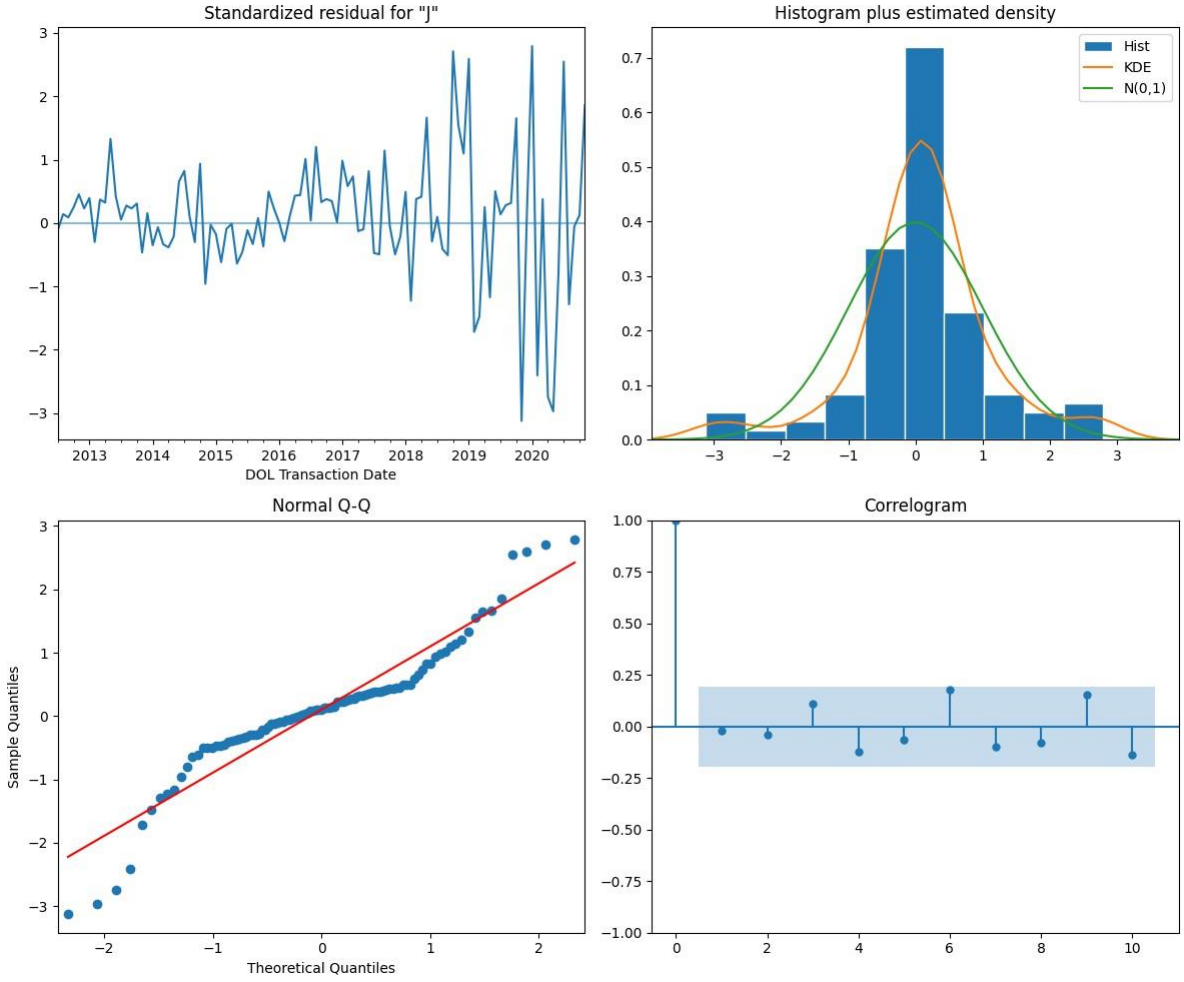
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(0, 2, 2)x(0, 0, 2, 12)	**Log Likelihood**	-488.381
Date:	Fri, 25 Aug 2023	**AIC**	986.761
Time:	18:19:57	**BIC**	999.837
Sample:	02-28-2010	**HQIC**	992.054
	- 11-30-2020		
Covariance Type:	opg		

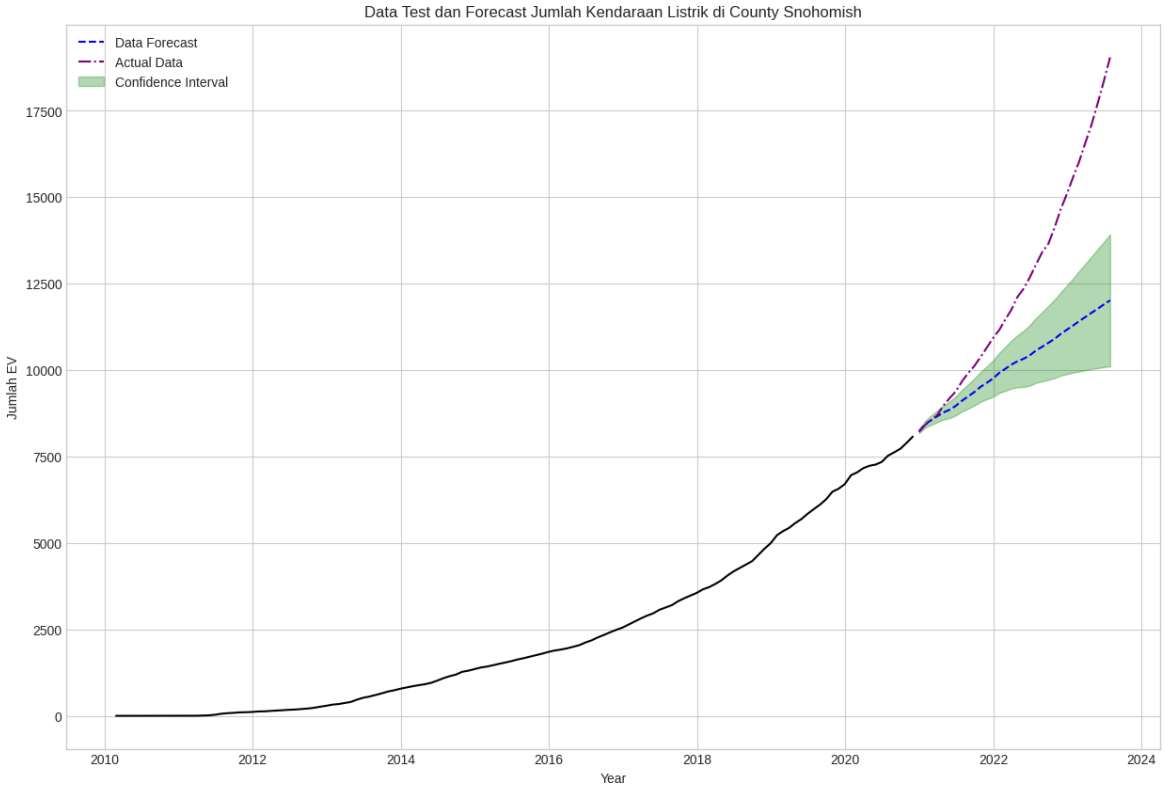
	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.6219	0.077	-8.126	0.000	-0.772	-0.472
ma.L2	-0.1815	0.085	-2.141	0.032	-0.348	-0.015
ma.S.L12	0.3637	0.088	4.126	0.000	0.191	0.536
ma.S.L24	0.4507	0.174	2.587	0.010	0.109	0.792
sigma2	875.3522	99.191	8.825	0.000	680.941	1069.763

Ljung-Box (L1) (Q):	0.05	**Jarque-Bera (JB):**	26.75
Prob(Q):	0.82	**Prob(JB):**	0.00
Heteroskedasticity (H):	11.88	**Skew:**	-0.31
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.45

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



In [ ]:
```
df_snohomish_forecast = get_forecast(model, train_snohomish, test_snohomish, 'Snoho
```

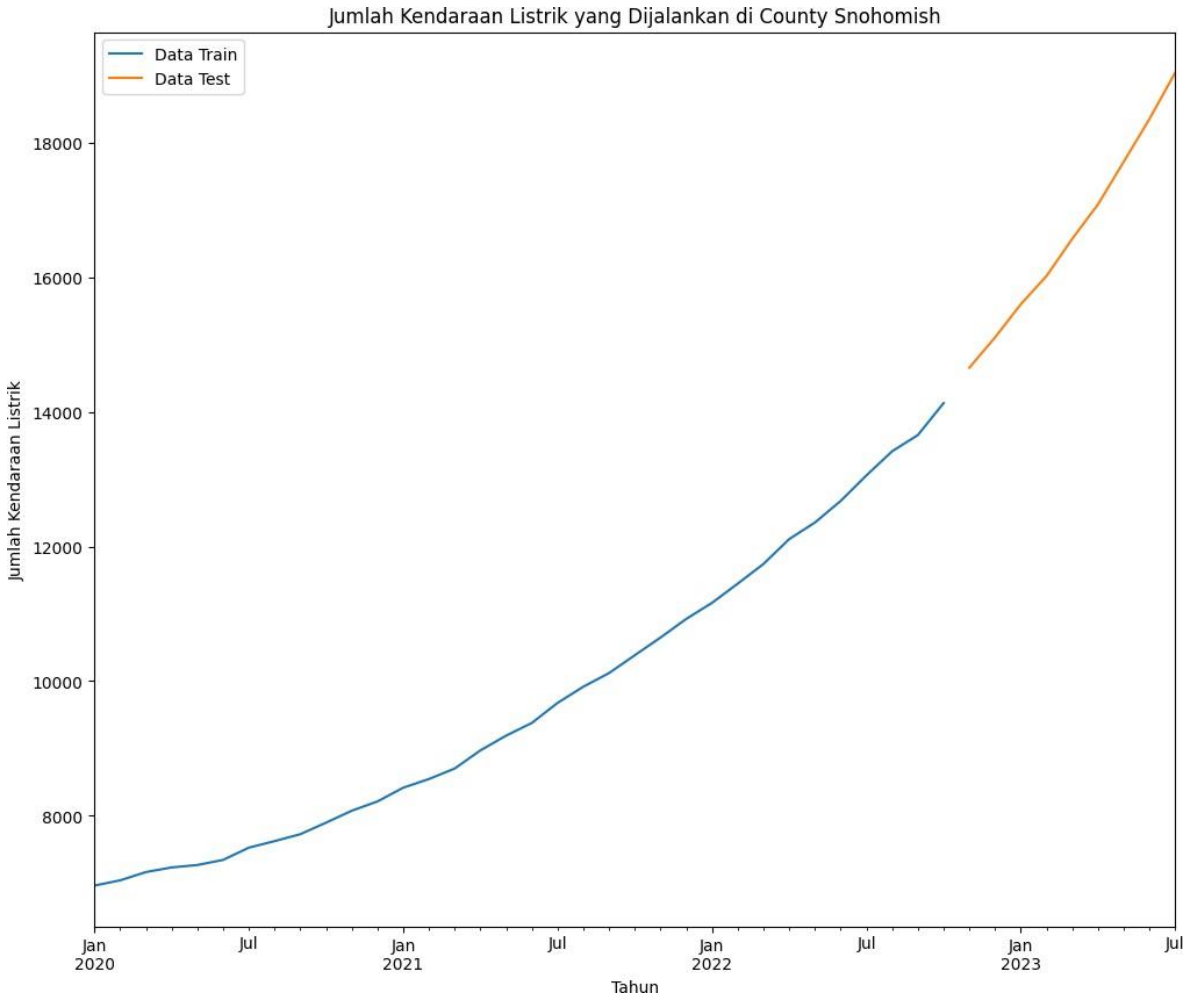


```
Mean Absolute Percentage Error: 0.15774814457582145

Mean Squared Error: 9548501.462224048

Root Mean Squared Error: 3090.064960842093

R-squared:  0.024365584159216525
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_snohomish, test_snohomish = train_test_split_ts(snohomish, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_snohomish, test_snohomish, 'Snohomish')
```



In [ ]:
```
auto_model = pm.auto_arima(train_snohomish, start_p = 0, start_d = 0, start_q = 0,
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 2)x(2, 0, [], 12)	**Log Likelihood**	-171.561
Date:	Fri, 25 Aug 2023	**AIC**	353.121
Time:	18:21:49	**BIC**	360.450
Sample:	01-31-2020	**HQIC**	355.551
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-1.1226	0.200	-5.626	0.000	-1.514	-0.731
ma.L2	0.5006	0.192	2.603	0.009	0.124	0.878
ar.S.L12	0.1786	0.143	1.253	0.210	-0.101	0.458
ar.S.L24	0.4742	0.393	1.207	0.227	-0.296	1.244
sigma2	1937.4065	784.646	2.469	0.014	399.529	3475.284

Ljung-Box (L1) (Q):	0.01	**Jarque-Bera (JB):**	0.21
Prob(Q):	0.91	**Prob(JB):**	0.90
Heteroskedasticity (H):	1.22	**Skew:**	0.08
Prob(H) (two-sided):	0.75	**Kurtosis:**	2.64

Warnings:

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

In [ ]:

```
model = SARIMAX(train_snohomish, order = (0, 2, 2), seasonal_order = (2, 0, 0, 12)
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 2)x(2, 0, [], 12)	**Log Likelihood**	-41.093
Date:	Fri, 25 Aug 2023	**AIC**	92.185
Time:	18:21:55	**BIC**	92.582
Sample:	01-31-2020	**HQIC**	89.506
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-1.8607	0.536	-3.474	0.001	-2.911	-0.811
ma.L2	1.0000	2.147	0.466	0.641	-3.209	5.209
ar.S.L12	0.4583	0.306	1.499	0.134	-0.141	1.058
ar.S.L24	0.6008	0.309	1.946	0.052	-0.004	1.206
sigma2	871.7908	0.003	3.12e+05	0.000	871.785	871.796

Ljung-Box (L1) (Q):	3.77	**Jarque-Bera (JB):**	0.58
Prob(Q):	0.05	**Prob(JB):**	0.75
Heteroskedasticity (H):	4.13	**Skew:**	-0.63
Prob(H) (two-sided):	0.27	**Kurtosis:**	2.64

Warnings:

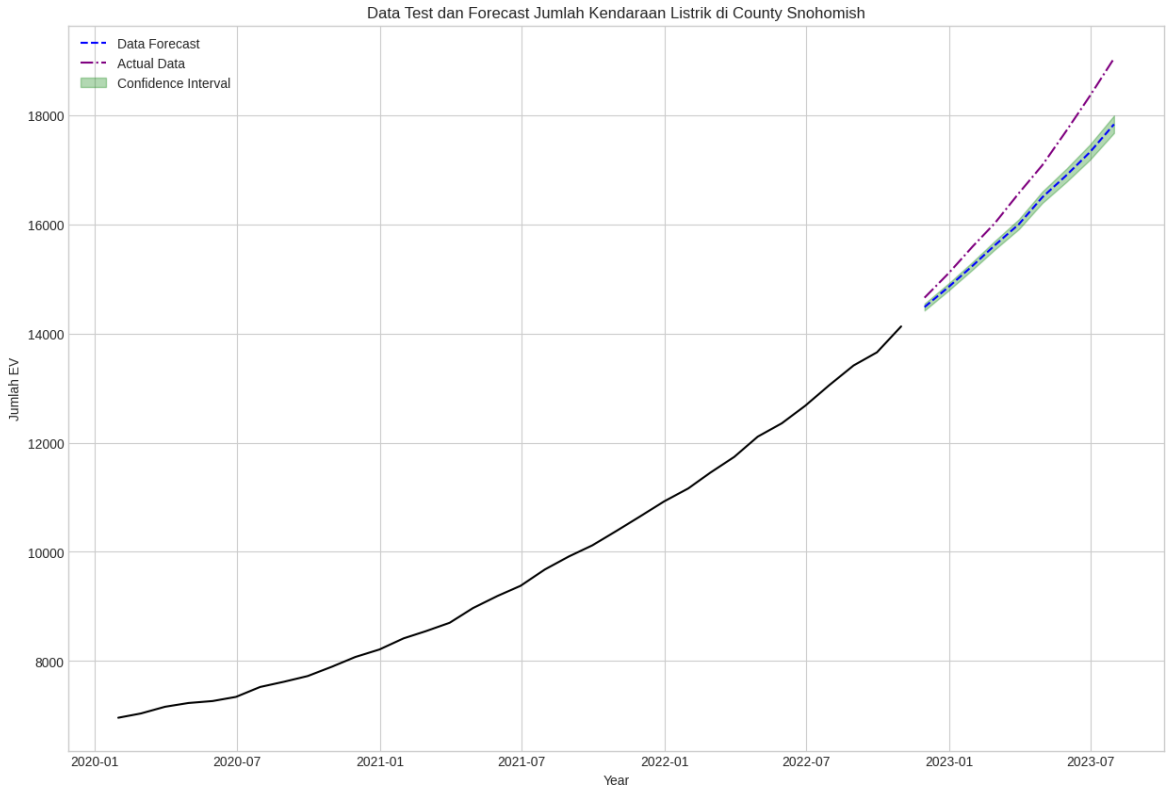
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

[2] Covariance matrix is singular or near-singular, with condition number 4.34e+21. Standard errors may be unstable.

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-143-5c376468cf1c> in <cell line: 3>()
      1 model = SARIMAX(train_snohomish, order = (0, 2, 2), seasonal_order = (2,
0, 0, 12),
      2                 enforce_invertibility = False, enforce_stationarity = Fals
e).fit()
----> 3 evaluate_model(model)

<ipython-input-67-01bf108b49e8> in evaluate_model(model)
      1 def evaluate_model(model):
      2   display(model.summary())
----> 3   model.plot_diagnostics()
      4   plt.tight_layout()

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/statespace/mlemodel.py in
plot_diagnostics(self, variable, lags, fig, figsize, truncate_endog_names, auto_yl
ims, bartlett_confint, acf_kwargs)
   4611
   4612         if resid.shape[0] < max(d, lags):
-> 4613             raise ValueError(
   4614                 "Length of endogenous variable must be larger the the numb
er "
   4615                 "of lags used in the model and the number of observations
"

ValueError: Length of endogenous variable must be larger the the number of lags us
ed in the model and the number of observations burned in the log-likelihood calcul
ation.
```

<Figure size 1200x1000 with 0 Axes>

In [ ]:
```
df_snohomish_forecast = get_forecast(model, train_snohomish, test_snohomish, 'Snoho
```



```
Mean Absolute Percentage Error: 0.034503954520701846

Mean Squared Error: 470623.97872810747

Root Mean Squared Error: 686.0203923558742

R-squared:  0.7620281671429404
```

Prediksi Masa Depan

Fit Model

In [ ]:
```
model = SARIMAX(snohomish, order = (0, 2, 2), seasonal_order = (2, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 2)x(2, 0, [], 12)	**Log Likelihood**	-96.802
Date:	Fri, 25 Aug 2023	**AIC**	203.605
Time:	18:32:00	**BIC**	207.771
Sample:	01-31-2020	**HQIC**	204.019
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7737	0.416	-1.861	0.063	-1.588	0.041
ma.L2	0.2198	0.337	0.651	0.515	-0.442	0.881
ar.S.L12	0.3797	0.449	0.845	0.398	-0.501	1.261
ar.S.L24	0.8083	0.387	2.091	0.037	0.051	1.566
sigma2	4912.1150	2381.808	2.062	0.039	243.858	9580.372

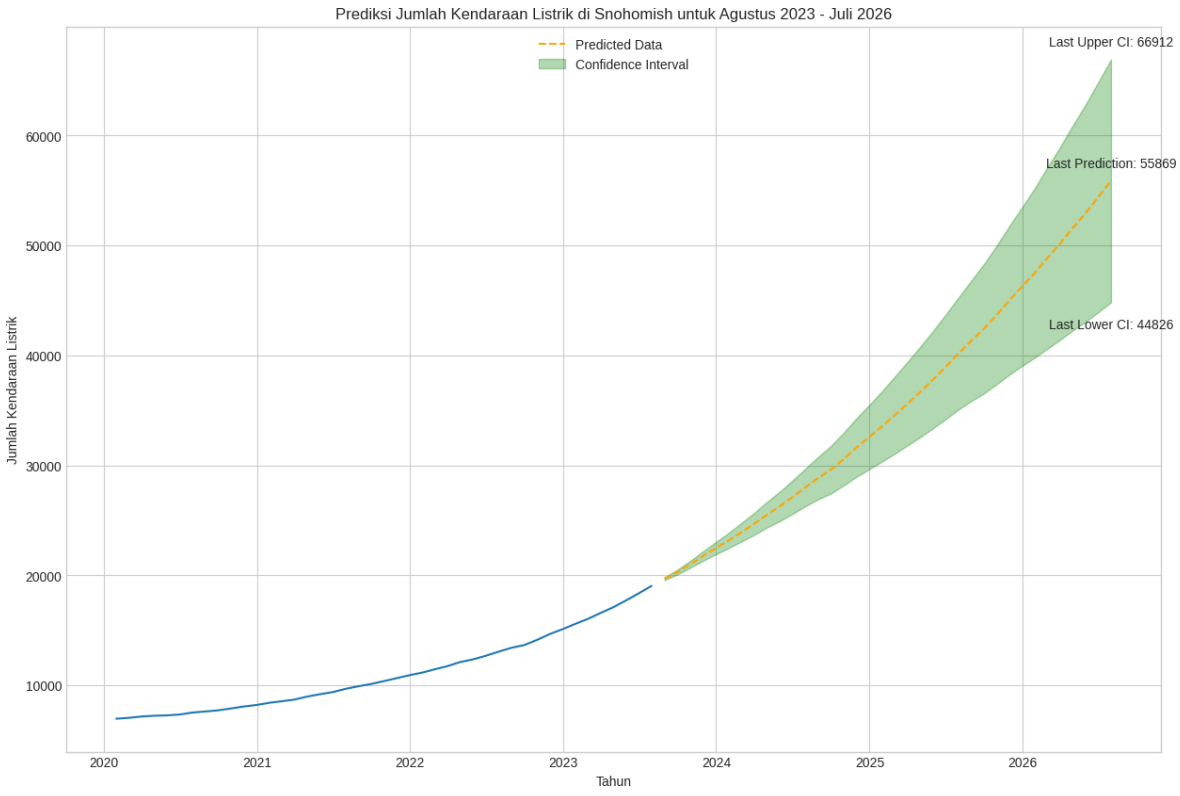
Ljung-Box (L1) (Q):	0.85	**Jarque-Bera (JB):**	0.73
Prob(Q):	0.36	**Prob(JB):**	0.69
Heteroskedasticity (H):	5.11	**Skew:**	0.01
Prob(H) (two-sided):	0.07	**Kurtosis:**	1.98

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

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-145-7fdad3a22466> in <cell line: 3>()
      1 model = SARIMAX(snohomish, order = (0, 2, 2), seasonal_order = (2, 0, 0, 1
2),
      2                 enforce_invertibility = False, enforce_stationarity = Fals
e).fit()
----> 3 evaluate_model(model)

<ipython-input-67-01bf108b49e8> in evaluate_model(model)
      1 def evaluate_model(model):
      2   display(model.summary())
----> 3   model.plot_diagnostics()
      4   plt.tight_layout()

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/statespace/mlemodel.py in
plot_diagnostics(self, variable, lags, fig, figsize, truncate_endog_names, auto_yl
ims, bartlett_confint, acf_kwargs)
   4611
   4612         if resid.shape[0] < max(d, lags):
-> 4613             raise ValueError(
   4614                 "Length of endogenous variable must be larger the the numb
er "
   4615                 "of lags used in the model and the number of observations
"

ValueError: Length of endogenous variable must be larger the the number of lags us
ed in the model and the number of observations burned in the log-likelihood calcul
ation.
<Figure size 1200x1000 with 0 Axes>
```

Plot

In [ ]:
```
df_snohomish_preds = get_prediction(model, snohomish['Jumlah EV'], test_snohomish,
```



Saving Prediction

In [ ]:
```
county_information['Snohomish']['Predictions'] = df_snohomish_preds
```

County Pierce

Inisialisasi Dataset

In [ ]:
```
county_dfs['Pierce']
```

Out[ ]:

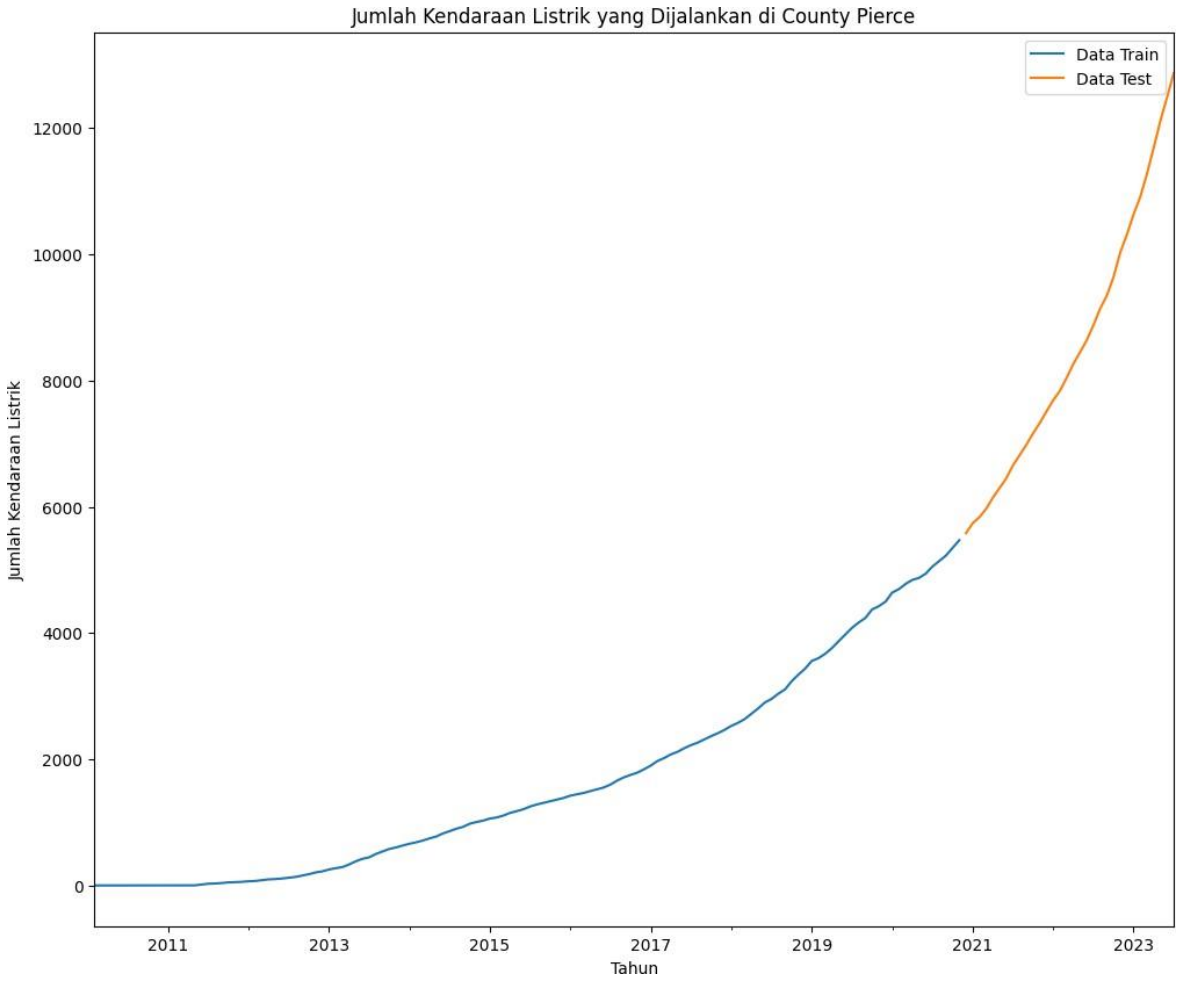
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	0.0
2010-05-31	0.0
2010-06-30	0.0
...	...
2023-03-31	11279.0
2023-04-30	11689.0
2023-05-31	12118.0
2023-06-30	12493.0
2023-07-31	12875.0

162 rows × 1 columns

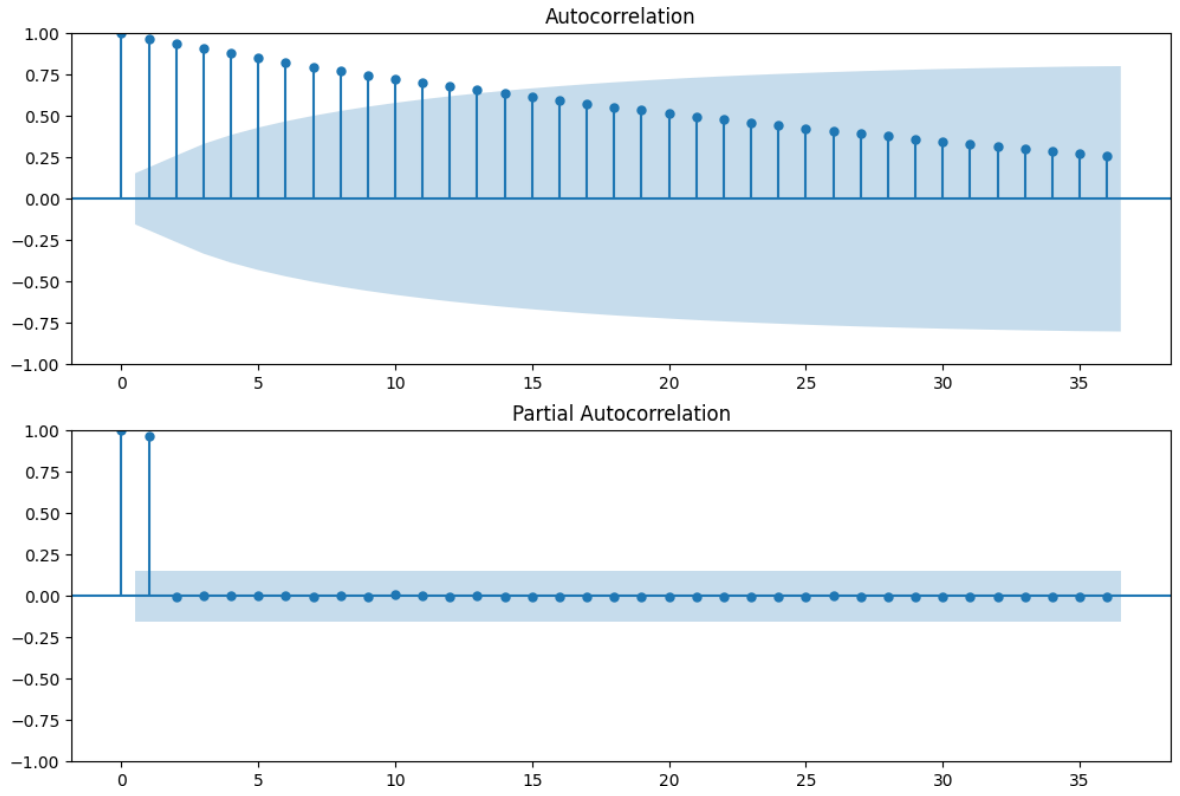
In [ ]:
```
pierce = county_dfs['Pierce'].copy()
pierce.reset_index(inplace=True)
mask = pierce['DOL Transaction Date'] >= '2020-01-31'
pierce = pierce[mask]

pierce.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_pierce, test_pierce = train_test_split_ts(county_information['Pierce']['df'],
```

In [ ]:
```
plot_train_test_split(train_pierce, test_pierce, 'Pierce')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['Pierce']['df'], lags = 36, ax =
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['Pierce']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_pierce, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(1, 2, 2)x(0, 0, [1], 12)	**Log Likelihood**	-539.936
Date:	Fri, 25 Aug 2023	**AIC**	1091.872
Time:	19:04:30	**BIC**	1108.984
Sample:	02-28-2010	**HQIC**	1098.825
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	1.4320	0.849	1.686	0.092	-0.232	3.096
ar.L1	-0.7531	0.133	-5.656	0.000	-1.014	-0.492
ma.L1	0.1178	0.126	0.932	0.352	-0.130	0.366
ma.L2	-0.6943	0.073	-9.544	0.000	-0.837	-0.552
ma.S.L12	0.2721	0.076	3.595	0.000	0.124	0.420
sigma2	266.3303	20.987	12.690	0.000	225.197	307.464

Ljung-Box (L1) (Q):	0.02	**Jarque-Bera (JB):**	51.46
Prob(Q):	0.89	**Prob(JB):**	0.00
Heteroskedasticity (H):	13.54	**Skew:**	0.05
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.10

Warnings:

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

In [ ]:
```
model = SARIMAX(train_pierce, order = (1, 2, 2), seasonal_order = (0, 0, 1, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

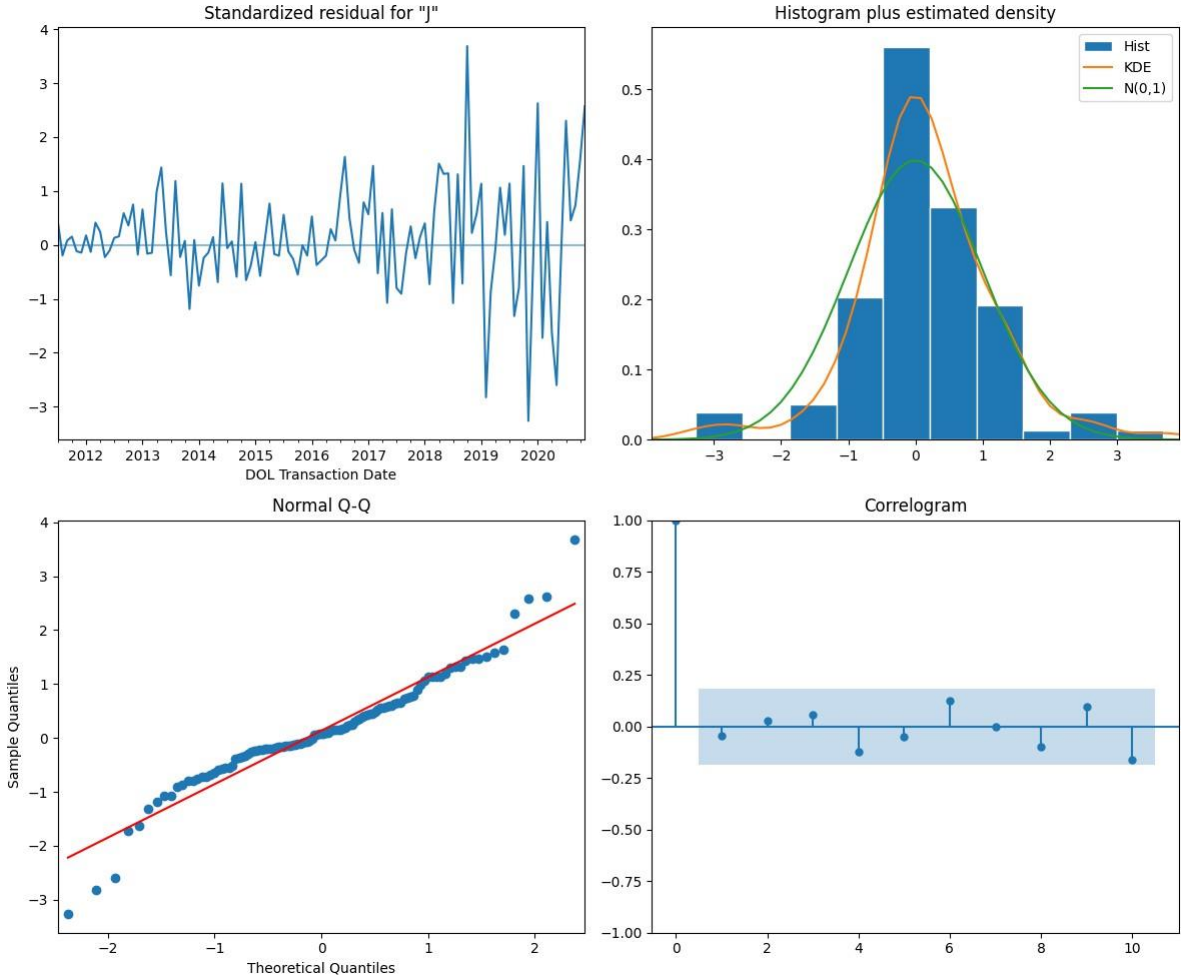
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(1, 2, 2)x(0, 0, [1], 12)	**Log Likelihood**	-484.550
Date:	Fri, 25 Aug 2023	**AIC**	979.100
Time:	19:04:39	**BIC**	992.736
Sample:	02-28-2010	**HQIC**	984.633
	- 11-30-2020		
Covariance Type:	opg		

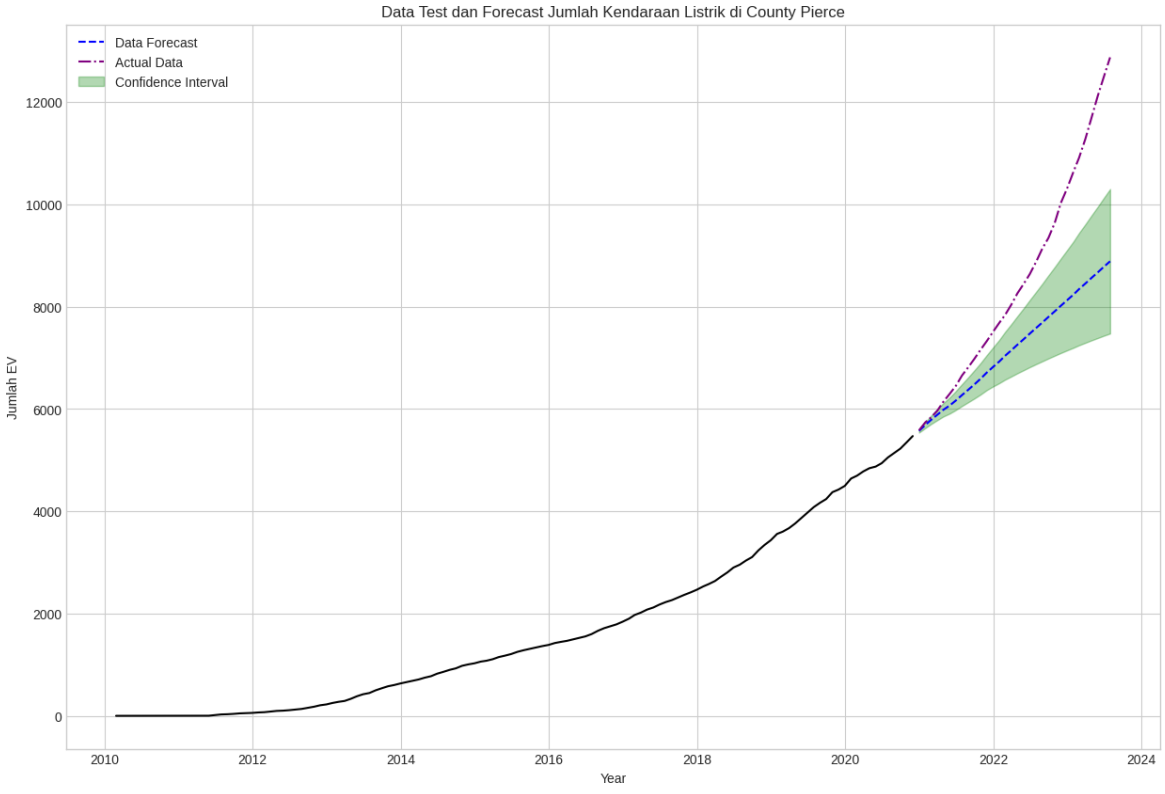
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.7398	0.165	-4.479	0.000	-1.064	-0.416
ma.L1	0.1539	0.165	0.934	0.350	-0.169	0.477
ma.L2	-0.6398	0.088	-7.271	0.000	-0.812	-0.467
ma.S.L12	0.3154	0.091	3.480	0.001	0.138	0.493
sigma2	306.5332	27.691	11.070	0.000	252.260	360.807

Ljung-Box (L1) (Q):	0.23	**Jarque-Bera (JB):**	29.28
Prob(Q):	0.63	**Prob(JB):**	0.00
Heteroskedasticity (H):	7.92	**Skew:**	-0.01
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.49

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



In [ ]:
```
df_pierce_forecast = get_forecast(model, train_pierce, test_pierce, 'Pierce', plot
```

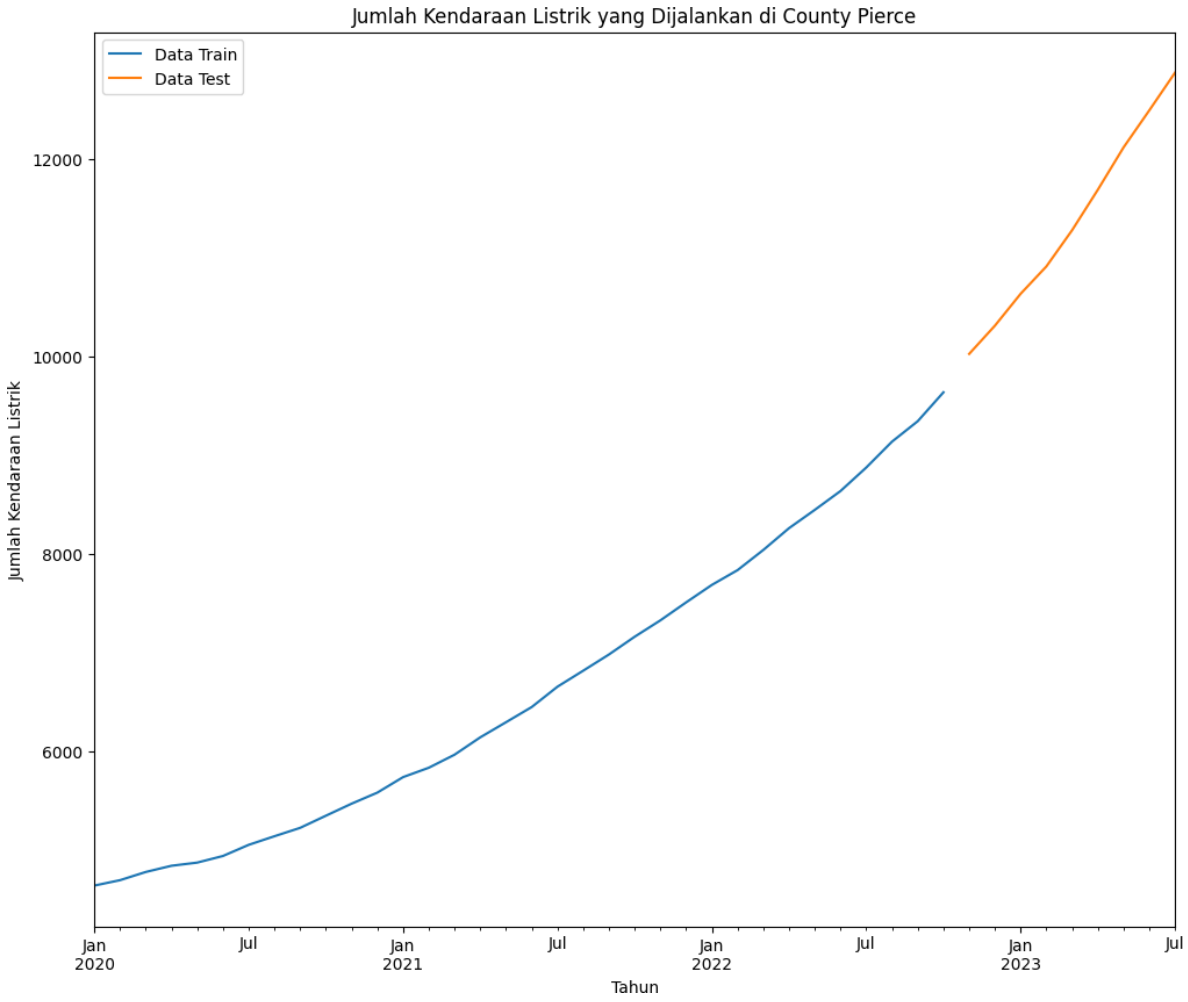


```
Mean Absolute Percentage Error: 0.1317337592944826

Mean Squared Error: 3035717.625288219

Root Mean Squared Error: 1742.3310894569433

R-squared:  0.32056266262923594
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_pierce, test_pierce = train_test_split_ts(pierce, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_pierce, test_pierce, 'Pierce')
```



In [ ]:
```
auto_model = pm.auto_arima(train_pierce, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-147.014
Date:	Fri, 25 Aug 2023	**AIC**	302.028
Time:	19:06:21	**BIC**	307.891
Sample:	01-31-2020	**HQIC**	303.972
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	15.2621	4.372	3.491	0.000	6.693	23.831
ar.L1	-0.6795	0.127	-5.356	0.000	-0.928	-0.431
ar.L2	-0.7074	0.192	-3.678	0.000	-1.084	-0.330
sigma2	544.3928	152.743	3.564	0.000	245.023	843.763

Ljung-Box (L1) (Q):	0.27	**Jarque-Bera (JB):**	0.10
Prob(Q):	0.61	**Prob(JB):**	0.95
Heteroskedasticity (H):	1.90	**Skew:**	-0.09
Prob(H) (two-sided):	0.30	**Kurtosis:**	2.79

Warnings:

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

In [ ]:

```
model = SARIMAX(train_pierce, order = (2, 2, 0),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

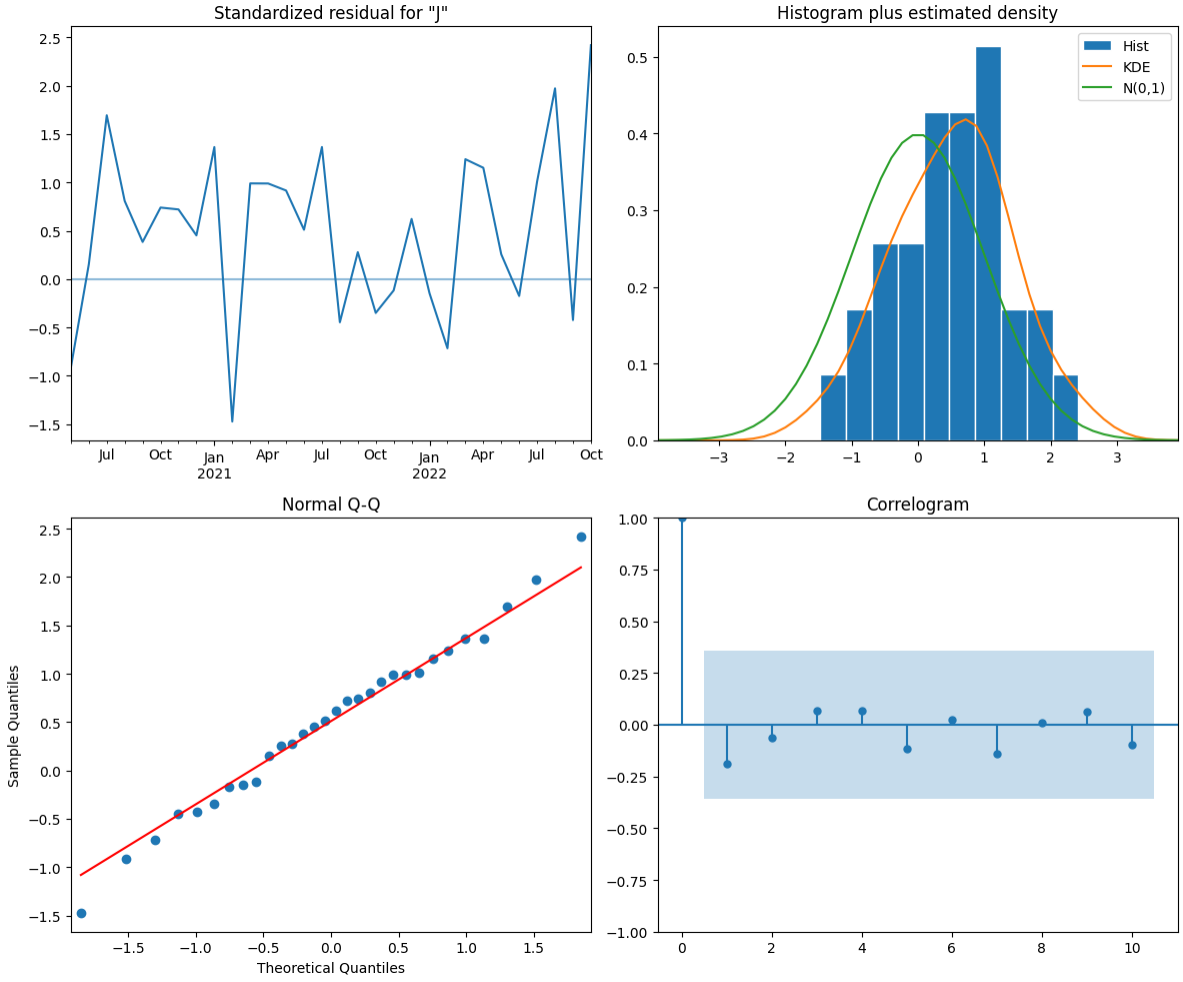
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-142.703
Date:	Fri, 25 Aug 2023	**AIC**	291.406
Time:	19:06:27	**BIC**	295.610
Sample:	01-31-2020	**HQIC**	292.751
	- 10-31-2022		
Covariance Type:	opg		

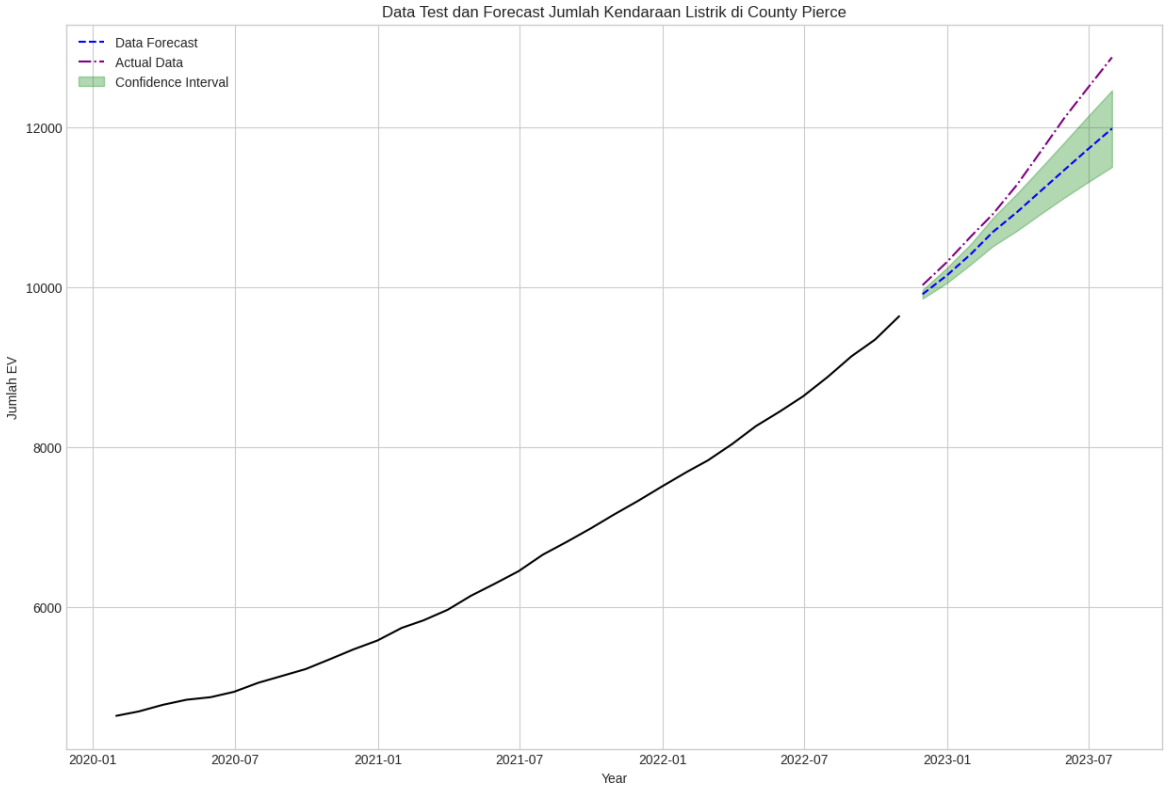
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.5928	0.148	-4.004	0.000	-0.883	-0.303
ar.L2	-0.6142	0.225	-2.727	0.006	-1.056	-0.173
sigma2	792.8681	230.653	3.437	0.001	340.797	1244.939

Ljung-Box (L1) (Q):	1.21	**Jarque-Bera (JB):**	0.08
Prob(Q):	0.27	**Prob(JB):**	0.96
Heteroskedasticity (H):	1.47	**Skew:**	-0.08
Prob(H) (two-sided):	0.55	**Kurtosis:**	2.80

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



In [ ]:
```
df_pierce_forecast = get_forecast(model, train_pierce, test_pierce, 'Pierce', plot
```



```
Mean Absolute Percentage Error: 0.0361198146992652

Mean Squared Error: 255835.62251706375

Root Mean Squared Error: 505.8019597797776

R-squared:  0.707481965976287
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(pierce, order = (2, 2, 0),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

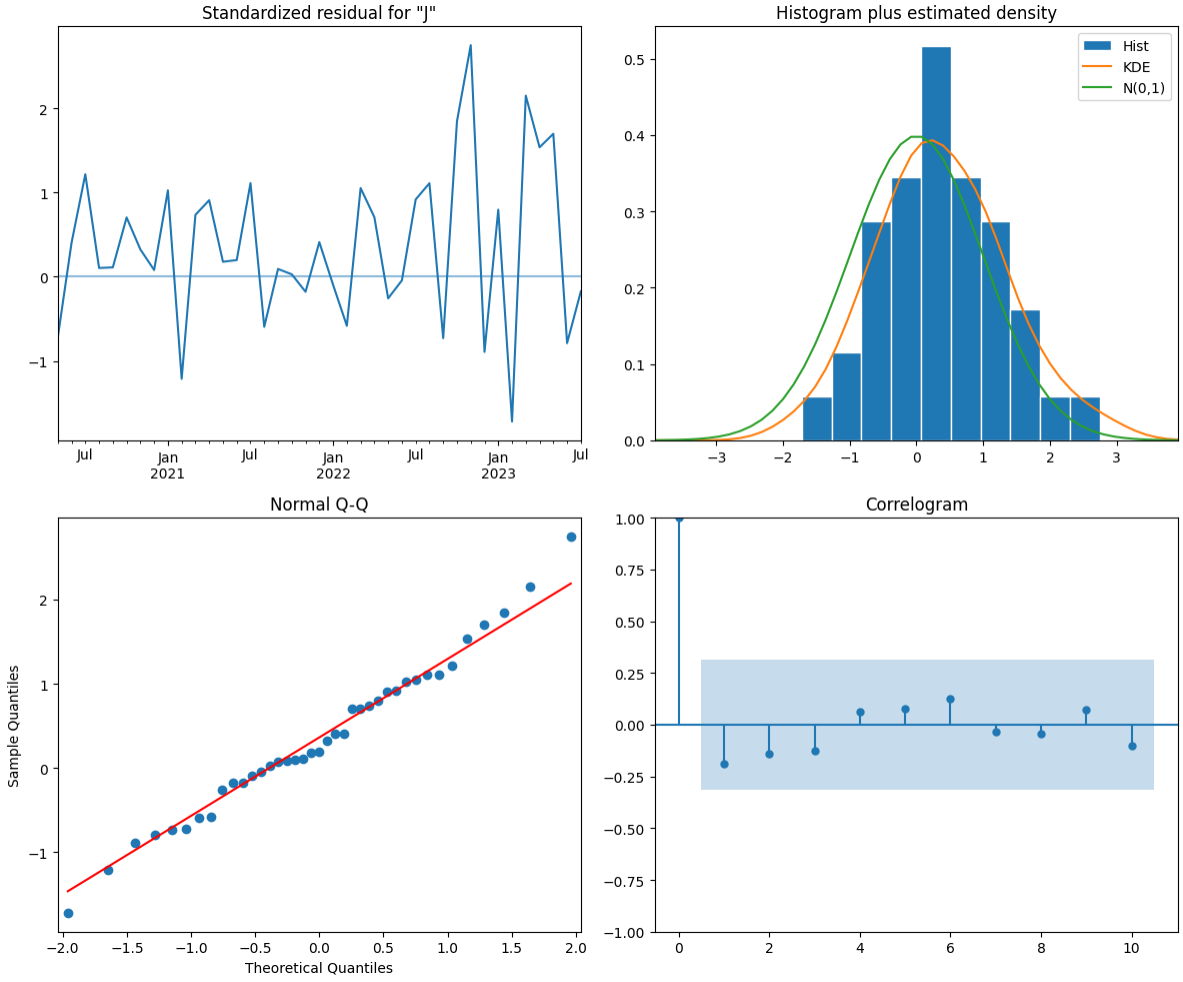
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-199.027
Date:	Fri, 25 Aug 2023	**AIC**	404.053
Time:	19:07:59	**BIC**	409.044
Sample:	01-31-2020	**HQIC**	405.844
	- 07-31-2023		
Covariance Type:	opg		

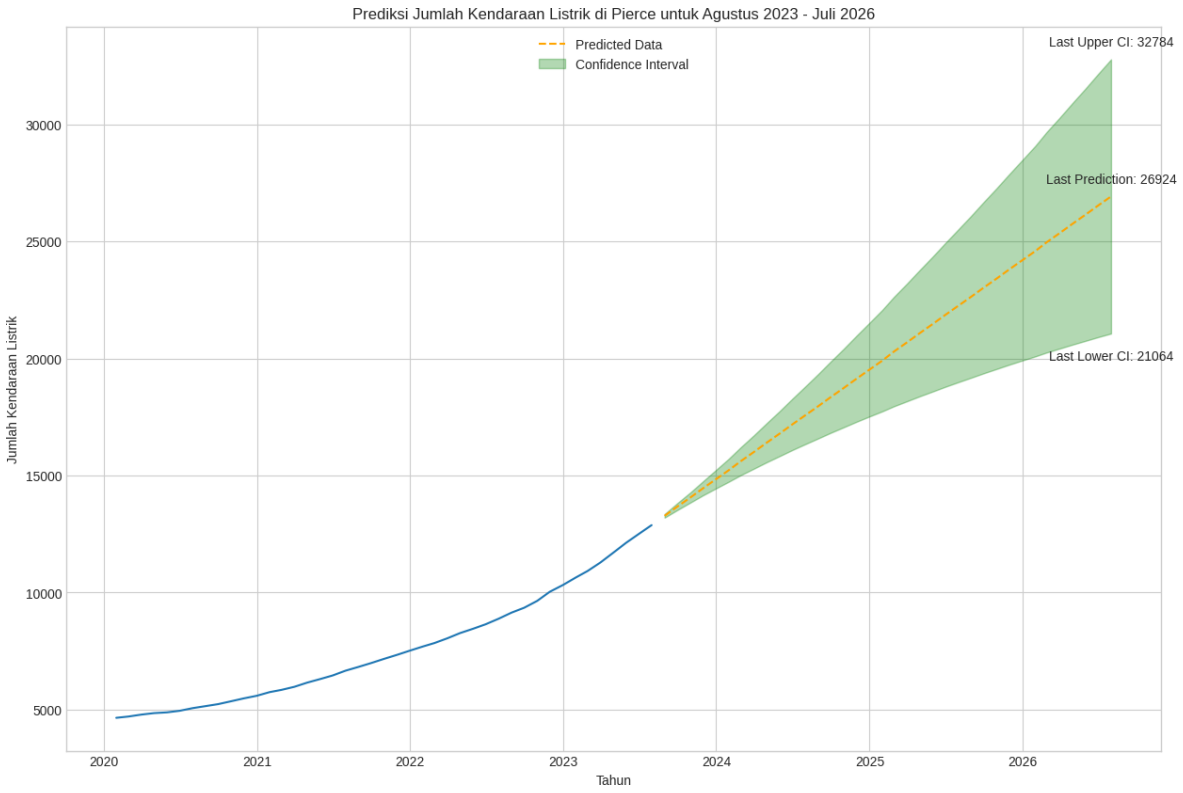
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.3836	0.138	-2.773	0.006	-0.655	-0.112
ar.L2	-0.3559	0.140	-2.543	0.011	-0.630	-0.082
sigma2	1585.4327	370.829	4.275	0.000	858.622	2312.243

Ljung-Box (L1) (Q):	1.49	**Jarque-Bera (JB):**	0.36
Prob(Q):	0.22	**Prob(JB):**	0.83
Heteroskedasticity (H):	4.25	**Skew:**	0.24
Prob(H) (two-sided):	0.01	**Kurtosis:**	3.00

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



In [ ]:
```
df_pierce_preds = get_prediction(model, pierce['Jumlah EV'], test_pierce, 'Pierce',
```



In [ ]:
```
county_information['Pierce']['Predictions'] = df_snohomish_preds
```

County Clark

Inisialisasi Dataset

In [ ]:
```
county_dfs['Clark']
```

Out[ ]:

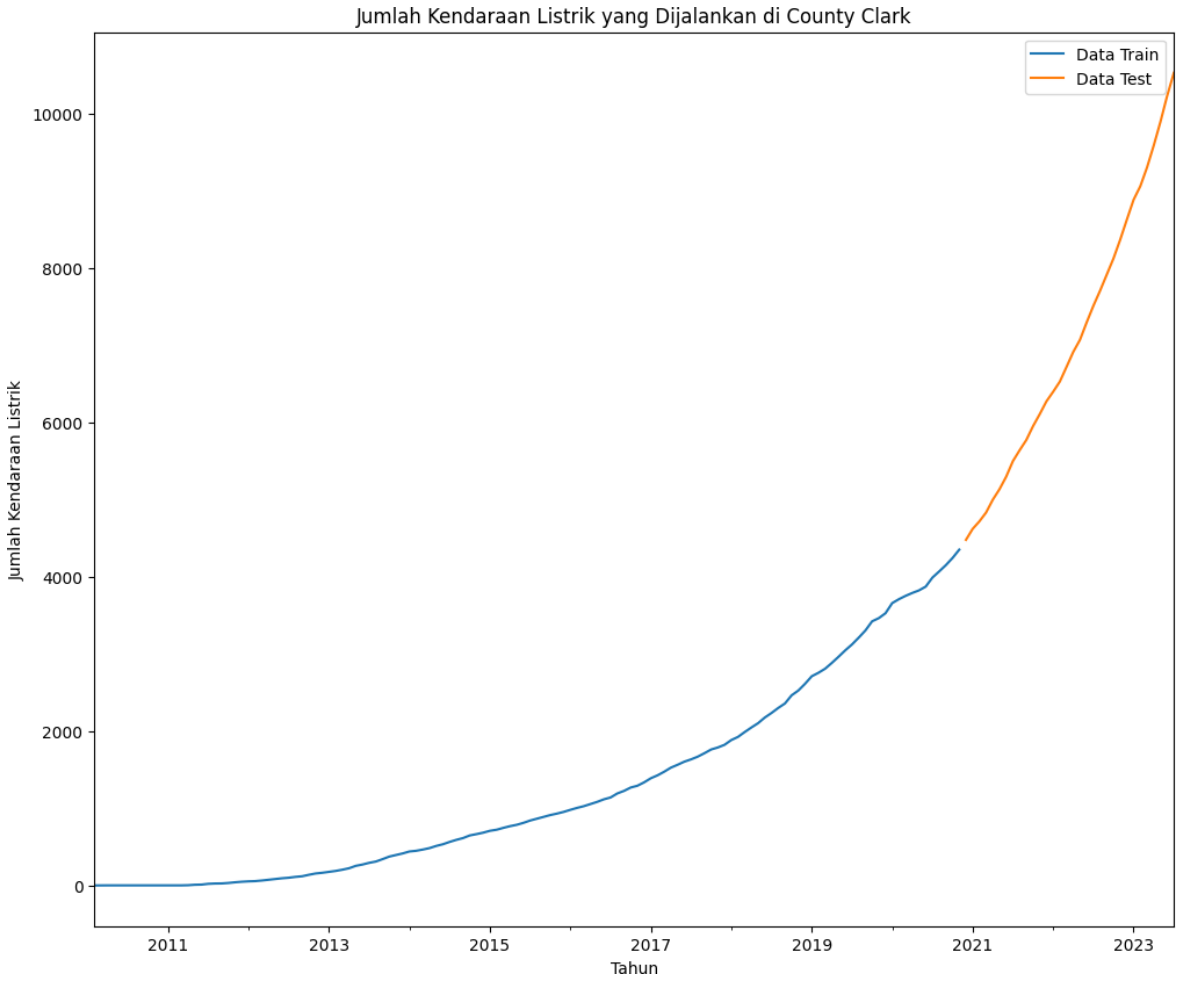
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	1.0
2010-04-30	1.0
2010-05-31	1.0
2010-06-30	1.0
...	...
2023-03-31	9305.0
2023-04-30	9589.0
2023-05-31	9896.0
2023-06-30	10232.0
2023-07-31	10531.0

162 rows × 1 columns

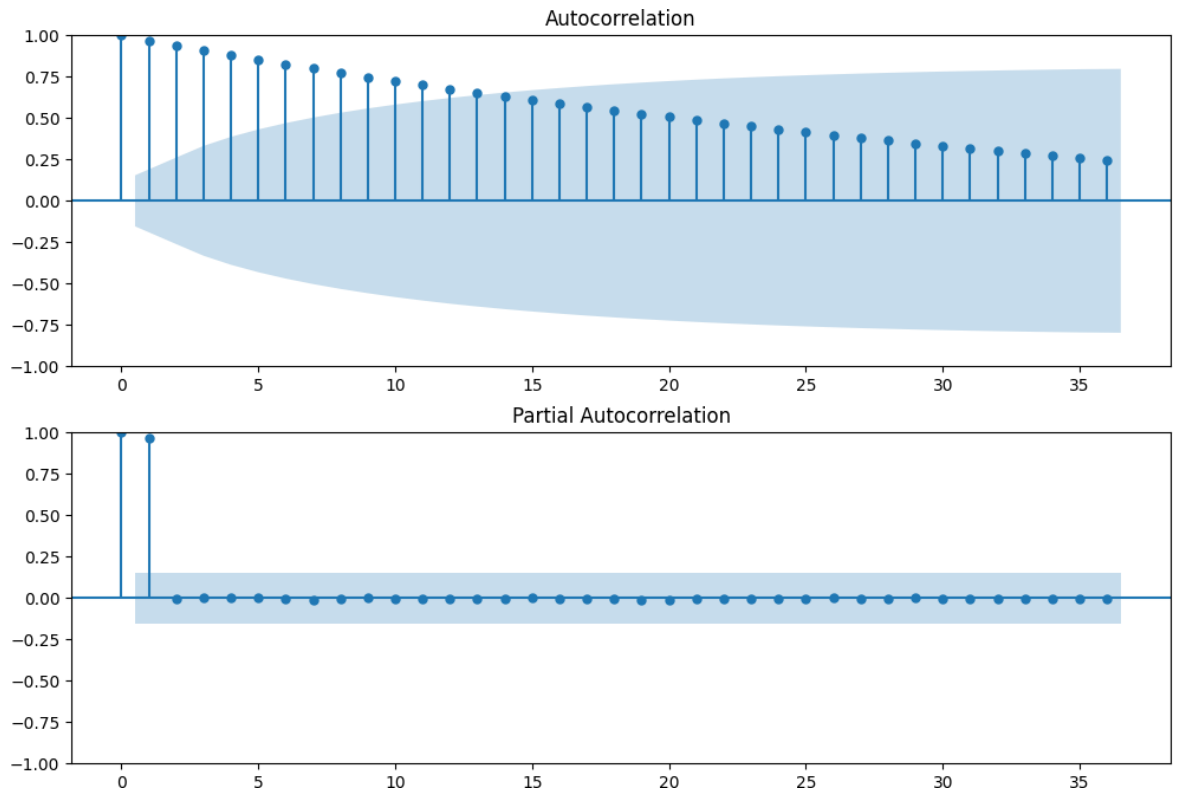
In [ ]:
```
clark = county_dfs['Clark'].copy()
clark.reset_index(inplace=True)
mask = clark['DOL Transaction Date'] >= '2020-01-31'
clark = clark[mask]

clark.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_clark, test_clark = train_test_split_ts(county_information['Clark']['df'], 0.
```

In [ ]:
```
plot_train_test_split(train_clark, test_clark, 'Clark')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['Clark']['df'], lags = 36, ax =
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['Clark']['df'], lags = 36, ax =
```



In [ ]:
```
auto_model = pm.auto_arima(train_clark, start_p = 0, start_d = 0, start_q = 0, max
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(1, 2, 1)x(1, 0, [], 12)	**Log Likelihood**	-518.259
Date:	Fri, 25 Aug 2023	**AIC**	1046.518
Time:	19:42:15	**BIC**	1060.778
Sample:	02-28-2010	**HQIC**	1052.312
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	0.2830	0.072	3.951	0.000	0.143	0.423
ar.L1	0.2898	0.072	4.000	0.000	0.148	0.432
ma.L1	-0.9568	0.030	-31.795	0.000	-1.016	-0.898
ar.S.L12	0.4032	0.071	5.688	0.000	0.264	0.542
sigma2	187.2825	16.226	11.542	0.000	155.480	219.085

Ljung-Box (L1) (Q):	0.01	**Jarque-Bera (JB):**	97.76
Prob(Q):	0.91	**Prob(JB):**	0.00
Heteroskedasticity (H):	25.80	**Skew:**	0.86
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.92

Warnings:

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

In [ ]:
```
model = SARIMAX(train_clark, order = (1, 2, 1), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

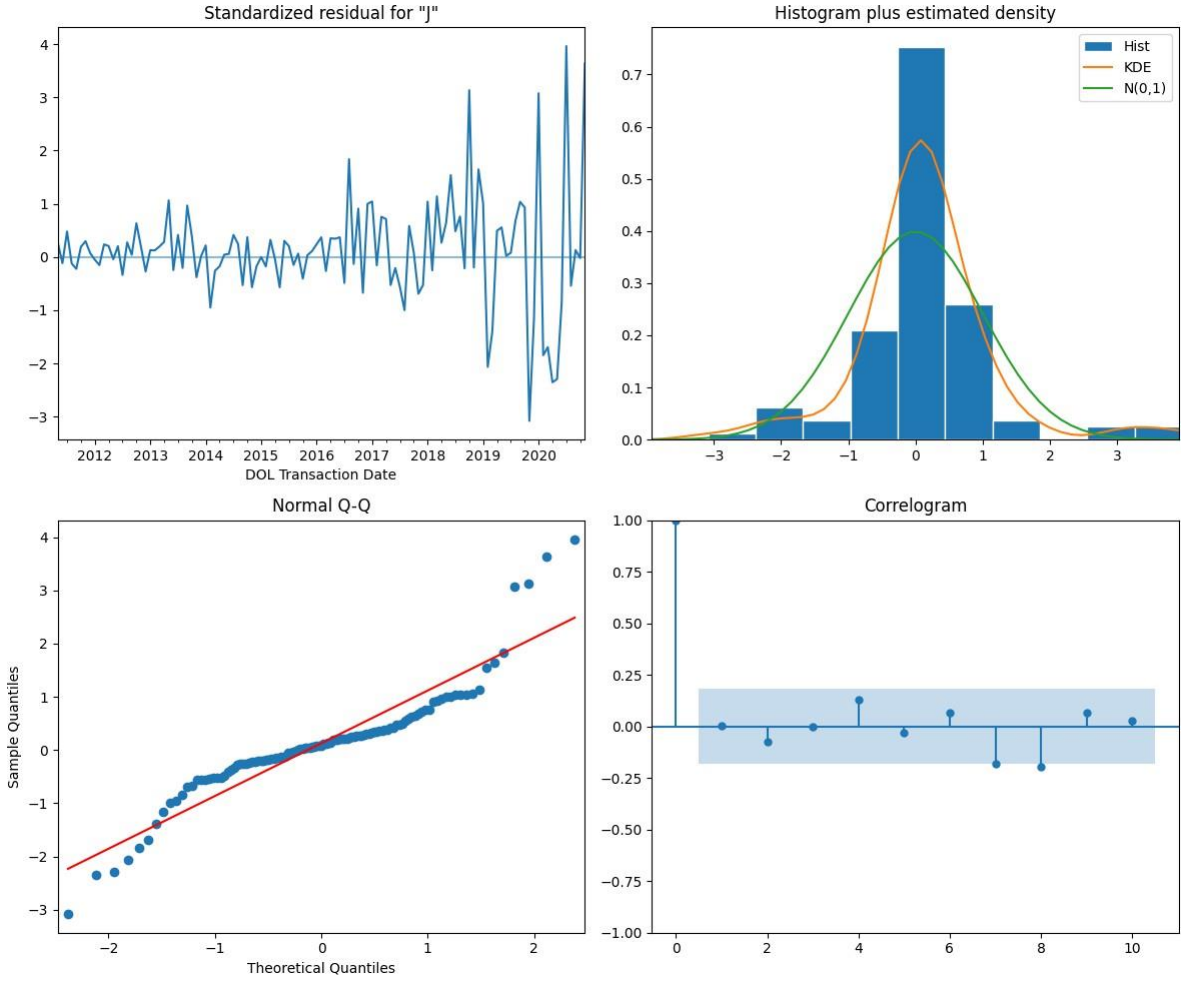
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(1, 2, 1)x(1, 0, [], 12)	**Log Likelihood**	-472.554
Date:	Fri, 25 Aug 2023	**AIC**	953.107
Time:	19:42:20	**BIC**	964.087
Sample:	02-28-2010	**HQIC**	957.564
	- 11-30-2020		
Covariance Type:	opg		

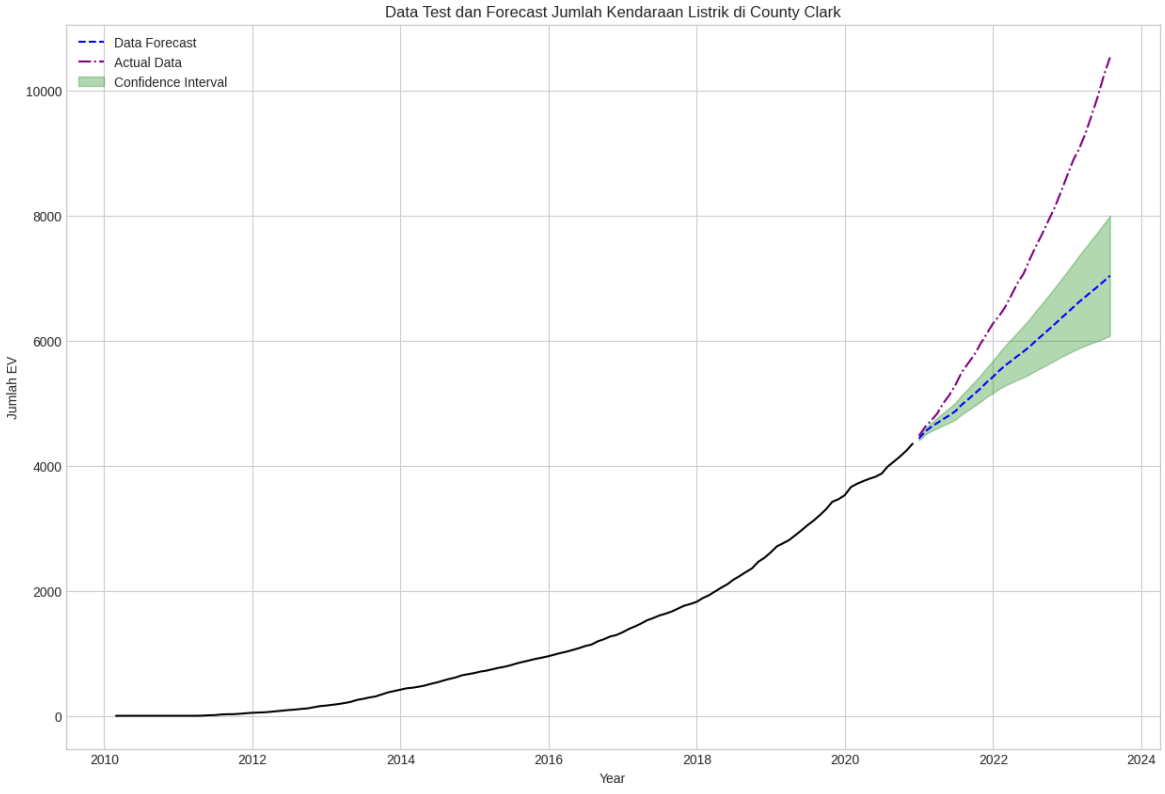
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.1833	0.113	1.626	0.104	-0.038	0.404
ma.L1	-0.8422	0.047	-18.040	0.000	-0.934	-0.751
ar.S.L12	0.4918	0.074	6.641	0.000	0.347	0.637
sigma2	215.8494	18.282	11.807	0.000	180.018	251.681

Ljung-Box (L1) (Q):	0.00	**Jarque-Bera (JB):**	90.54
Prob(Q):	0.95	**Prob(JB):**	0.00
Heteroskedasticity (H):	18.57	**Skew:**	0.64
Prob(H) (two-sided):	0.00	**Kurtosis:**	7.15

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



In [ ]:
```
df_clark_forecast = get_forecast(model, train_clark, test_clark, 'Clark', plot = T
```

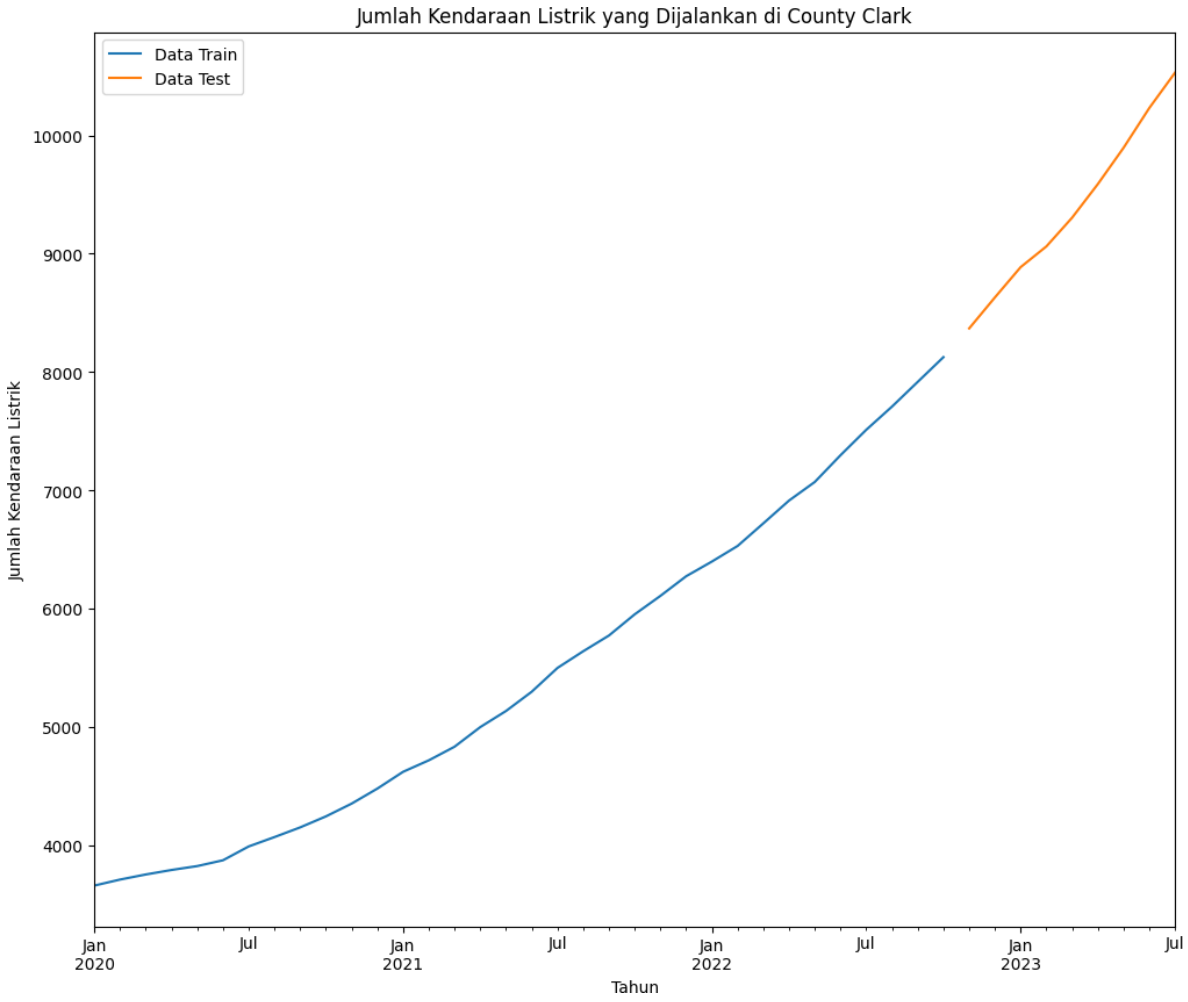


```
Mean Absolute Percentage Error: 0.16729033779917613

Mean Squared Error: 2794525.444902896

Root Mean Squared Error: 1671.6834164706236

R-squared: 0.10122202082907361
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_clark, test_clark = train_test_split_ts(clark, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_clark, test_clark, 'Clark')
```



In [ ]:
```
auto_model = pm.auto_arima(train_clark, start_p = 0, start_d = 0, start_q = 0, max
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-150.155
Date:	Fri, 25 Aug 2023	**AIC**	306.310
Time:	19:43:38	**BIC**	310.707
Sample:	01-31-2020	**HQIC**	307.768
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	5.2853	0.910	5.805	0.000	3.501	7.070
ma.L1	-0.8286	0.104	-7.929	0.000	-1.033	-0.624
sigma2	671.1752	182.912	3.669	0.000	312.674	1029.676

Ljung-Box (L1) (Q):	0.31	**Jarque-Bera (JB):**	0.25
Prob(Q):	0.58	**Prob(JB):**	0.88
Heteroskedasticity (H):	1.41	**Skew:**	0.15
Prob(H) (two-sided):	0.58	**Kurtosis:**	2.69

Warnings:

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

In [ ]:

```
model = SARIMAX(train_clark, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

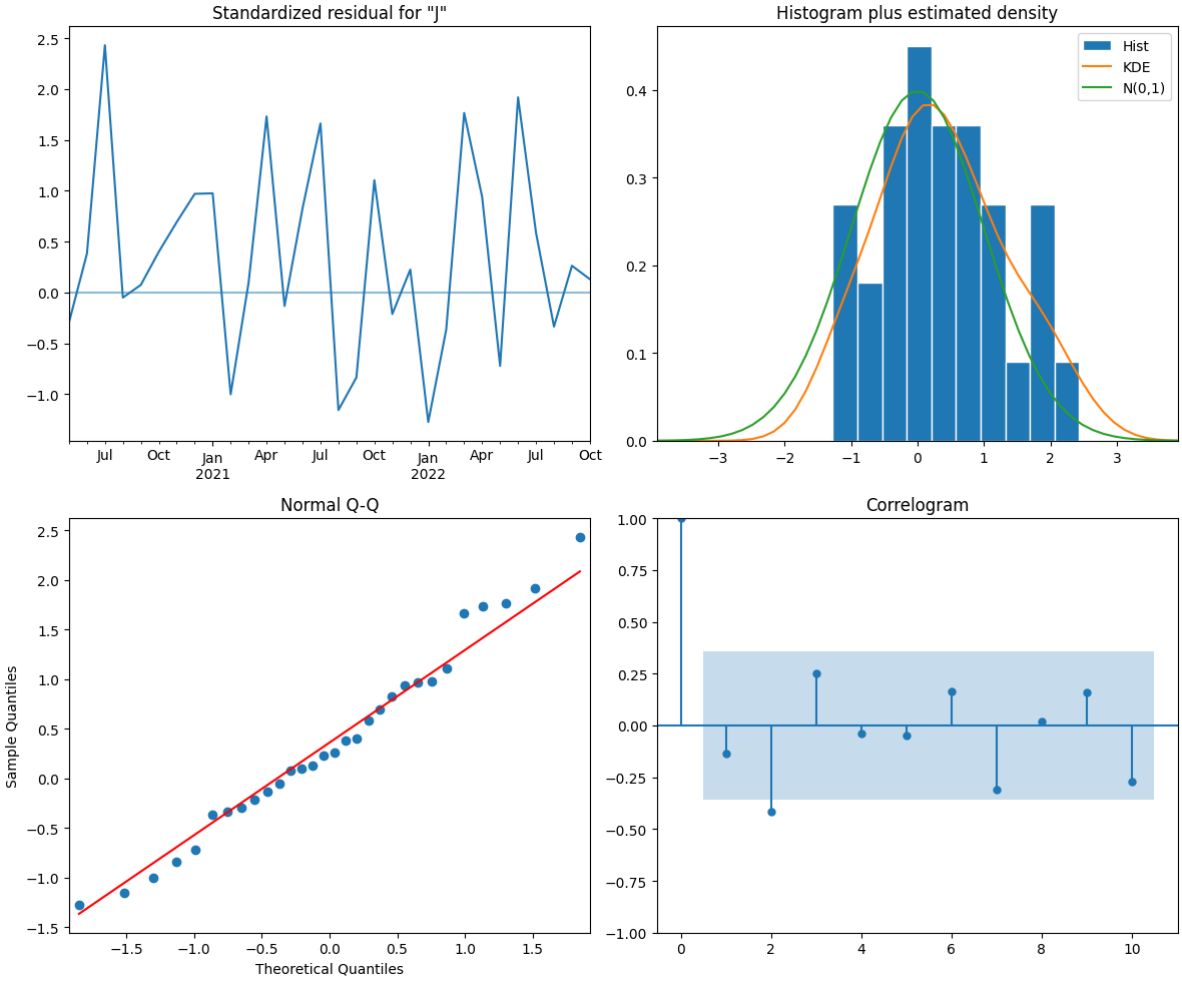
Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-144.925
Date:	Fri, 25 Aug 2023	**AIC**	293.850
Time:	19:43:42	**BIC**	296.653
Sample:	01-31-2020	**HQIC**	294.747
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.4948	0.196	-2.523	0.012	-0.879	-0.110
sigma2	919.1475	245.742	3.740	0.000	437.502	1400.793

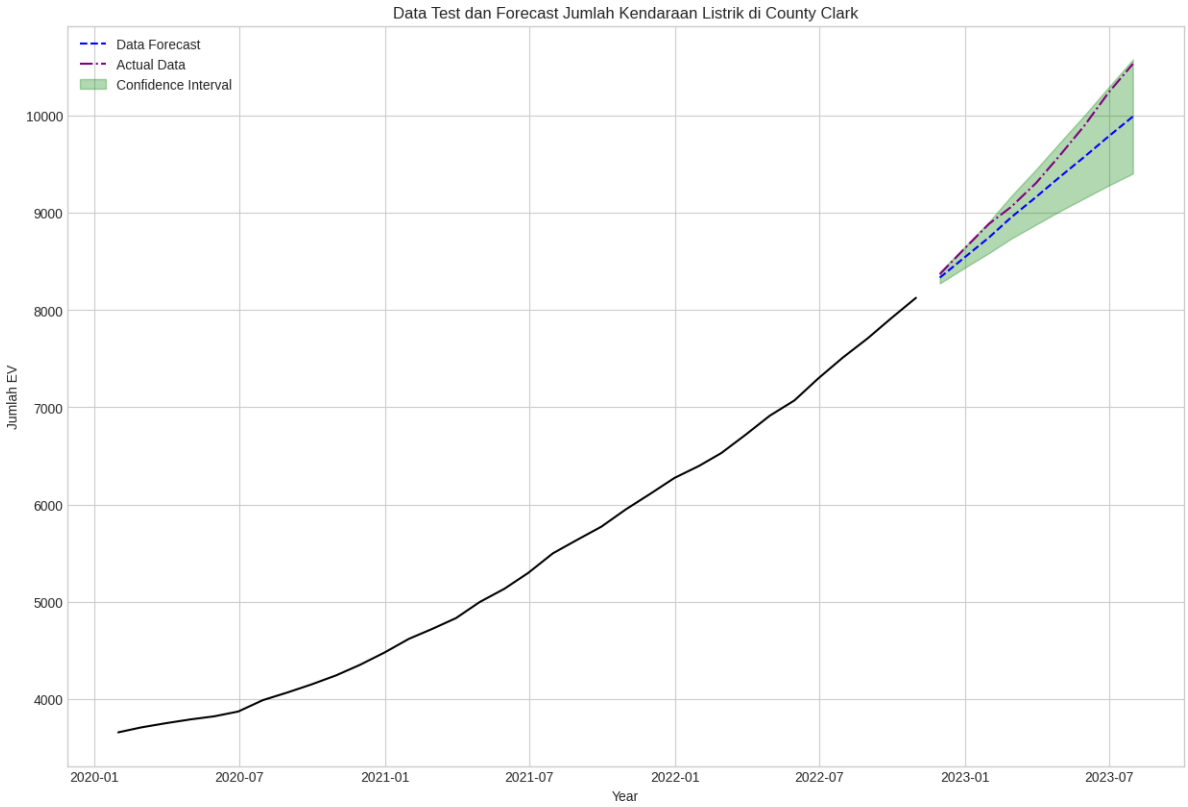
Ljung-Box (L1) (Q):	0.59	**Jarque-Bera (JB):**	0.76
Prob(Q):	0.44	**Prob(JB):**	0.68
Heteroskedasticity (H):	1.08	**Skew:**	0.27
Prob(H) (two-sided):	0.90	**Kurtosis:**	2.44

Warnings:

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



In [ ]:
```
df_clark_forecast = get_forecast(model, train_clark, test_clark, 'Clark', plot = T
```




```
Mean Absolute Percentage Error: 0.023186308879907122

Mean Squared Error: 78694.79298330103

Root Mean Squared Error: 280.5259221236088

R-squared: 0.835014284290971
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(clark, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

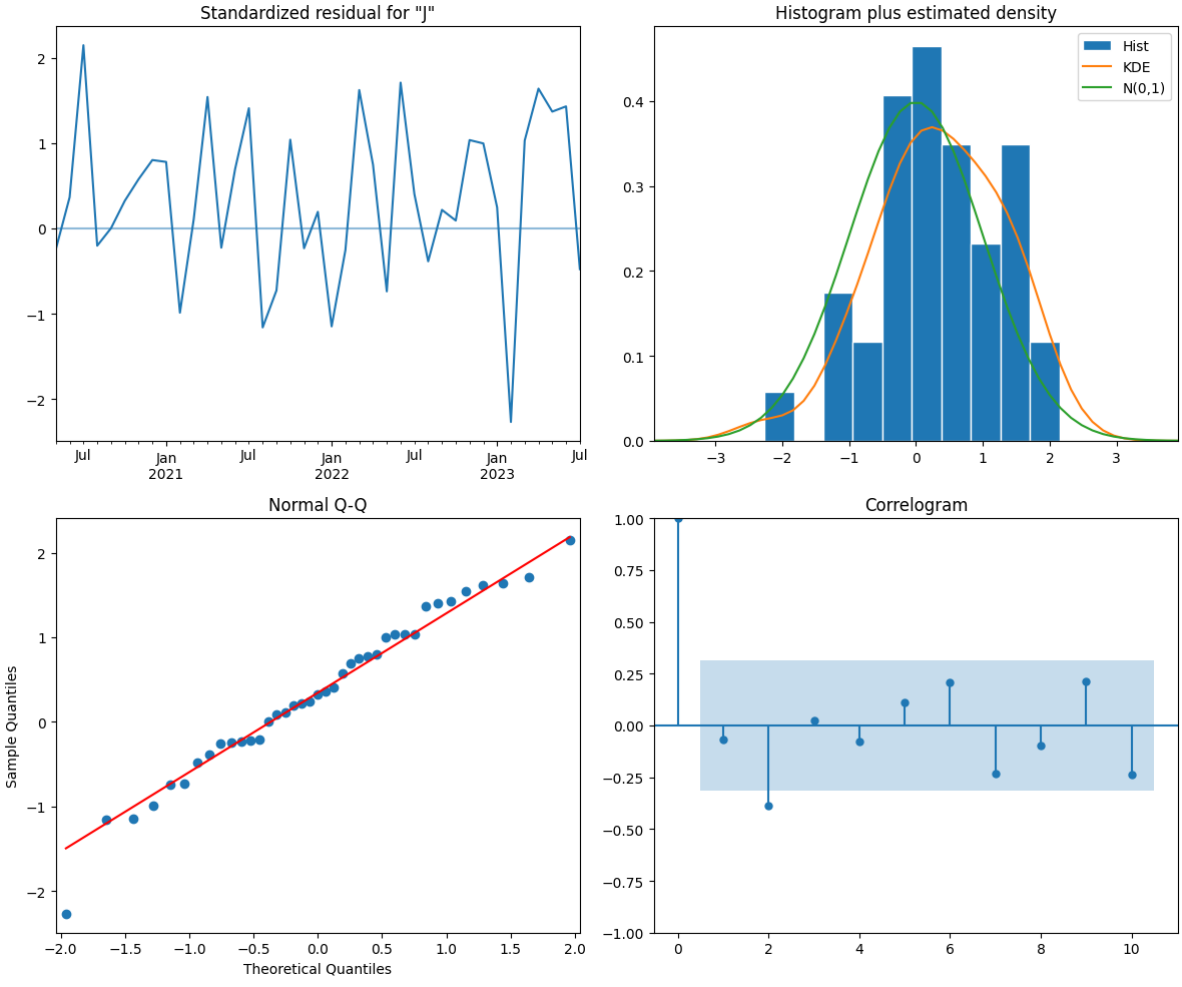
Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-193.028
Date:	Fri, 25 Aug 2023	**AIC**	390.055
Time:	19:44:44	**BIC**	393.383
Sample:	01-31-2020	**HQIC**	391.249
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.4241	0.160	-2.655	0.008	-0.737	-0.111
sigma2	1165.4466	302.466	3.853	0.000	572.624	1758.270

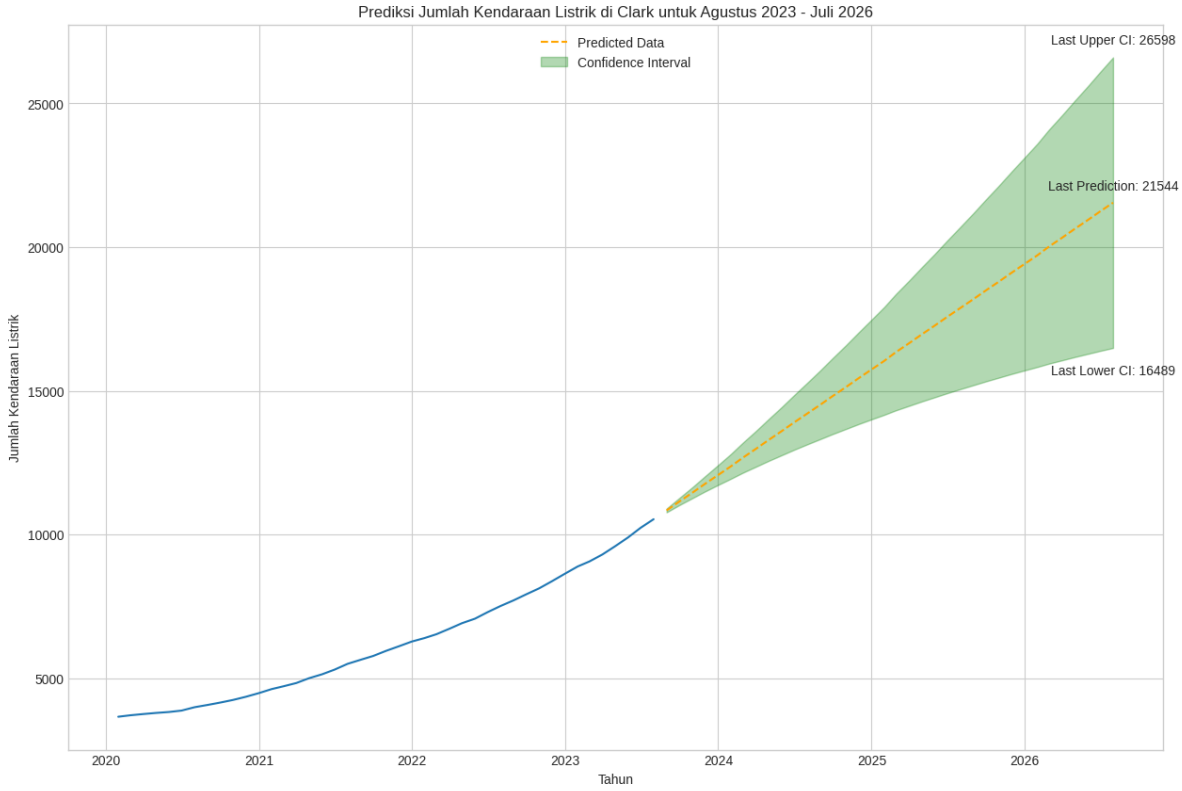
Ljung-Box (L1) (Q):	0.20	**Jarque-Bera (JB):**	0.90
Prob(Q):	0.66	**Prob(JB):**	0.64
Heteroskedasticity (H):	1.56	**Skew:**	-0.37
Prob(H) (two-sided):	0.43	**Kurtosis:**	2.98

Warnings:

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



In [ ]:
```
df_clark_preds = get_prediction(model, clark['Jumlah EV'], test_clark, 'Clark', pl
```



In [ ]:
```
county_information['Clark']['Predictions'] = df_clark_preds
```

County Thurston

Inisialisasi Dataset

In [ ]:
```
county_dfs['Thurston']
```

Out[ ]:

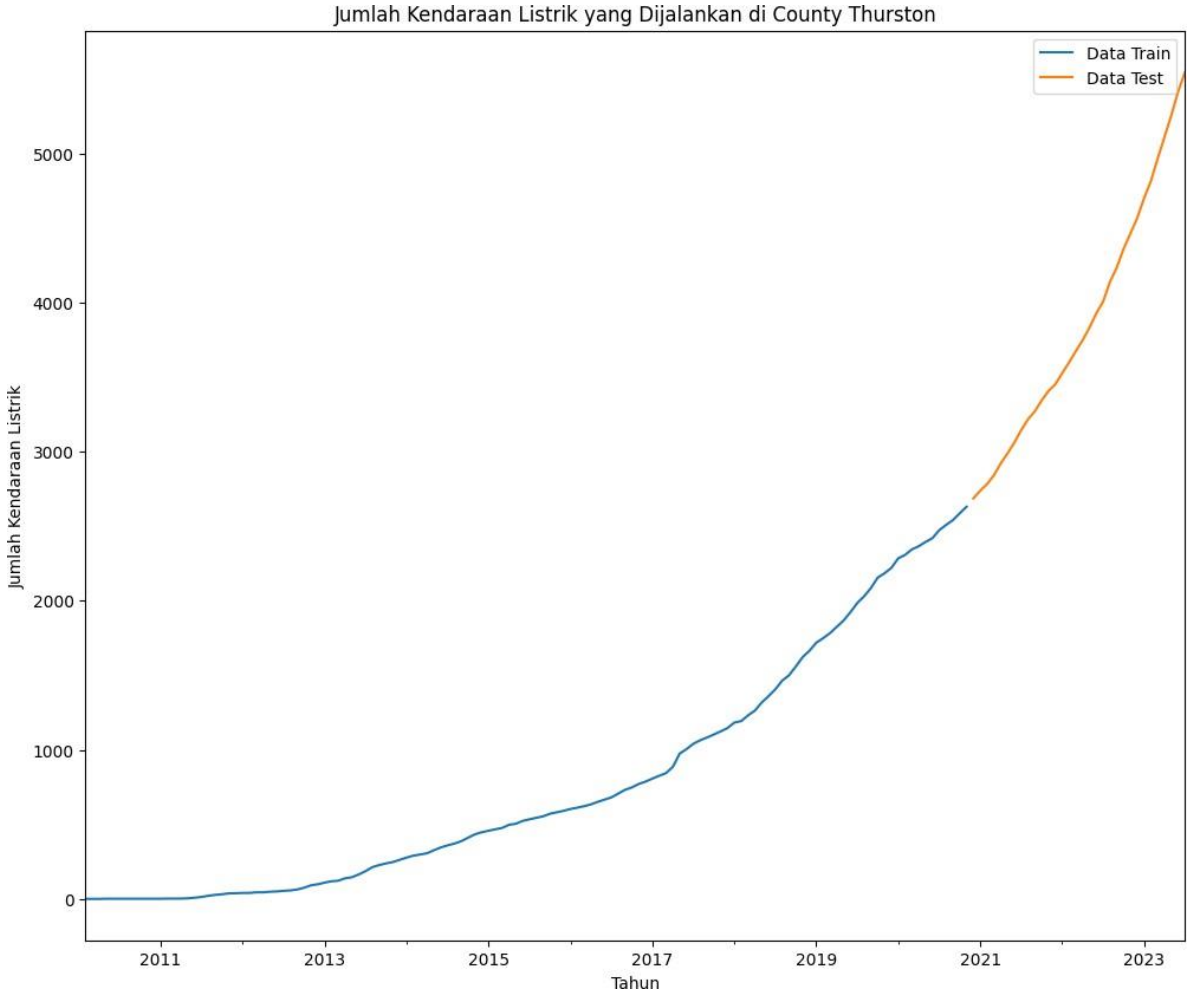
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	0.0
2010-05-31	1.0
2010-06-30	1.0
...	...
2023-03-31	4970.0
2023-04-30	5114.0
2023-05-31	5260.0
2023-06-30	5420.0
2023-07-31	5548.0

162 rows × 1 columns

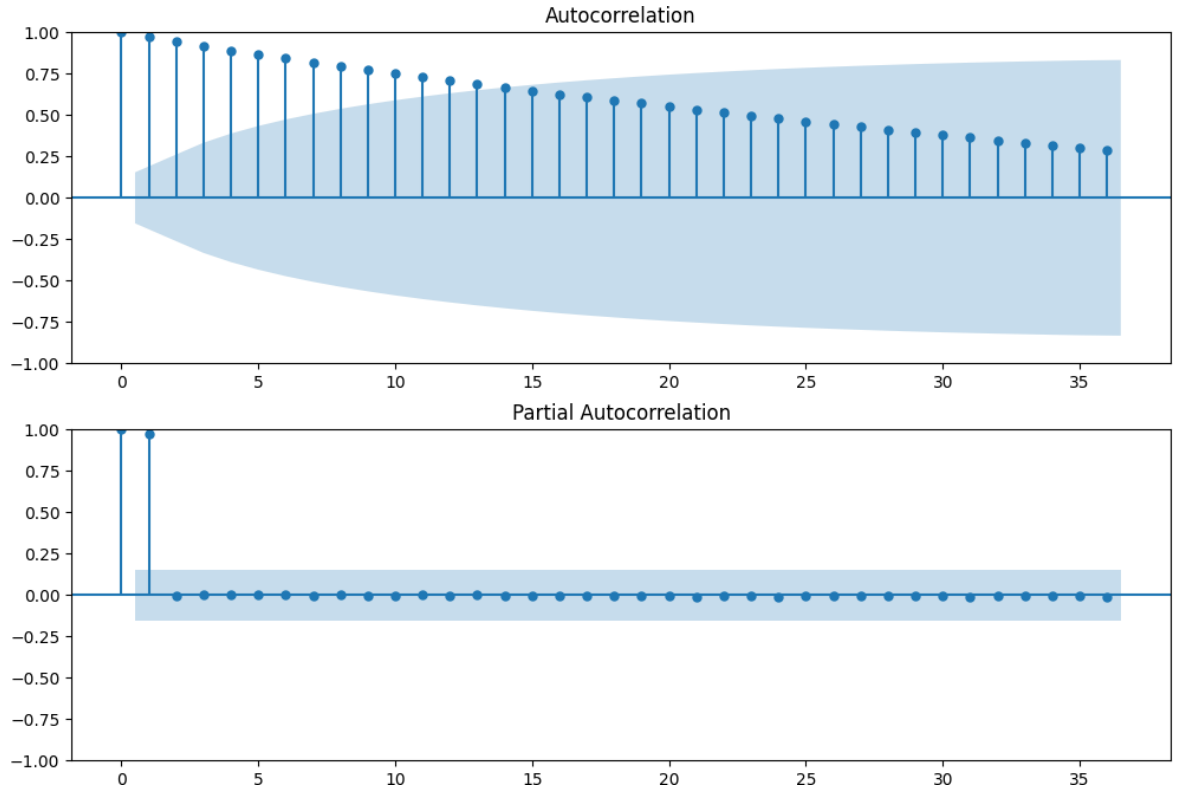
In [ ]:
```
thurston = county_dfs['Thurston'].copy()
thurston.reset_index(inplace=True)
mask = thurston['DOL Transaction Date'] >= '2020-01-31'
thurston = thurston[mask]

thurston.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_thurston, test_thurston = train_test_split_ts(county_information['Thurston'][
```

In [ ]:
```
plot_train_test_split(train_thurston, test_thurston, 'Thurston')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['Thurston']['df'], lags = 36, ax
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['Thurston']['df'], lags = 36, a
```



In [ ]:
```
auto_model = pm.auto_arima(train_thurston, start_p = 0, start_d = 0, start_q = 0,
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)x(1, 0, [], 12)	**Log Likelihood**	-482.512
Date:	Fri, 25 Aug 2023	**AIC**	971.024
Time:	09:50:57	**BIC**	979.580
Sample:	02-28-2010	**HQIC**	974.501
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7002	0.048	-14.556	0.000	-0.794	-0.606
ar.S.L12	0.1690	0.075	2.266	0.023	0.023	0.315
sigma2	109.2175	6.718	16.259	0.000	96.051	122.384

Ljung-Box (L1) (Q):	0.23	**Jarque-Bera (JB):**	436.31
Prob(Q):	0.63	**Prob(JB):**	0.00
Heteroskedasticity (H):	13.96	**Skew:**	1.38
Prob(H) (two-sided):	0.00	**Kurtosis:**	11.62

Warnings:

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

In [ ]:
```
model = SARIMAX(train_thurston, order = (0, 2, 1), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

SARIMAX Results

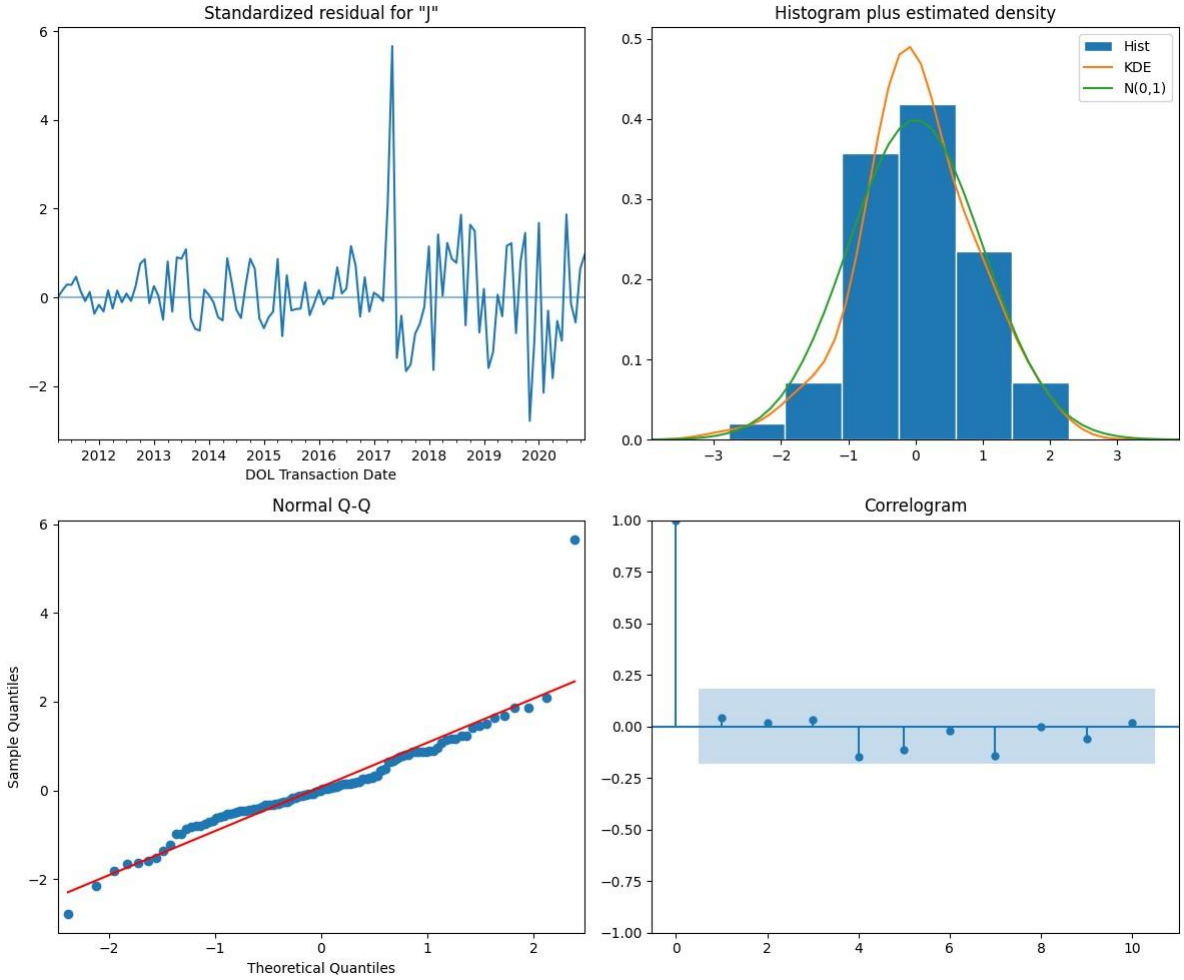
Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)x(1, 0, [], 12)	**Log Likelihood**	-442.812
Date:	Fri, 25 Aug 2023	**AIC**	891.624
Time:	19:46:23	**BIC**	899.885
Sample:	02-28-2010	**HQIC**	894.978
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7016	0.053	-13.189	0.000	-0.806	-0.597
ar.S.L12	0.1878	0.084	2.223	0.026	0.022	0.353
sigma2	120.4280	8.226	14.640	0.000	104.305	136.551

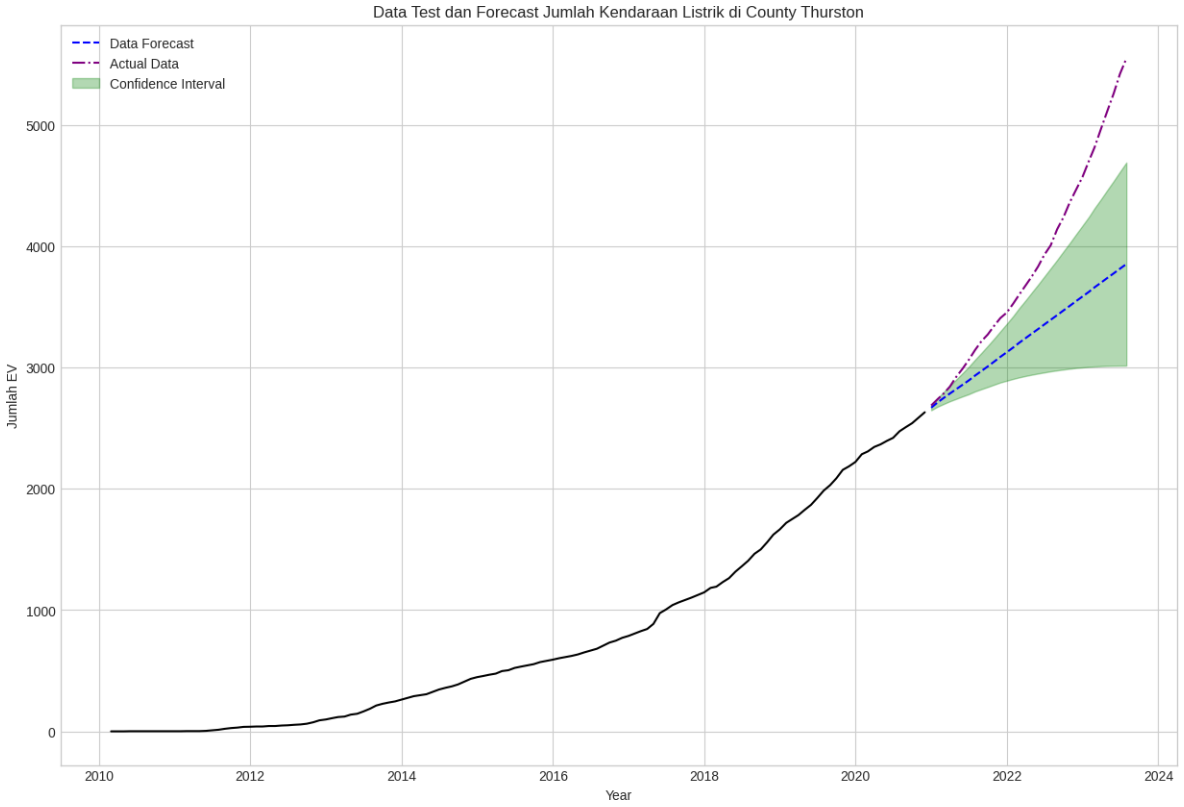
Ljung-Box (L1) (Q):	0.22	**Jarque-Bera (JB):**	302.63
Prob(Q):	0.64	**Prob(JB):**	0.00
Heteroskedasticity (H):	6.64	**Skew:**	1.29
Prob(H) (two-sided):	0.00	**Kurtosis:**	10.48

Warnings:

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



In [ ]:
```
df_thurston_forecast = get_forecast(model, train_thurston, test_thurston, 'Thurston
```

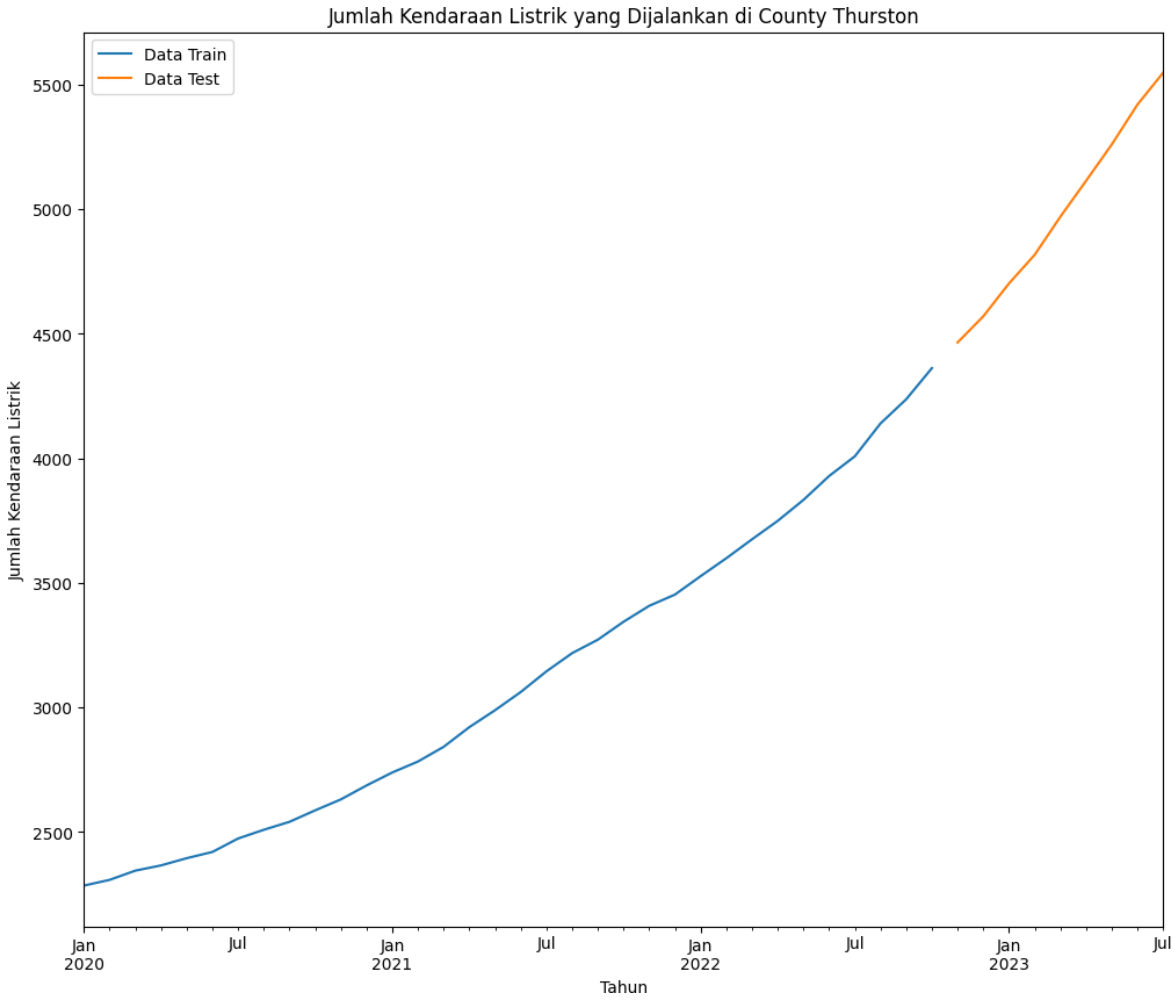


```
Mean Absolute Percentage Error: 0.13816395292108716

Mean Squared Error: 609168.1808653686

Root Mean Squared Error: 780.4922682931385

R-squared:  0.12495745736319219
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_thurston, test_thurston = train_test_split_ts(thurston, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_thurston, test_thurston, 'Thurston')
```



In [ ]:
```
auto_model = pm.auto_arima(train_thurston, start_p = 0, start_d = 0, start_q = 0,
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-128.258
Date:	Fri, 25 Aug 2023	**AIC**	264.515
Time:	09:51:09	**BIC**	270.378
Sample:	01-31-2020	**HQIC**	266.459
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	6.1450	3.207	1.916	0.055	-0.141	12.431
ar.L1	-0.8111	0.305	-2.663	0.008	-1.408	-0.214
ar.L2	-0.3394	0.330	-1.028	0.304	-0.986	0.308
sigma2	173.5791	39.268	4.420	0.000	96.616	250.542

Ljung-Box (L1) (Q):	0.06	**Jarque-Bera (JB):**	2.04
Prob(Q):	0.81	**Prob(JB):**	0.36
Heteroskedasticity (H):	2.33	**Skew:**	0.37
Prob(H) (two-sided):	0.18	**Kurtosis:**	3.99

Warnings:

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

In [ ]:

```
model = SARIMAX(train_thurston, order = (2, 2, 0),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

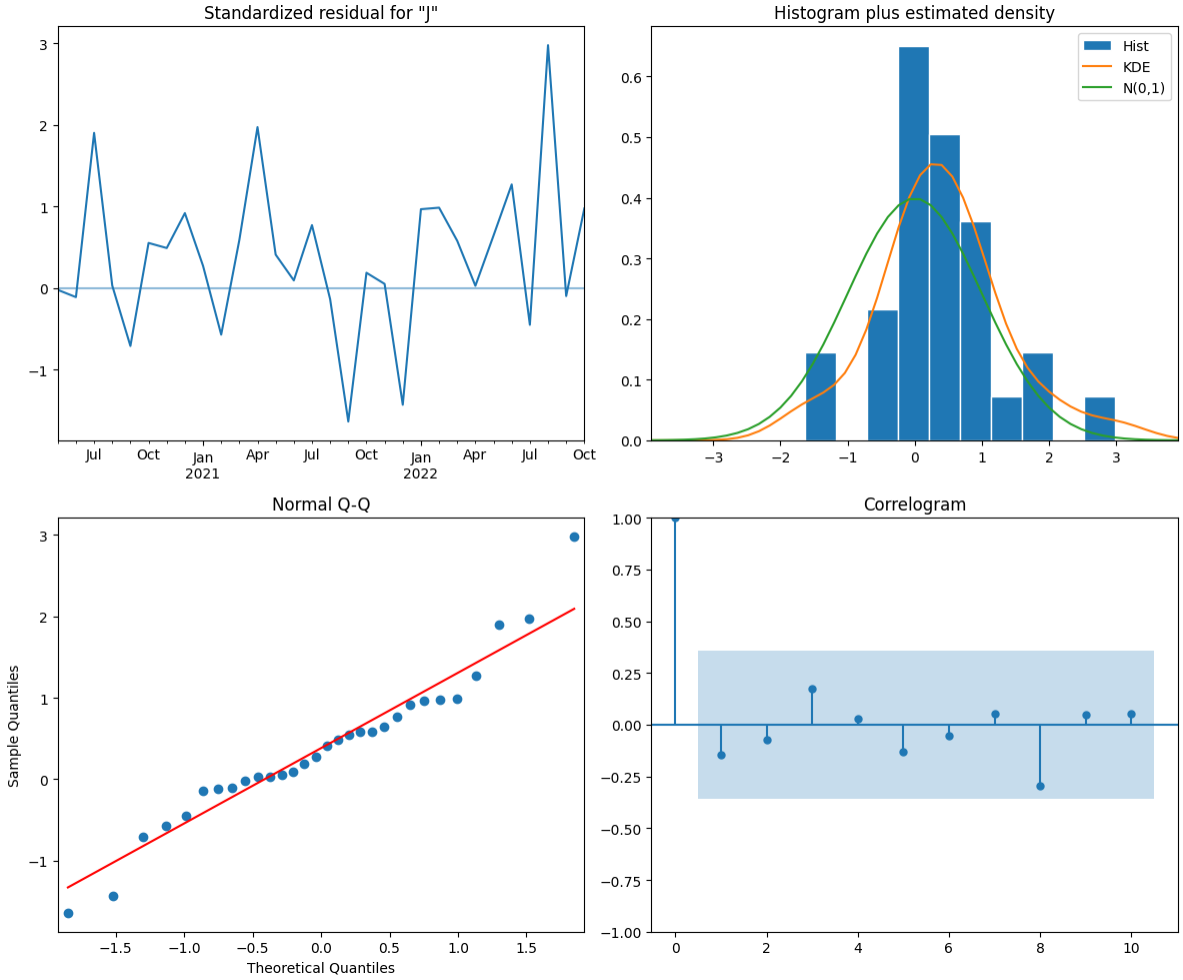
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-123.066
Date:	Fri, 25 Aug 2023	**AIC**	252.132
Time:	19:47:31	**BIC**	256.335
Sample:	01-31-2020	**HQIC**	253.476
	- 10-31-2022		
Covariance Type:	opg		

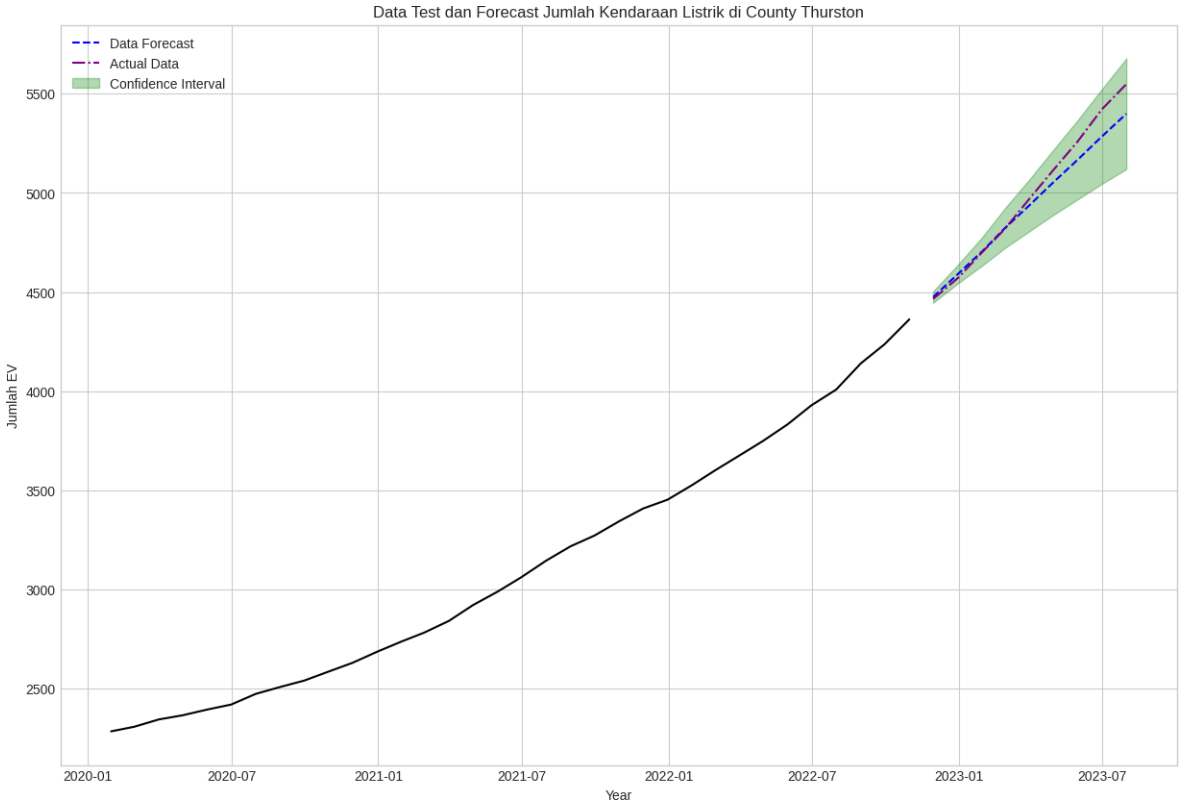
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6977	0.297	-2.352	0.019	-1.279	-0.116
ar.L2	-0.2016	0.285	-0.706	0.480	-0.761	0.358
sigma2	214.1138	46.921	4.563	0.000	122.150	306.078

Ljung-Box (L1) (Q):	0.71	**Jarque-Bera (JB):**	2.10
Prob(Q):	0.40	**Prob(JB):**	0.35
Heteroskedasticity (H):	2.41	**Skew:**	0.38
Prob(H) (two-sided):	0.18	**Kurtosis:**	4.05

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



In [ ]:
```
df_thurston_forecast = get_forecast(model, train_thurston, test_thurston, 'Thurston
```



```
Mean Absolute Percentage Error: 0.010754101411773128

Mean Squared Error: 6118.102921225692

Root Mean Squared Error: 78.21830298098835

R-squared: 0.9521034881758056
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(thurston, order = (2, 2, 0),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

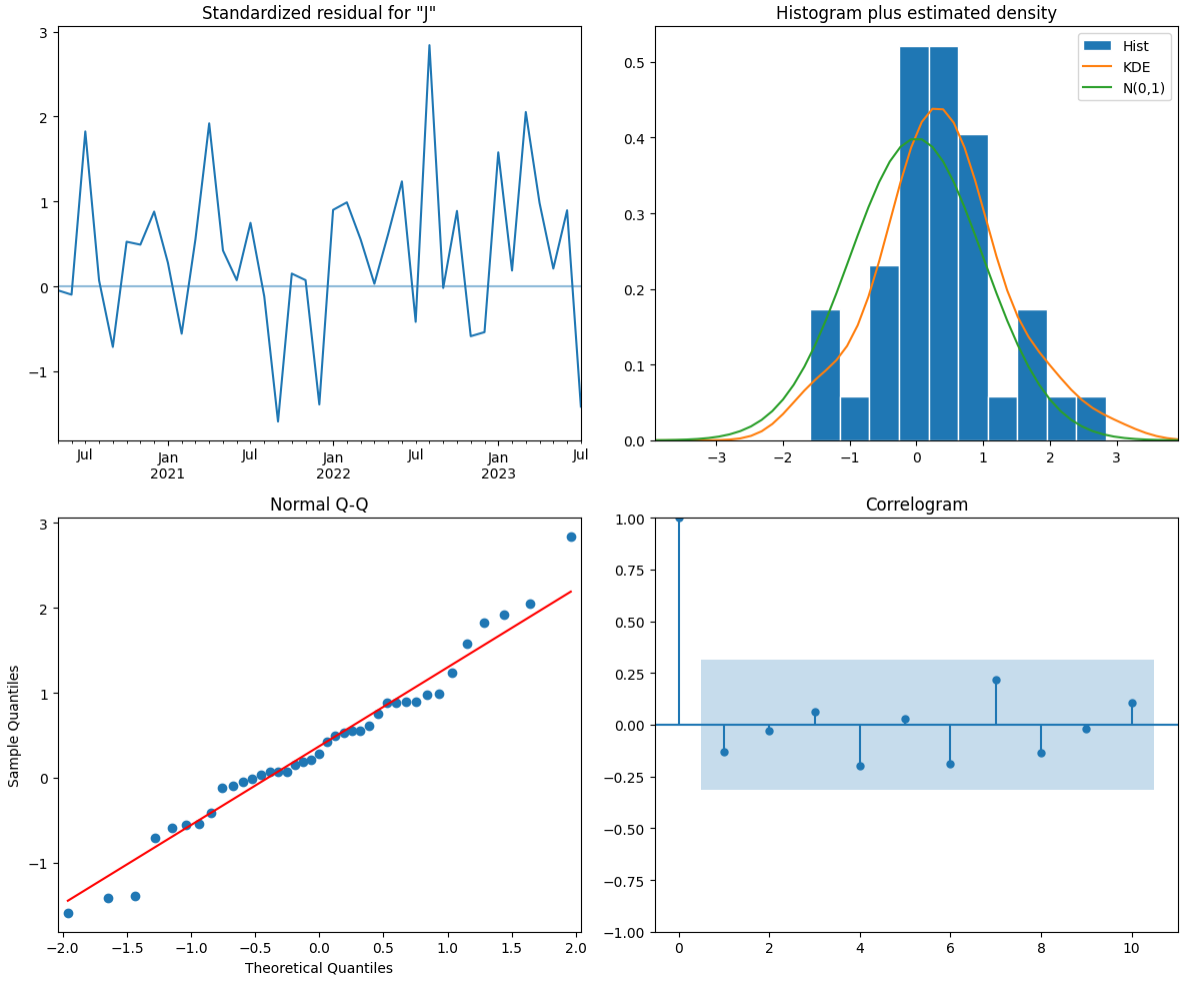
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(2, 2, 0)	**Log Likelihood**	-161.477
Date:	Fri, 25 Aug 2023	**AIC**	328.954
Time:	19:48:38	**BIC**	333.944
Sample:	01-31-2020	**HQIC**	330.744
	- 07-31-2023		
Covariance Type:	opg		

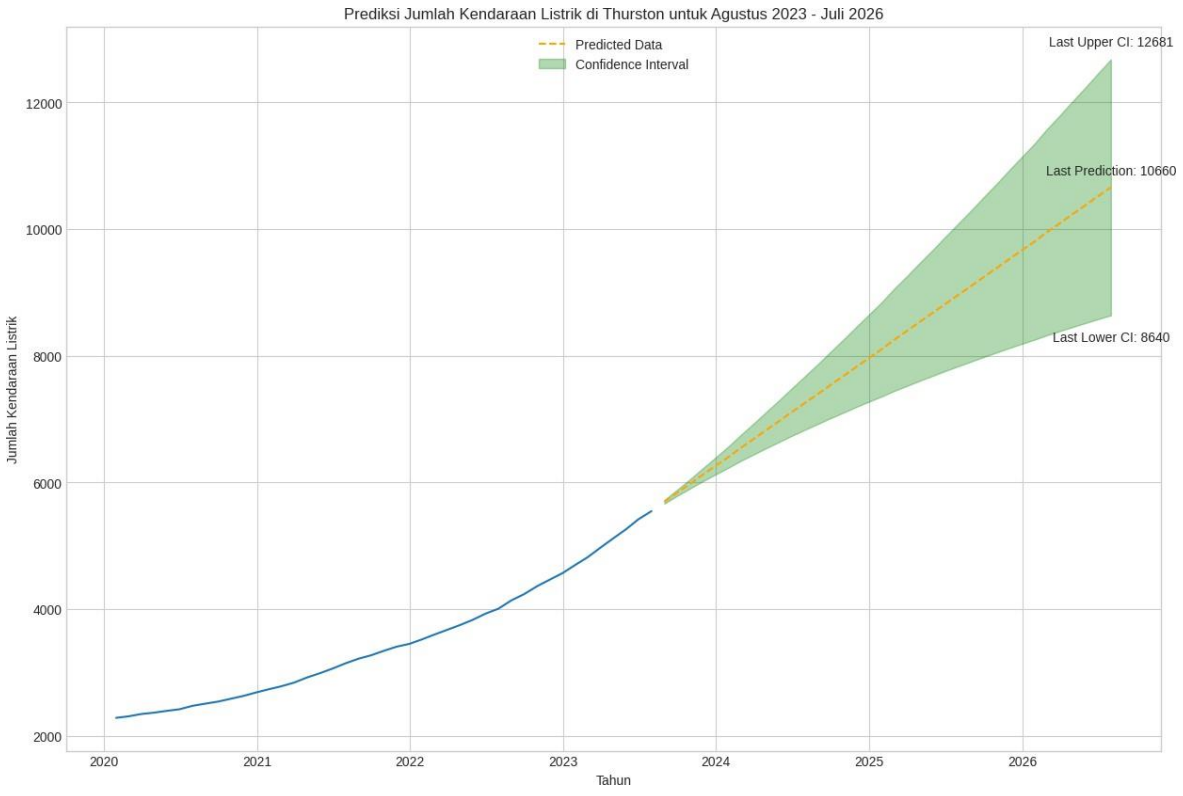
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.7202	0.247	-2.911	0.004	-1.205	-0.235
ar.L2	-0.2021	0.218	-0.927	0.354	-0.629	0.225
sigma2	231.1308	50.845	4.546	0.000	131.477	330.785

Ljung-Box (L1) (Q):	0.70	**Jarque-Bera (JB):**	0.51
Prob(Q):	0.40	**Prob(JB):**	0.77
Heteroskedasticity (H):	2.08	**Skew:**	0.21
Prob(H) (two-sided):	0.20	**Kurtosis:**	3.37

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



In [ ]:
```
df_thurston_preds = get_prediction(model, thurston['Jumlah EV'], test_thurston, 'Th
```



In [ ]:
```
county_information['Thurston']['Predictions'] = df_thurston_preds
```

County Kitsap

Inisialisasi Dataset

In [ ]:
```
county_dfs['Kitsap']
```

Out[ ]:

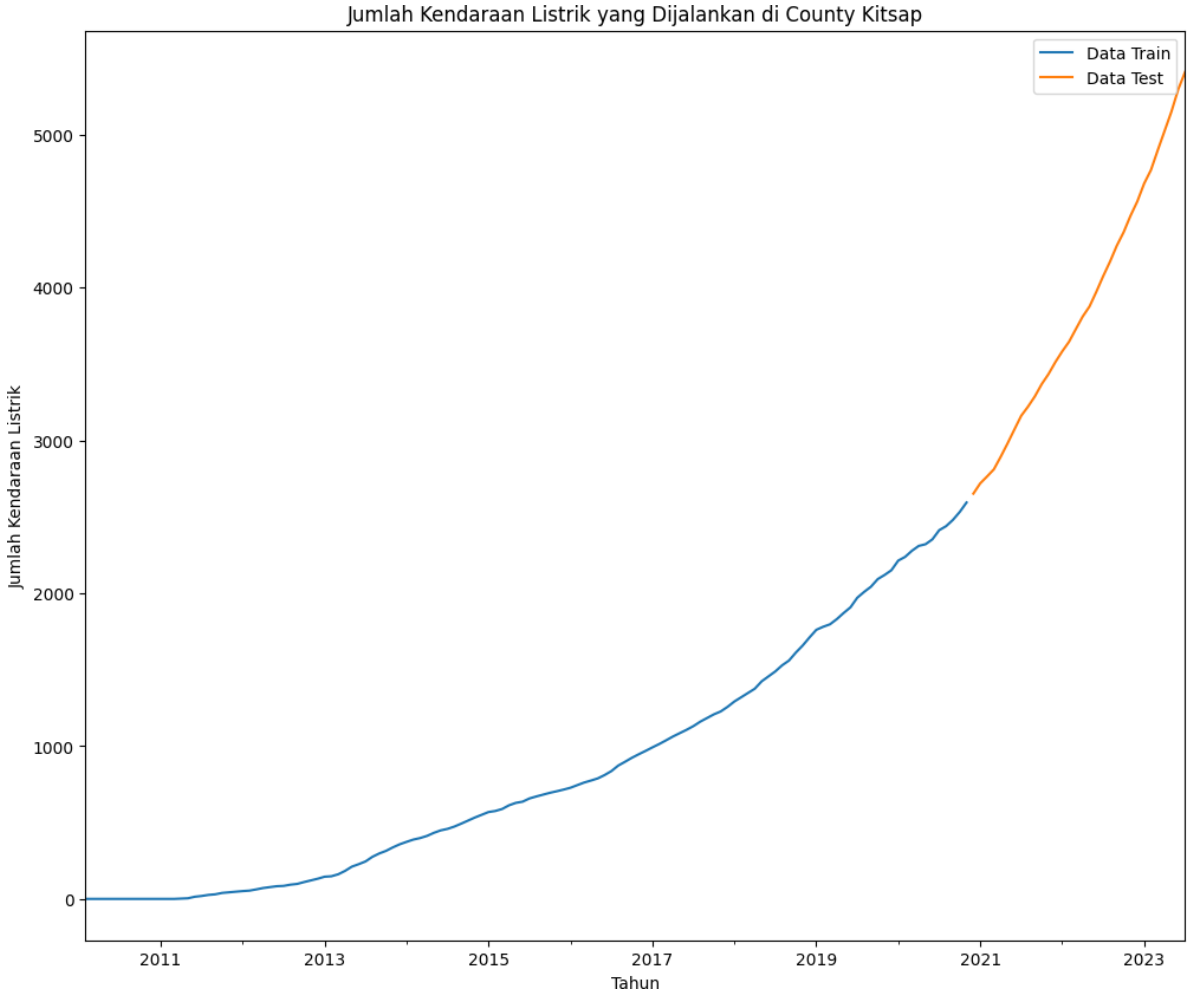
DOL Transaction Date	Jumlah EV
2010-02-28	1
2010-03-31	1
2010-04-30	1
2010-05-31	1
2010-06-30	1
...	...
2023-03-31	4899
2023-04-30	5025
2023-05-31	5151
2023-06-30	5297
2023-07-31	5410

162 rows × 1 columns

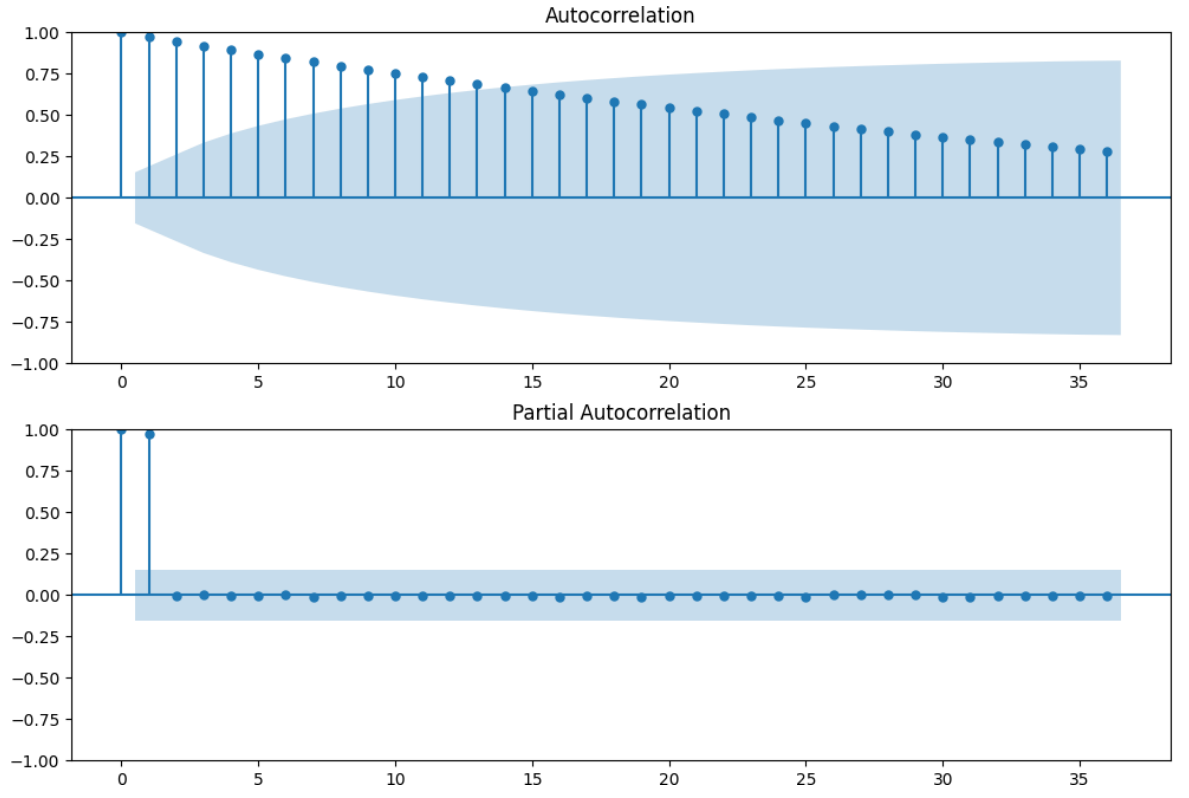
In [ ]:
```
kitsap = county_dfs['Kitsap'].copy()
kitsap.reset_index(inplace=True)
mask = kitsap['DOL Transaction Date'] >= '2020-01-31'
kitsap = kitsap[mask]

kitsap.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_kitsap, test_kitsap = train_test_split_ts(county_information['Kitsap']['df'],
```

In [ ]:
```
plot_train_test_split(train_kitsap, test_kitsap, 'Kitsap')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(county_information['Kitsap']['df'], lags = 36, ax =
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(county_information['Kitsap']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_kitsap, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(2, 2, 4)	**Log Likelihood**	-443.412
Date:	Fri, 25 Aug 2023	**AIC**	902.825
Time:	09:52:18	**BIC**	925.641
Sample:	02-28-2010	**HQIC**	912.095
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	1.0833	0.362	2.991	0.003	0.374	1.793
ar.L1	-1.0314	0.189	-5.443	0.000	-1.403	-0.660
ar.L2	-0.9520	0.109	-8.758	0.000	-1.165	-0.739
ma.L1	0.3973	0.222	1.793	0.073	-0.037	0.832
ma.L2	0.0006	0.159	0.004	0.997	-0.312	0.313
ma.L3	-0.7626	0.184	-4.155	0.000	-1.122	-0.403
ma.L4	-0.3181	0.103	-3.098	0.002	-0.519	-0.117
sigma2	58.6161	5.846	10.027	0.000	47.158	70.074

Ljung-Box (L1) (Q):	0.10	**Jarque-Bera (JB):**	52.61
Prob(Q):	0.75	**Prob(JB):**	0.00
Heteroskedasticity (H):	6.30	**Skew:**	0.80
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.70

Warnings:

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

In [ ]:
```
model = SARIMAX(train_kitsap, order = (2, 2, 4),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

SARIMAX Results

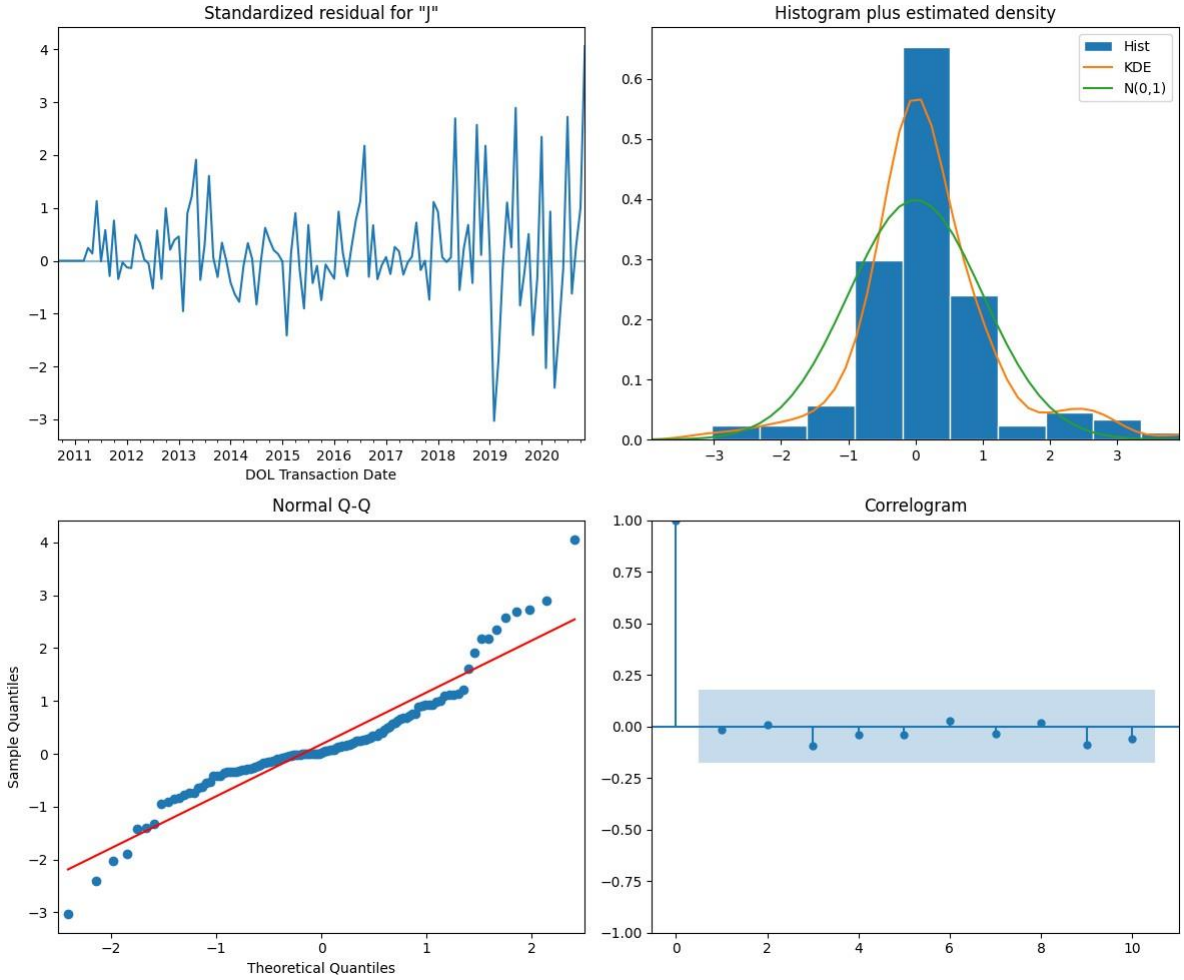
Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(2, 2, 4)	**Log Likelihood**	-431.370
Date:	Fri, 25 Aug 2023	**AIC**	876.740
Time:	19:49:21	**BIC**	896.426
Sample:	02-28-2010	**HQIC**	884.737
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-1.1453	0.129	-8.882	0.000	-1.398	-0.893
ar.L2	-0.9679	0.100	-9.727	0.000	-1.163	-0.773
ma.L1	0.6046	0.175	3.461	0.001	0.262	0.947
ma.L2	0.0572	0.147	0.388	0.698	-0.231	0.346
ma.L3	-0.6447	0.162	-3.982	0.000	-0.962	-0.327
ma.L4	-0.1712	0.115	-1.495	0.135	-0.396	0.053
sigma2	64.5216	5.768	11.187	0.000	53.217	75.826

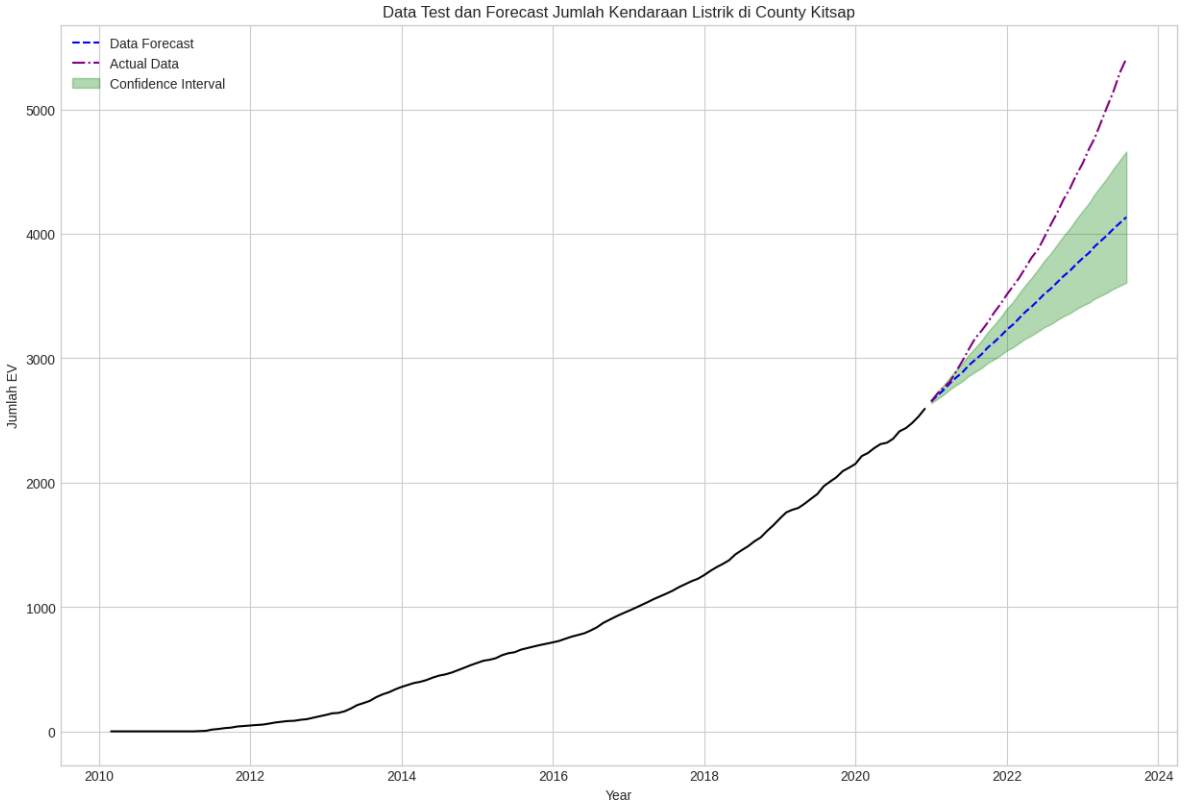
Ljung-Box (L1) (Q):	0.02	**Jarque-Bera (JB):**	54.88
Prob(Q):	0.88	**Prob(JB):**	0.00
Heteroskedasticity (H):	6.11	**Skew:**	0.64
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.01

Warnings:

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



In [ ]:
```
df_kitsap_forecast = get_forecast(model, train_kitsap, test_kitsap, 'Kitsap', plot
```

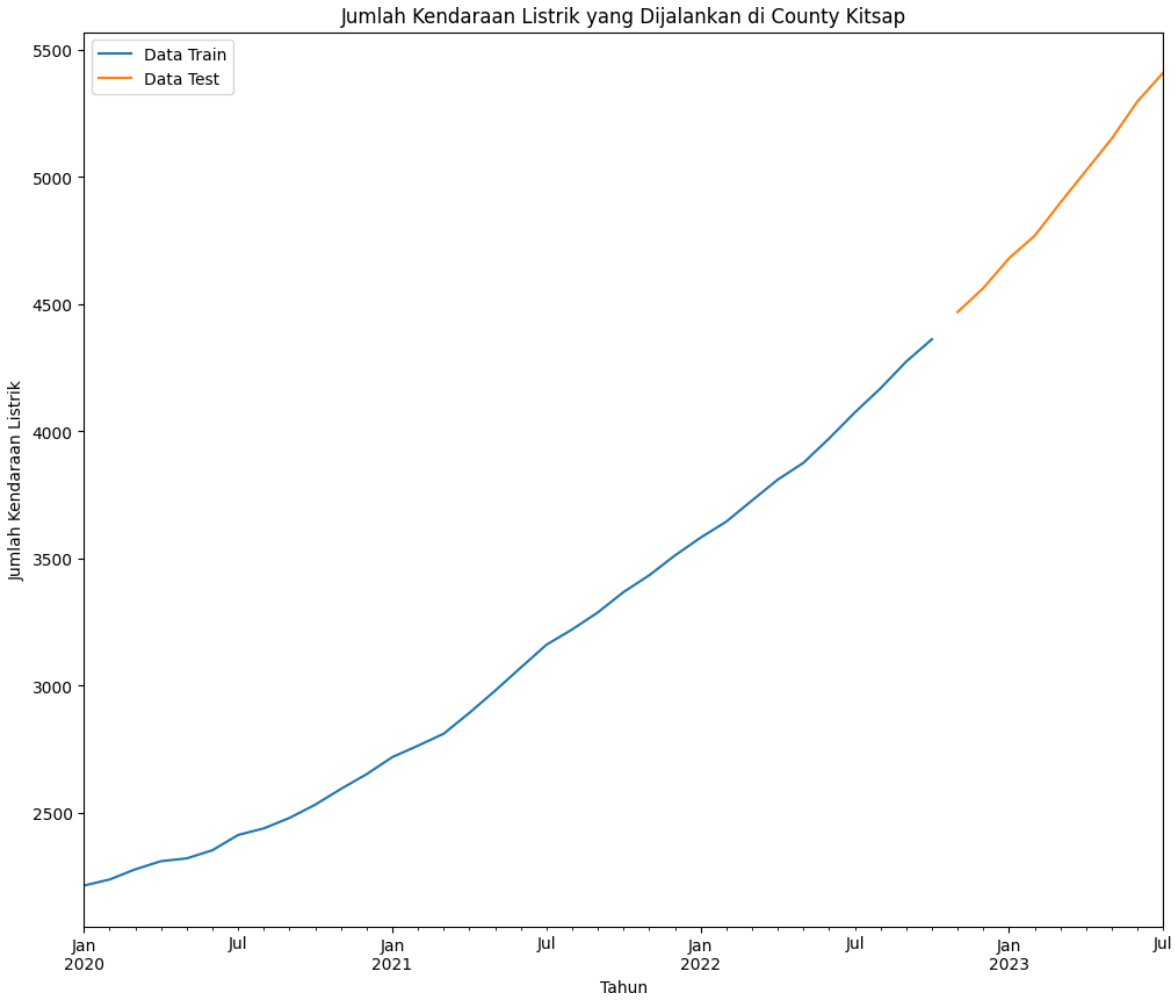


```
Mean Absolute Percentage Error: 0.1070715374503407

Mean Squared Error: 357051.7742437116

Root Mean Squared Error: 597.5380943870538

R-squared: 0.4511837164041266
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_kitsap, test_kitsap = train_test_split_ts(kitsap, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_kitsap, test_kitsap, 'Kitsap')
```



In [ ]:
```
auto_model = pm.auto_arima(train_kitsap, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-130.619
Date:	Fri, 25 Aug 2023	**AIC**	267.238
Time:	09:52:31	**BIC**	271.636
Sample:	01-31-2020	**HQIC**	268.696
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	2.1575	0.552	3.906	0.000	1.075	3.240
ma.L1	-0.8233	0.106	-7.757	0.000	-1.031	-0.615
sigma2	198.5490	75.839	2.618	0.009	49.907	347.191

Ljung-Box (L1) (Q):	0.98	**Jarque-Bera (JB):**	1.72
Prob(Q):	0.32	**Prob(JB):**	0.42
Heteroskedasticity (H):	0.72	**Skew:**	0.00
Prob(H) (two-sided):	0.60	**Kurtosis:**	1.86

Warnings:

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

In [ ]:

```
model = SARIMAX(train_kitsap, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

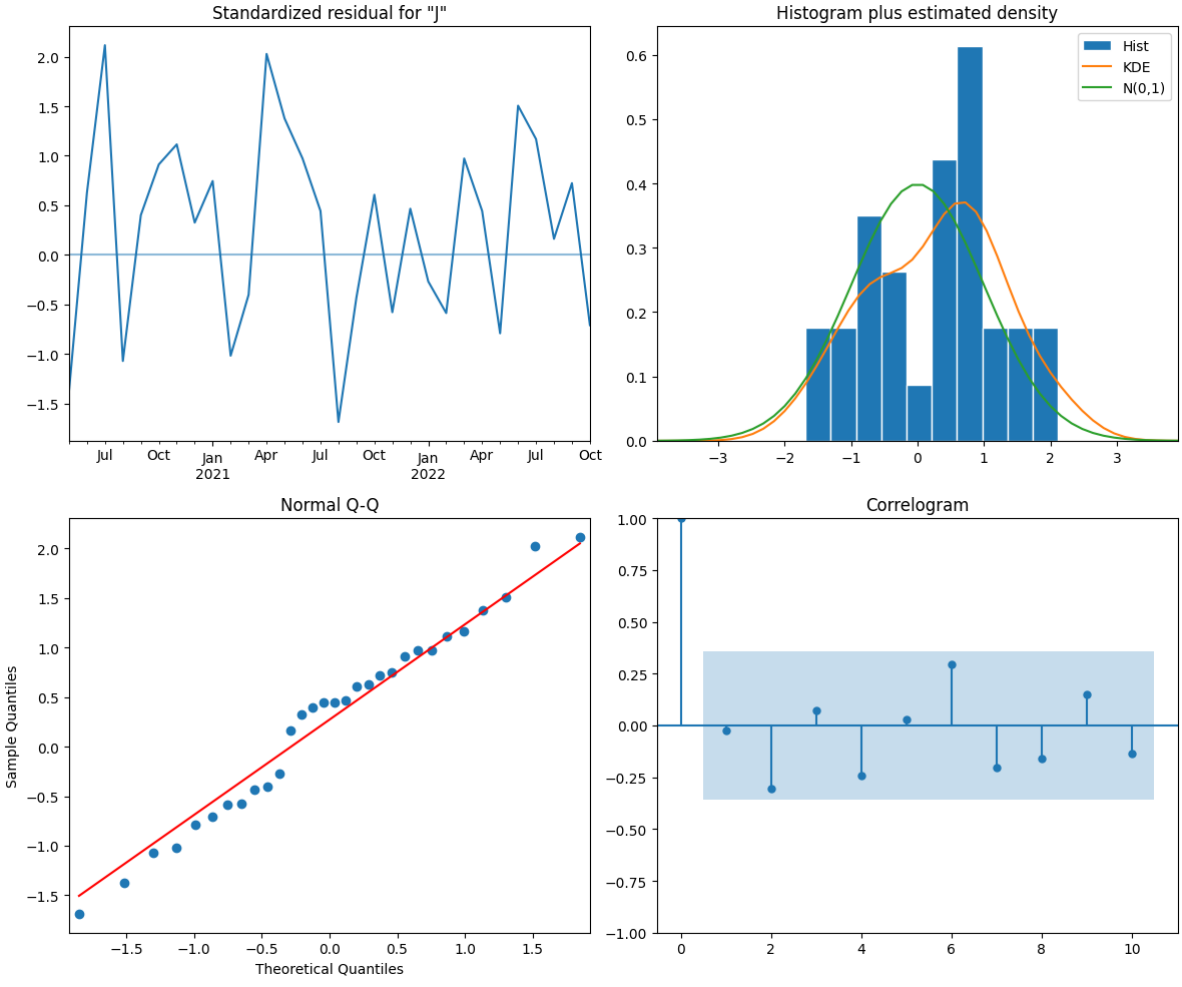
Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-125.069
Date:	Fri, 25 Aug 2023	**AIC**	254.137
Time:	19:50:43	**BIC**	256.940
Sample:	01-31-2020	**HQIC**	255.034
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.5212	0.171	-3.044	0.002	-0.857	-0.186
sigma2	244.5064	81.788	2.989	0.003	84.204	404.809

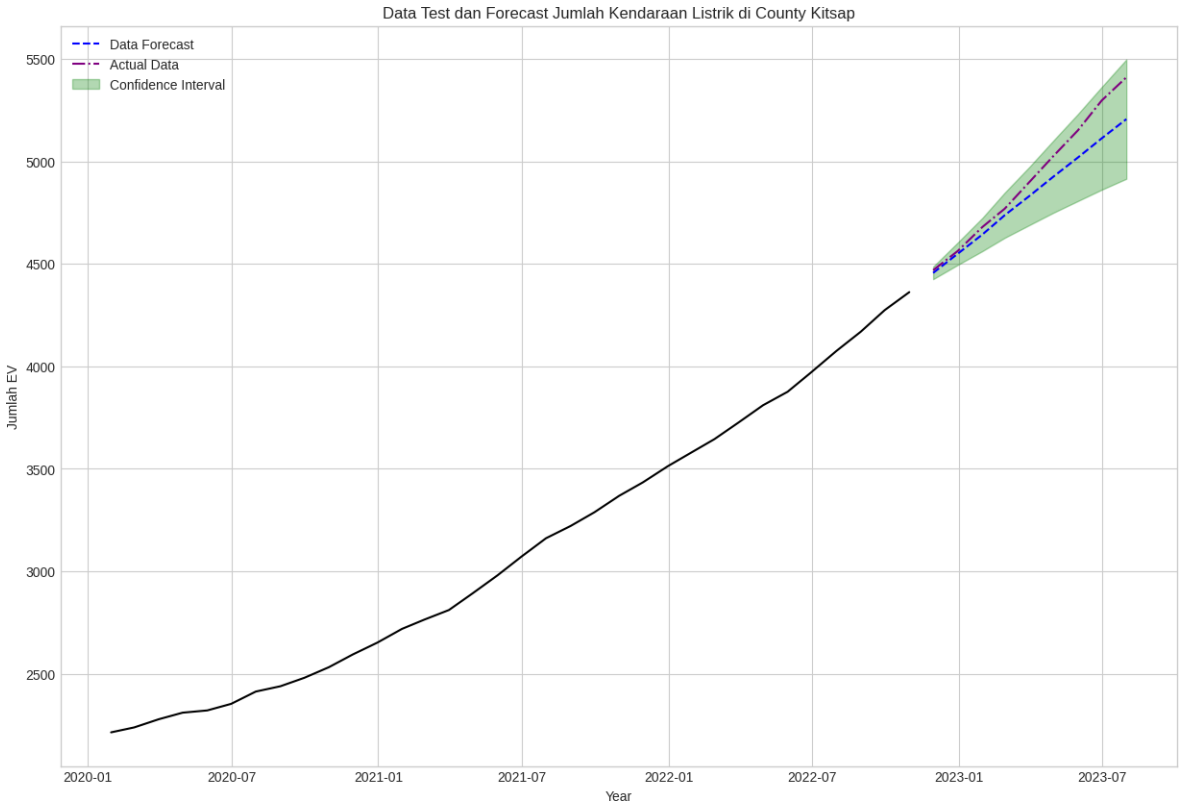
Ljung-Box (L1) (Q):	0.02	**Jarque-Bera (JB):**	0.71
Prob(Q):	0.88	**Prob(JB):**	0.70
Heteroskedasticity (H):	0.58	**Skew:**	-0.13
Prob(H) (two-sided):	0.40	**Kurtosis:**	2.29

Warnings:

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



In [ ]:
```
df_kitsap_forecast = get_forecast(model, train_kitsap, test_kitsap, 'Kitsap', plot
```




```
Mean Absolute Percentage Error: 0.0169490993719556

Mean Squared Error: 12294.940793737209

Root Mean Squared Error: 110.88255405489724

R-squared: 0.8710733955098154
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(kitsap, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

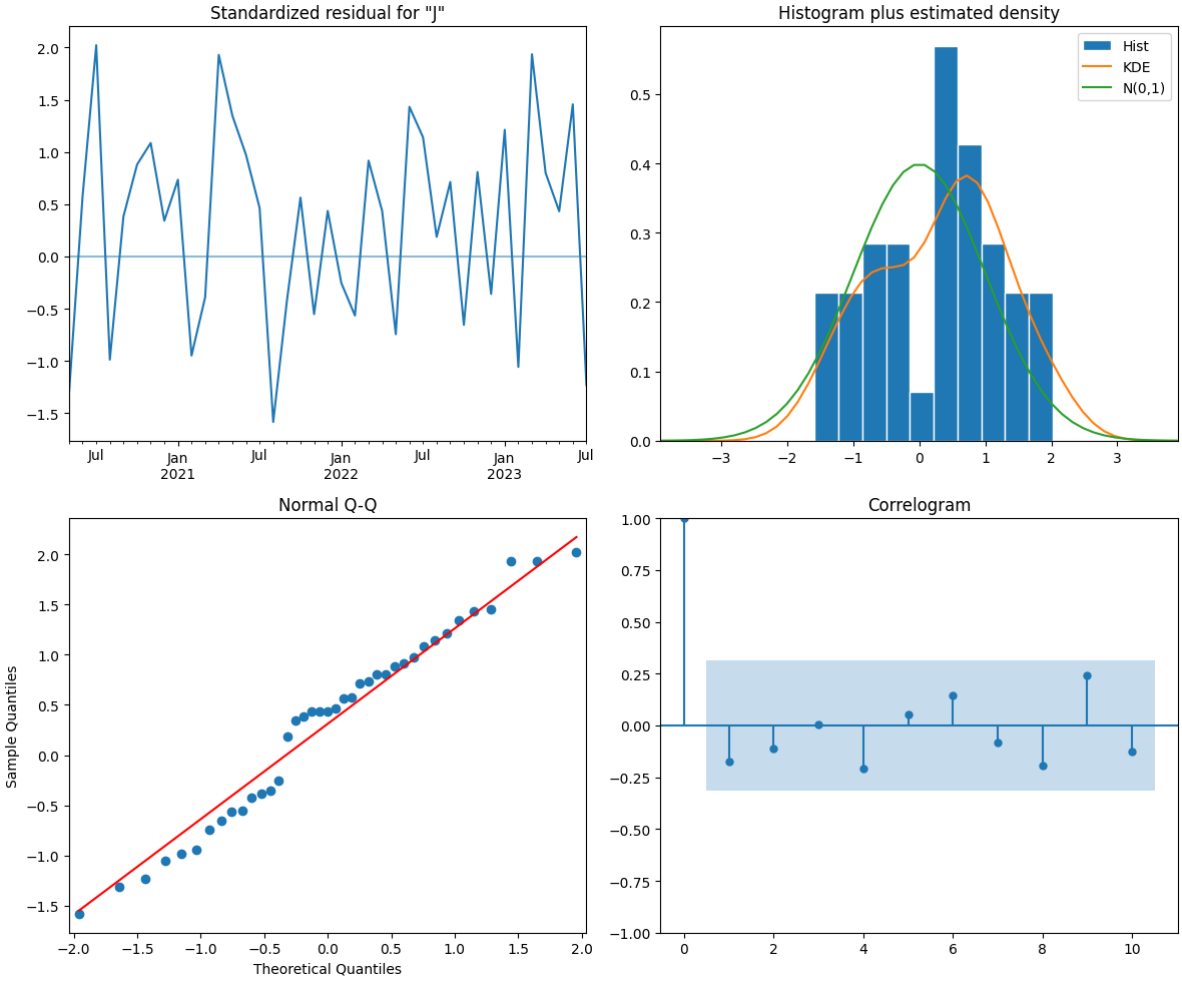
Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-164.348
Date:	Fri, 25 Aug 2023	**AIC**	332.695
Time:	19:51:27	**BIC**	336.022
Sample:	01-31-2020	**HQIC**	333.889
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.5402	0.146	-3.695	0.000	-0.827	-0.254
sigma2	267.6043	83.895	3.190	0.001	103.173	432.035

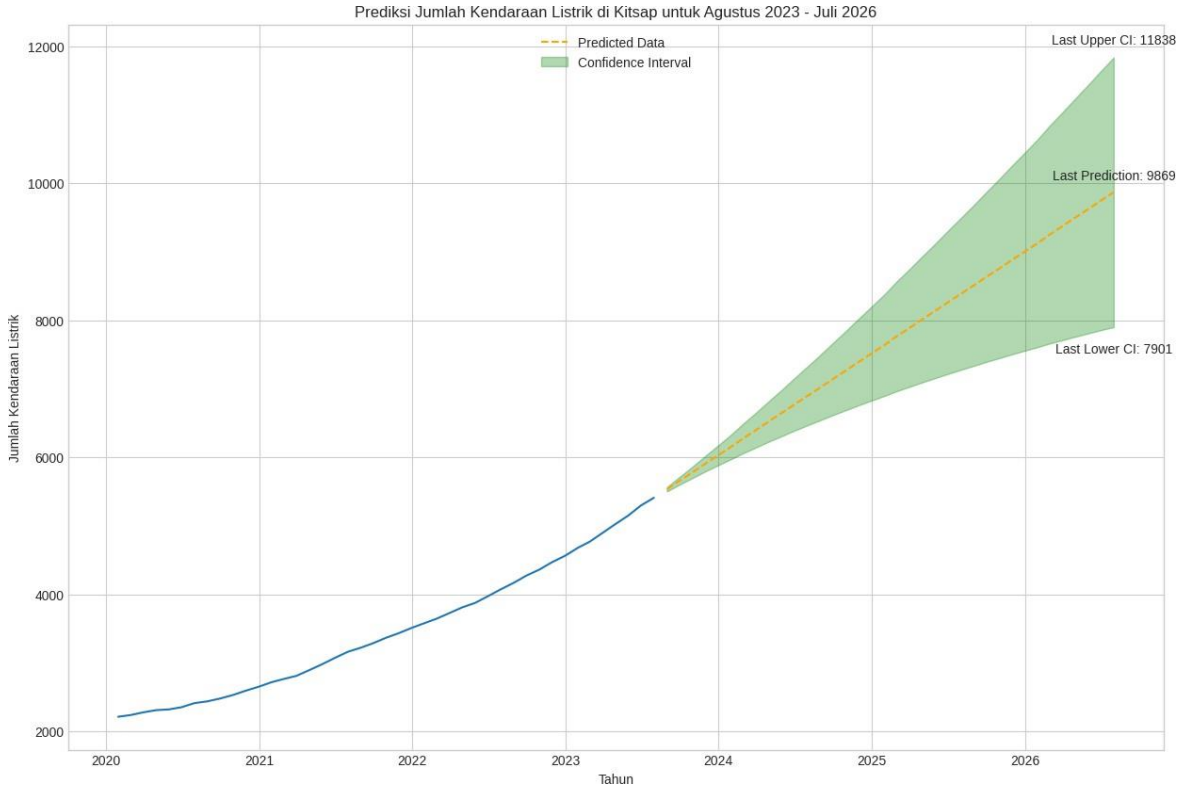
Ljung-Box (L1) (Q):	1.26	**Jarque-Bera (JB):**	1.45
Prob(Q):	0.26	**Prob(JB):**	0.48
Heteroskedasticity (H):	0.84	**Skew:**	-0.17
Prob(H) (two-sided):	0.76	**Kurtosis:**	2.12

Warnings:

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



In [ ]:
```
df_kitsap_preds = get_prediction(model, kitsap['Jumlah EV'], test_kitsap, 'Kitsap',
```



In [ ]:
```
county_information['Kitsap']['Predictions'] = df_kitsap_preds
```

County Spokane

Inisialisasi Dataset

In [ ]:
```
county_dfs['Spokane']
```

Out[ ]:

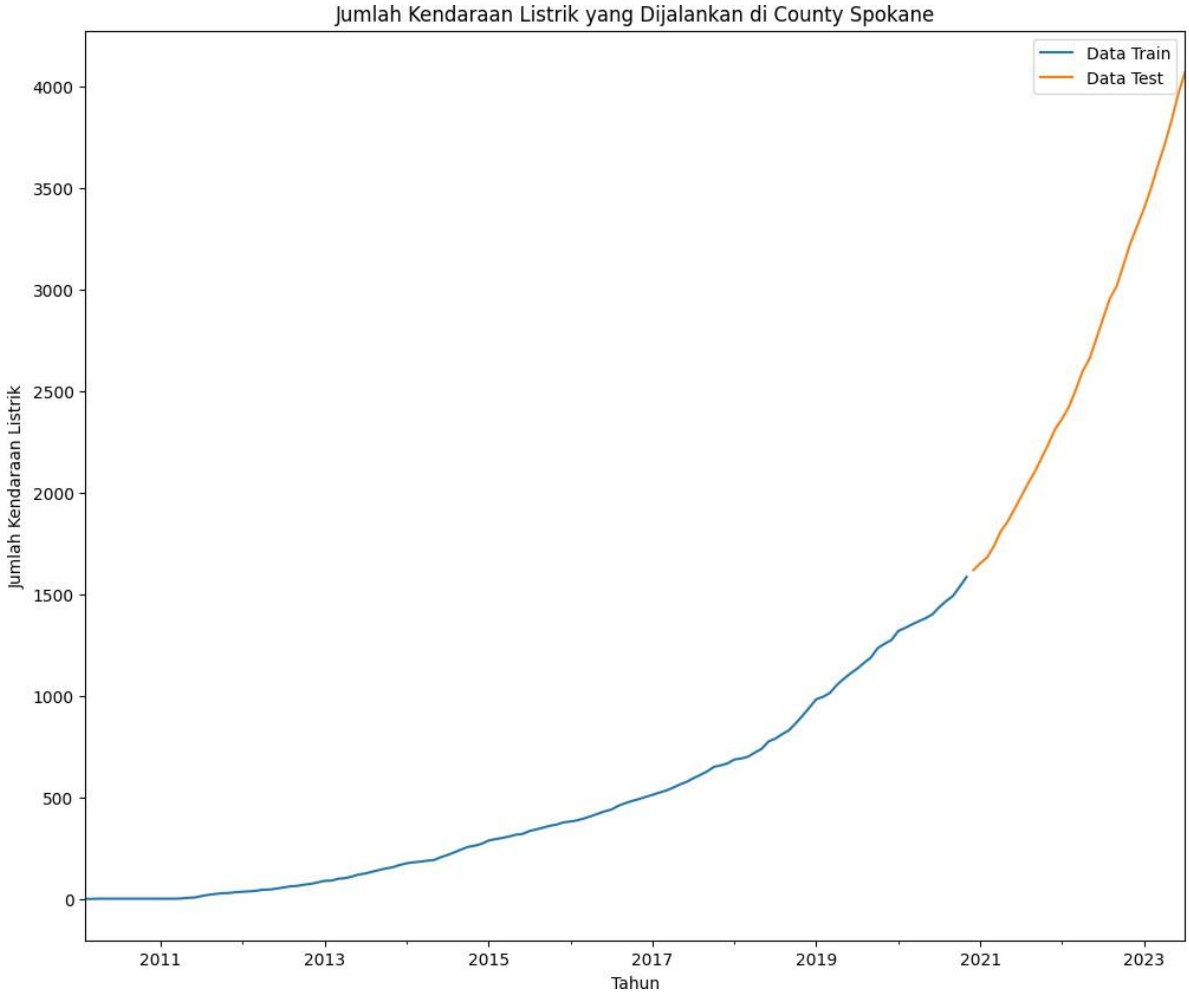
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	1.0
2010-05-31	1.0
2010-06-30	1.0
...	...
2023-03-31	3609.0
2023-04-30	3712.0
2023-05-31	3830.0
2023-06-30	3963.0
2023-07-31	4071.0

162 rows × 1 columns

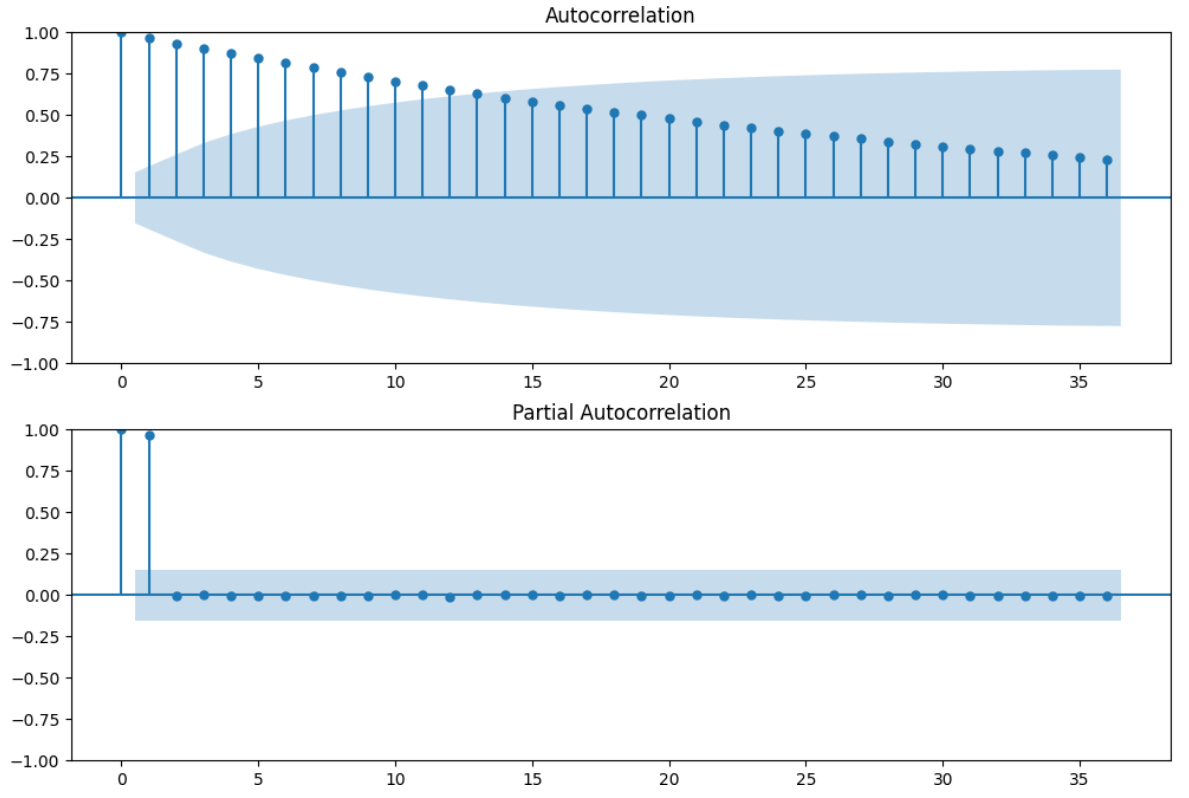
In [ ]:
```
spokane = county_dfs['Spokane'].copy()
spokane.reset_index(inplace=True)
mask = spokane['DOL Transaction Date'] >= '2020-01-31'
spokane = spokane[mask]

spokane.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_spokane, test_spokane = train_test_split_ts(county_information['Spokane']['df
```

In [ ]:
```
plot_train_test_split(train_spokane, test_spokane, 'Spokane')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig =  sm.graphics.tsa.plot_acf(county_information['Spokane']['df'], lags = 36, ax
ax2 = fig.add_subplot(212)
fig =  sm.graphics.tsa.plot_pacf(county_information['Spokane']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_kitsap, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-130.619
Date:	Fri, 25 Aug 2023	**AIC**	267.238
Time:	09:52:54	**BIC**	271.636
Sample:	01-31-2020	**HQIC**	268.696
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	2.1575	0.552	3.906	0.000	1.075	3.240
ma.L1	-0.8233	0.106	-7.757	0.000	-1.031	-0.615
sigma2	198.5490	75.839	2.618	0.009	49.907	347.191

Ljung-Box (L1) (Q):	0.98	**Jarque-Bera (JB):**	1.72
Prob(Q):	0.32	**Prob(JB):**	0.42
Heteroskedasticity (H):	0.72	**Skew:**	0.00
Prob(H) (two-sided):	0.60	**Kurtosis:**	1.86

Warnings:

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

In [ ]:
```
model = SARIMAX(train_spokane, order = (2, 2, 4),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

SARIMAX Results

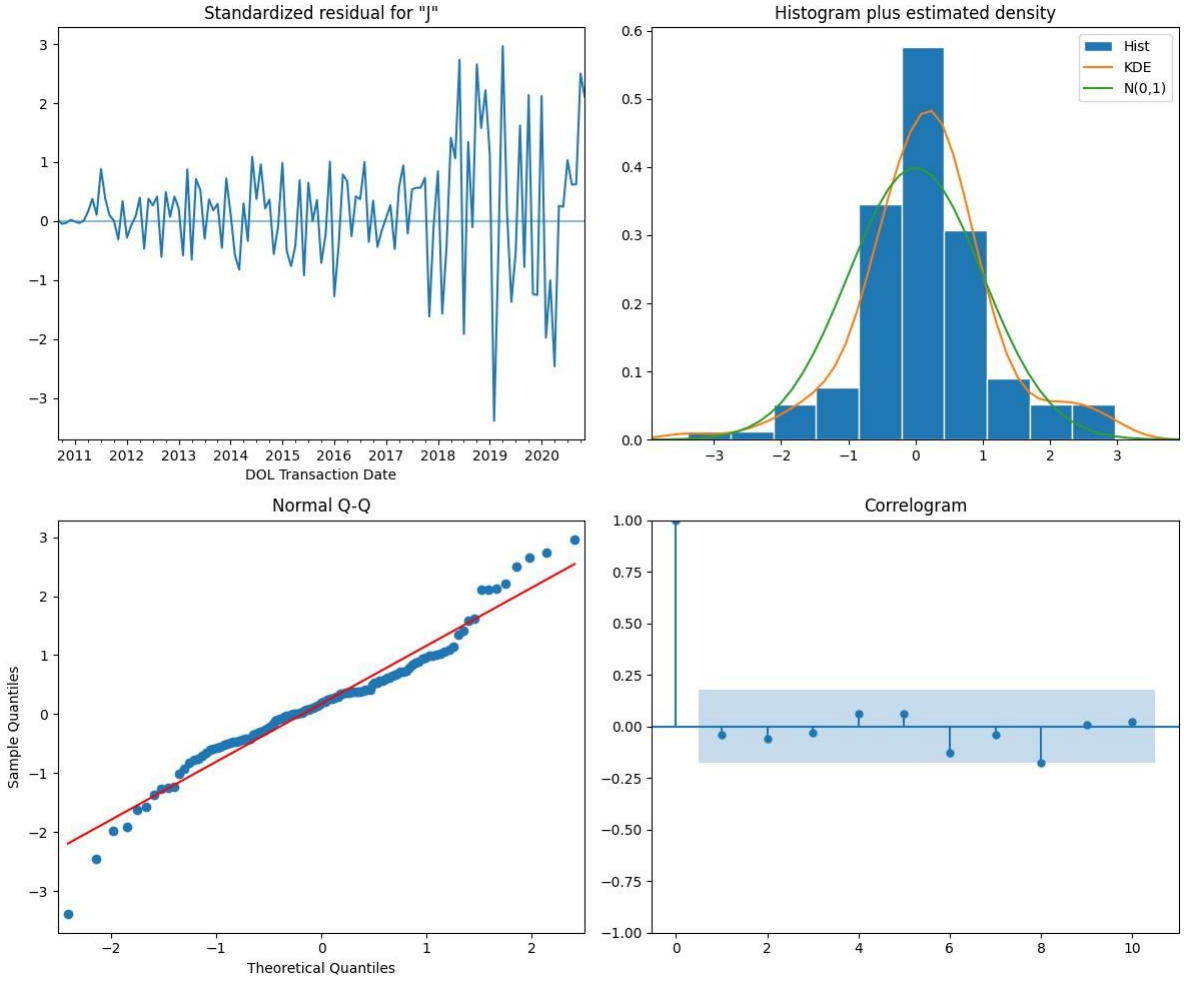
Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(2, 2, 4)	**Log Likelihood**	-400.284
Date:	Fri, 25 Aug 2023	**AIC**	814.568
Time:	19:52:10	**BIC**	834.253
Sample:	02-28-2010	**HQIC**	822.564
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6678	0.044	-15.052	0.000	-0.755	-0.581
ar.L2	-0.8716	0.049	-17.672	0.000	-0.968	-0.775
ma.L1	0.0873	119.803	0.001	0.999	-234.723	234.897
ma.L2	0.4596	438.182	0.001	0.999	-858.361	859.281
ma.L3	-0.5729	237.949	-0.002	0.998	-466.944	465.798
ma.L4	-0.3410	166.004	-0.002	0.998	-325.703	325.021
sigma2	37.2045	1.81e+04	0.002	0.998	-3.55e+04	3.55e+04

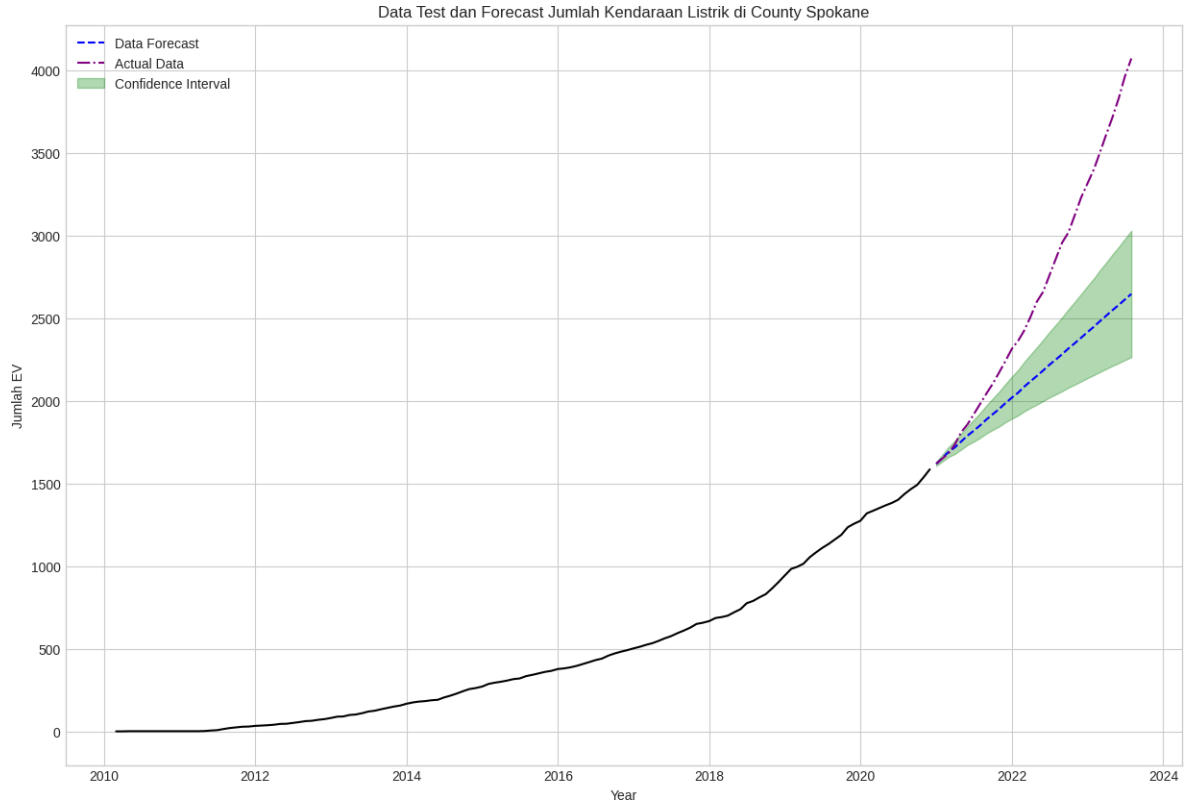
Ljung-Box (L1) (Q):	0.21	**Jarque-Bera (JB):**	15.49
Prob(Q):	0.64	**Prob(JB):**	0.00
Heteroskedasticity (H):	15.73	**Skew:**	-0.03
Prob(H) (two-sided):	0.00	**Kurtosis:**	4.74

Warnings:

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



In [ ]:
```
df_spokane_forecast = get_forecast(model, train_spokane, test_spokane, 'Spokane',
```

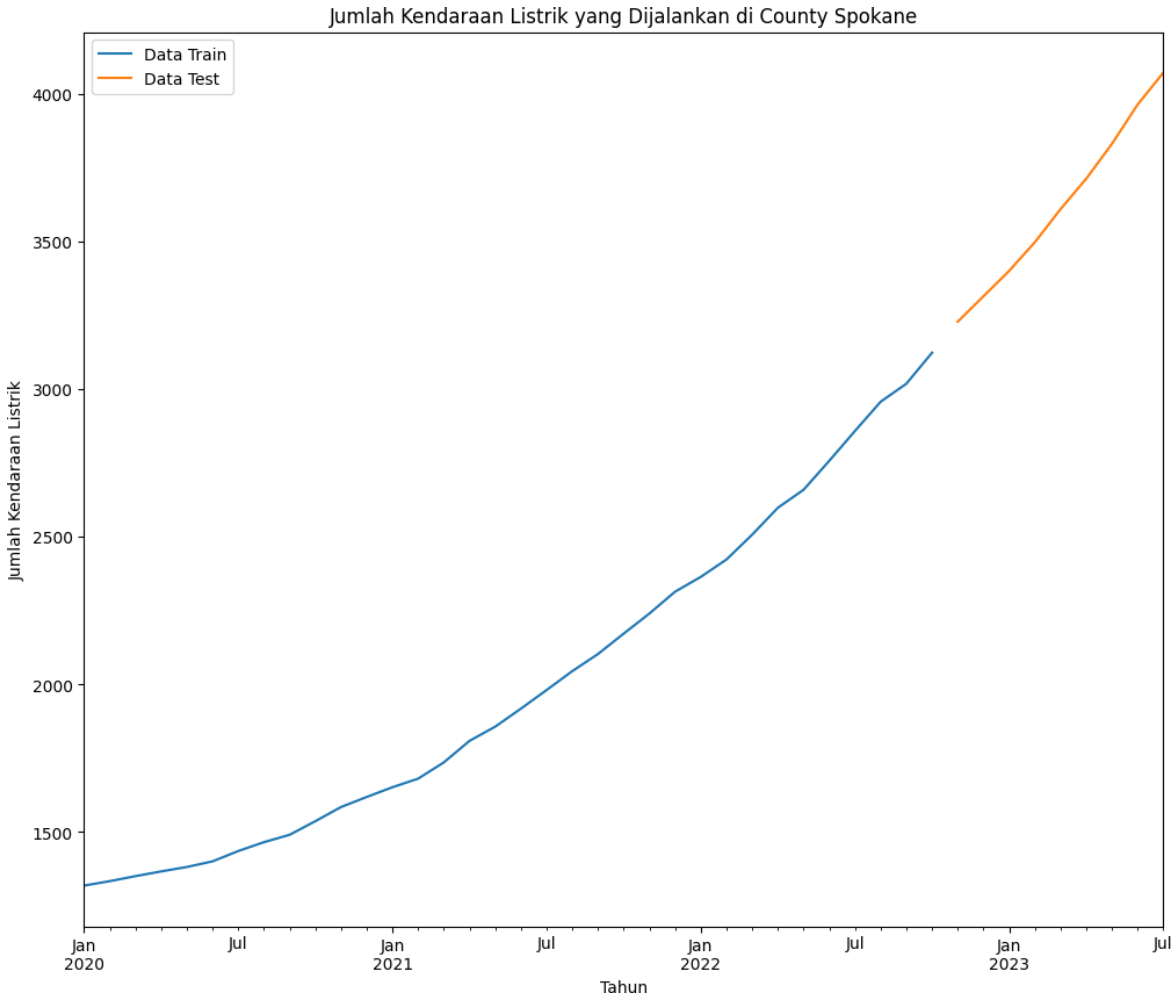


```
Mean Absolute Percentage Error: 0.1671106299218674

Mean Squared Error: 460540.04621232476

Root Mean Squared Error: 678.6310088791439

R-squared:  0.14461380616831476
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_spokane, test_spokane = train_test_split_ts(spokane, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_spokane, test_spokane, 'Spokane')
```



In [ ]:
```
auto_model = pm.auto_arima(train_kitsap, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-130.619
Date:	Fri, 25 Aug 2023	**AIC**	267.238
Time:	09:53:07	**BIC**	271.636
Sample:	01-31-2020	**HQIC**	268.696
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	2.1575	0.552	3.906	0.000	1.075	3.240
ma.L1	-0.8233	0.106	-7.757	0.000	-1.031	-0.615
sigma2	198.5490	75.839	2.618	0.009	49.907	347.191

Ljung-Box (L1) (Q):	0.98	**Jarque-Bera (JB):**	1.72
Prob(Q):	0.32	**Prob(JB):**	0.42
Heteroskedasticity (H):	0.72	**Skew:**	0.00
Prob(H) (two-sided):	0.60	**Kurtosis:**	1.86

Warnings:

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

In [ ]:

```
model = SARIMAX(train_spokane, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

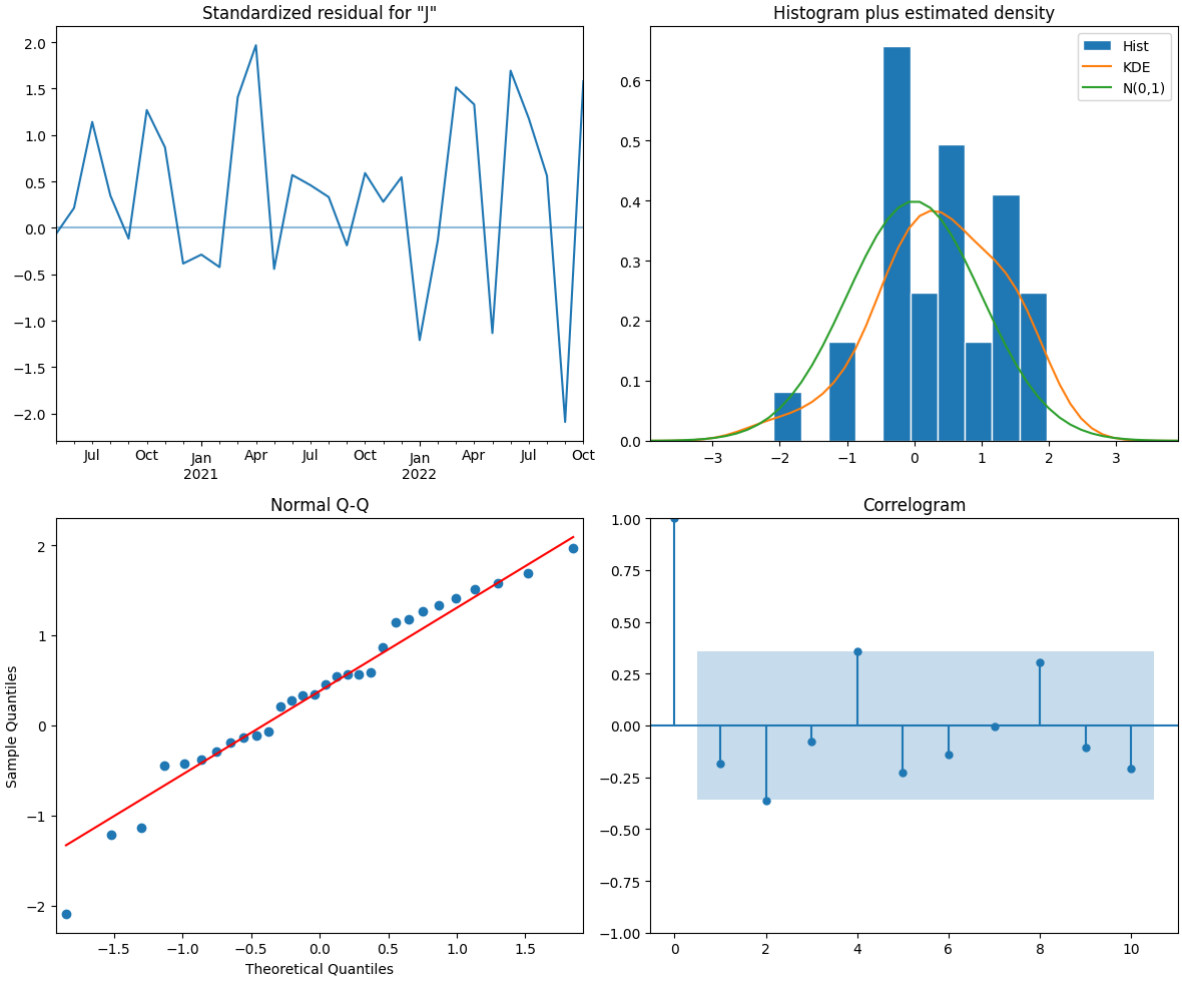
Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-125.209
Date:	Fri, 25 Aug 2023	**AIC**	254.418
Time:	19:53:55	**BIC**	257.221
Sample:	01-31-2020	**HQIC**	255.315
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.5838	0.155	-3.778	0.000	-0.887	-0.281
sigma2	246.7196	78.288	3.151	0.002	93.278	400.161

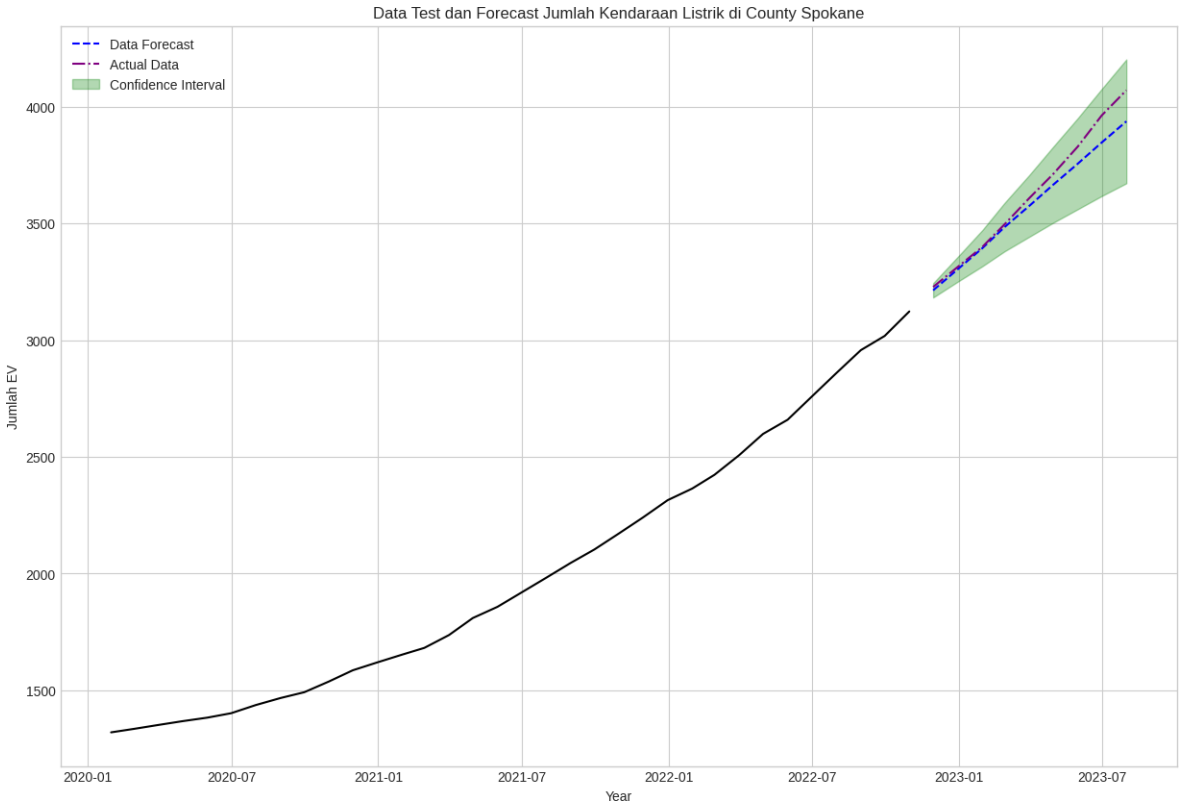
Ljung-Box (L1) (Q):	1.14	**Jarque-Bera (JB):**	1.21
Prob(Q):	0.29	**Prob(JB):**	0.55
Heteroskedasticity (H):	4.29	**Skew:**	-0.49
Prob(H) (two-sided):	0.03	**Kurtosis:**	3.05

Warnings:

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



In [ ]:
```
df_spokane_forecast = get_forecast(model, train_spokane, test_spokane, 'Spokane',
```




```
Mean Absolute Percentage Error: 0.01281857877930003

Mean Squared Error: 4482.155223533024

Root Mean Squared Error: 66.94890009203306

R-squared: 0.9410543398743696
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(spokane, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

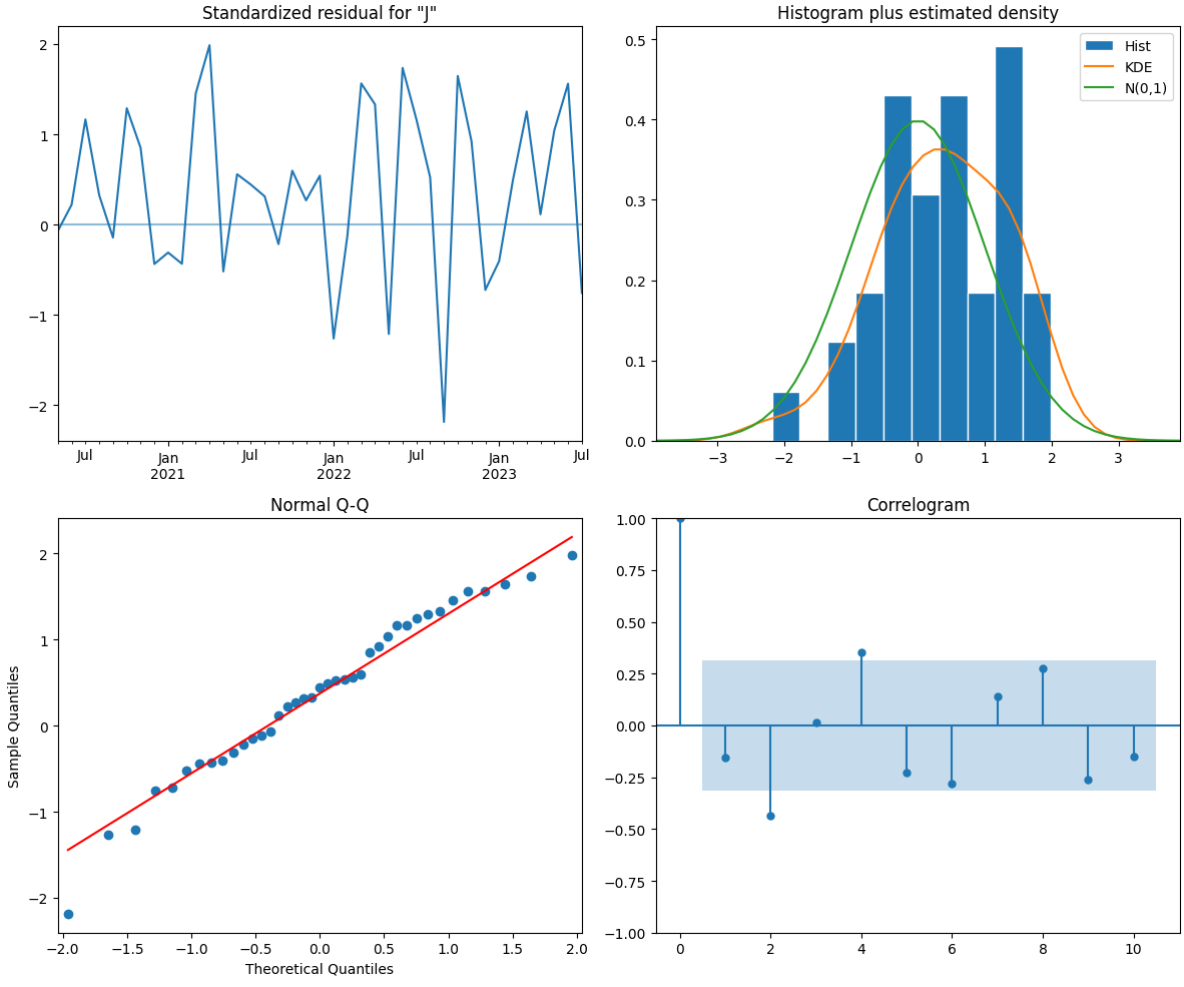
Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-161.817
Date:	Fri, 25 Aug 2023	**AIC**	327.634
Time:	19:54:34	**BIC**	330.961
Sample:	01-31-2020	**HQIC**	328.827
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.5596	0.133	-4.218	0.000	-0.820	-0.300
sigma2	235.0135	65.476	3.589	0.000	106.682	363.345

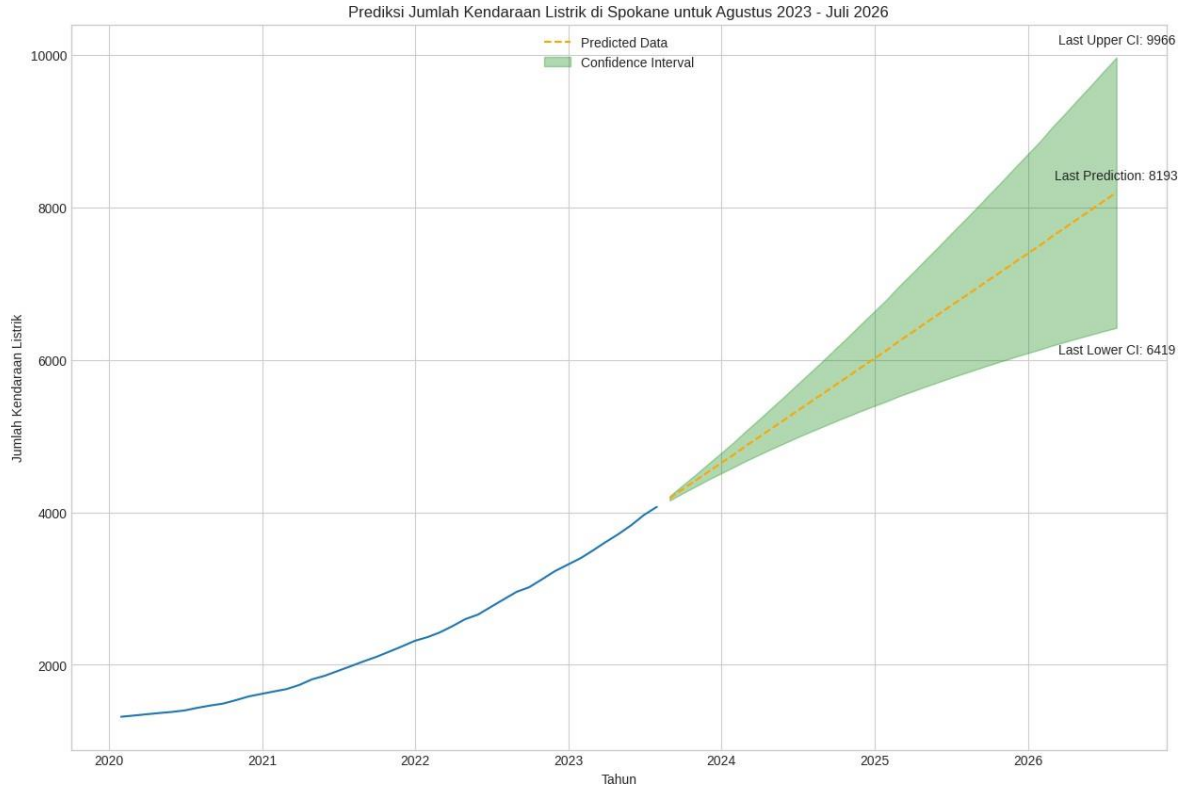
Ljung-Box (L1) (Q):	1.04	**Jarque-Bera (JB):**	1.28
Prob(Q):	0.31	**Prob(JB):**	0.53
Heteroskedasticity (H):	1.55	**Skew:**	-0.44
Prob(H) (two-sided):	0.44	**Kurtosis:**	2.89

Warnings:

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



In [ ]:
```
df_spokane_preds = get_prediction(model, spokane['Jumlah EV'], test_spokane, 'Spoka
```



In [ ]:
```
county_information['Spokane']['Predictions'] = df_spokane_preds
```

County Whatcom

Inisialisasi Dataset

In [ ]:
```
county_dfs['Whatcom']
```

Out[ ]:

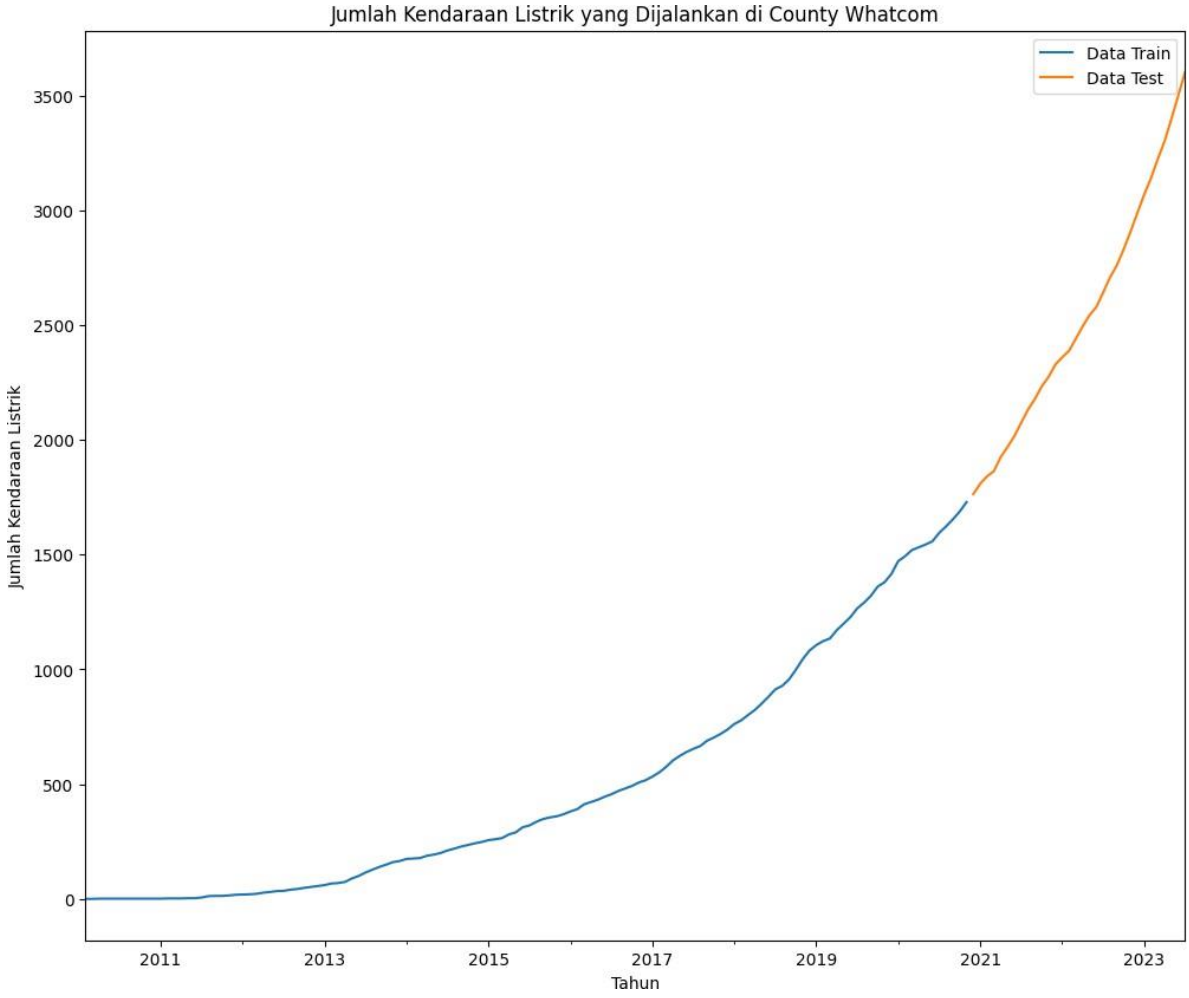
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	1.0
2010-05-31	1.0
2010-06-30	1.0
...	...
2023-03-31	3224.0
2023-04-30	3302.0
2023-05-31	3399.0
2023-06-30	3501.0
2023-07-31	3603.0

162 rows × 1 columns

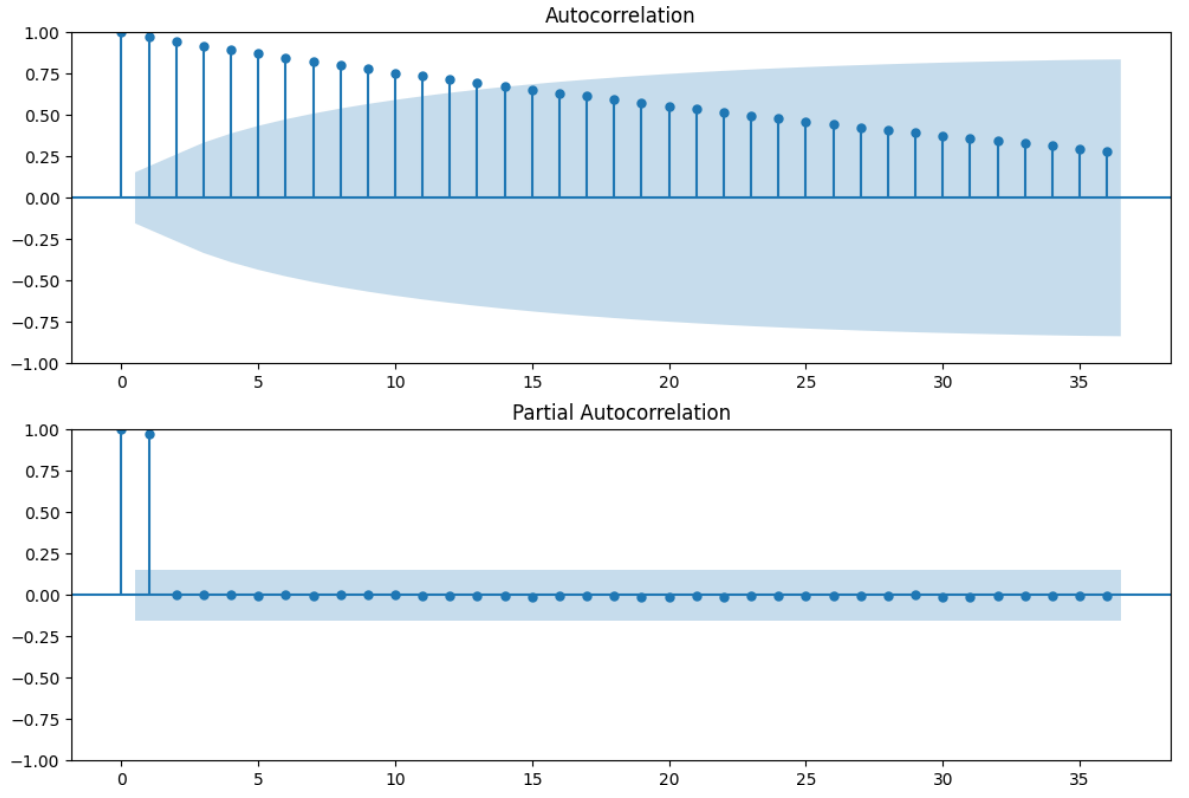
In [ ]:
```
whatcom = county_dfs['Whatcom'].copy()
whatcom.reset_index(inplace=True)
mask = whatcom['DOL Transaction Date'] >= '2020-01-31'
whatcom = whatcom[mask]

whatcom.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_whatcom, test_whatcom = train_test_split_ts(county_information['Whatcom']['df
```

In [ ]:
```
plot_train_test_split(train_whatcom, test_whatcom, 'Whatcom')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig =  sm.graphics.tsa.plot_acf(county_information['Whatcom']['df'], lags = 36, ax
ax2 = fig.add_subplot(212)
fig =  sm.graphics.tsa.plot_pacf(county_information['Whatcom']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_whatcom, start_p = 0, start_d = 0, start_q = 0, m
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(1, 2, 1)	**Log Likelihood**	-418.124
Date:	Fri, 25 Aug 2023	**AIC**	844.248
Time:	09:53:27	**BIC**	855.656
Sample:	02-28-2010	**HQIC**	848.883
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	0.1817	0.029	6.286	0.000	0.125	0.238
ar.L1	0.3207	0.056	5.767	0.000	0.212	0.430
ma.L1	-0.9656	0.026	-37.347	0.000	-1.016	-0.915
sigma2	39.6159	3.676	10.777	0.000	32.411	46.820

Ljung-Box (L1) (Q):	0.05	**Jarque-Bera (JB):**	31.48
Prob(Q):	0.82	**Prob(JB):**	0.00
Heteroskedasticity (H):	16.82	**Skew:**	0.61
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.10

Warnings:

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

In [ ]:
```
model = SARIMAX(train_whatcom, order = (1, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

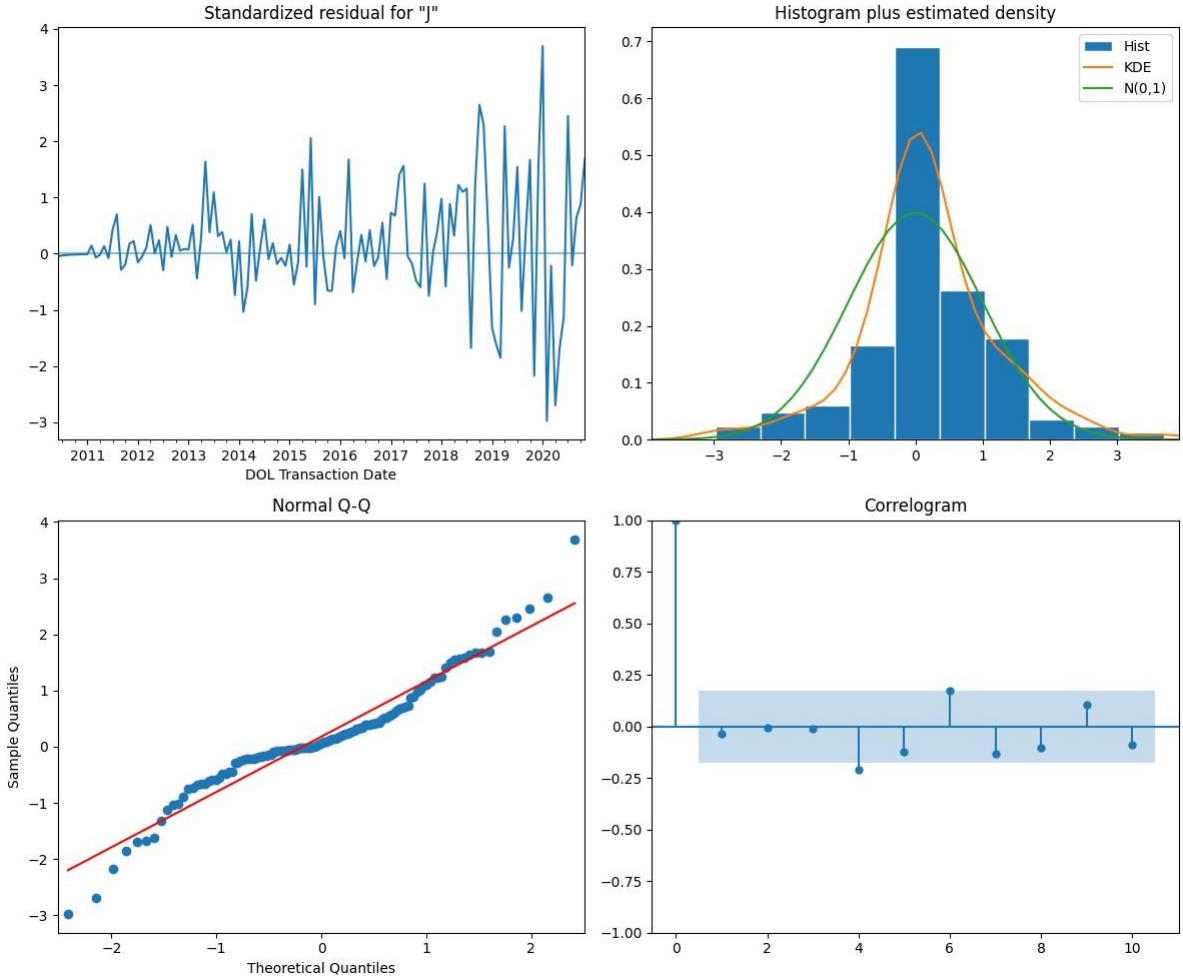
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(1, 2, 1)	**Log Likelihood**	-416.707
Date:	Fri, 25 Aug 2023	**AIC**	839.414
Time:	19:55:19	**BIC**	847.923
Sample:	02-28-2010	**HQIC**	842.871
	- 11-30-2020		
Covariance Type:	opg		

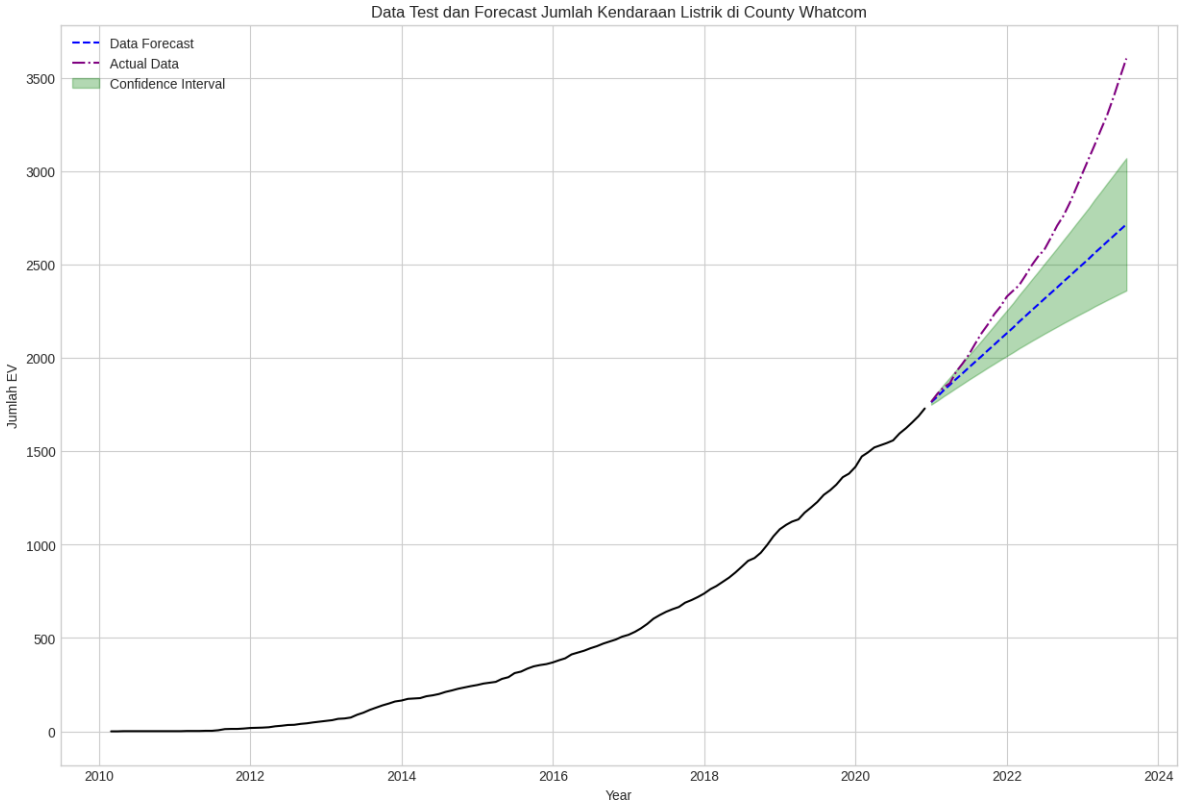
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.2635	0.082	3.209	0.001	0.103	0.424
ma.L1	-0.8488	0.052	-16.350	0.000	-0.951	-0.747
sigma2	43.4112	3.928	11.052	0.000	35.713	51.110

Ljung-Box (L1) (Q):	0.15	**Jarque-Bera (JB):**	19.72
Prob(Q):	0.69	**Prob(JB):**	0.00
Heteroskedasticity (H):	14.69	**Skew:**	0.14
Prob(H) (two-sided):	0.00	**Kurtosis:**	4.92

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



In [ ]:
```
df_whatcom_forecast = get_forecast(model, train_whatcom, test_whatcom, 'Whatcom',
```

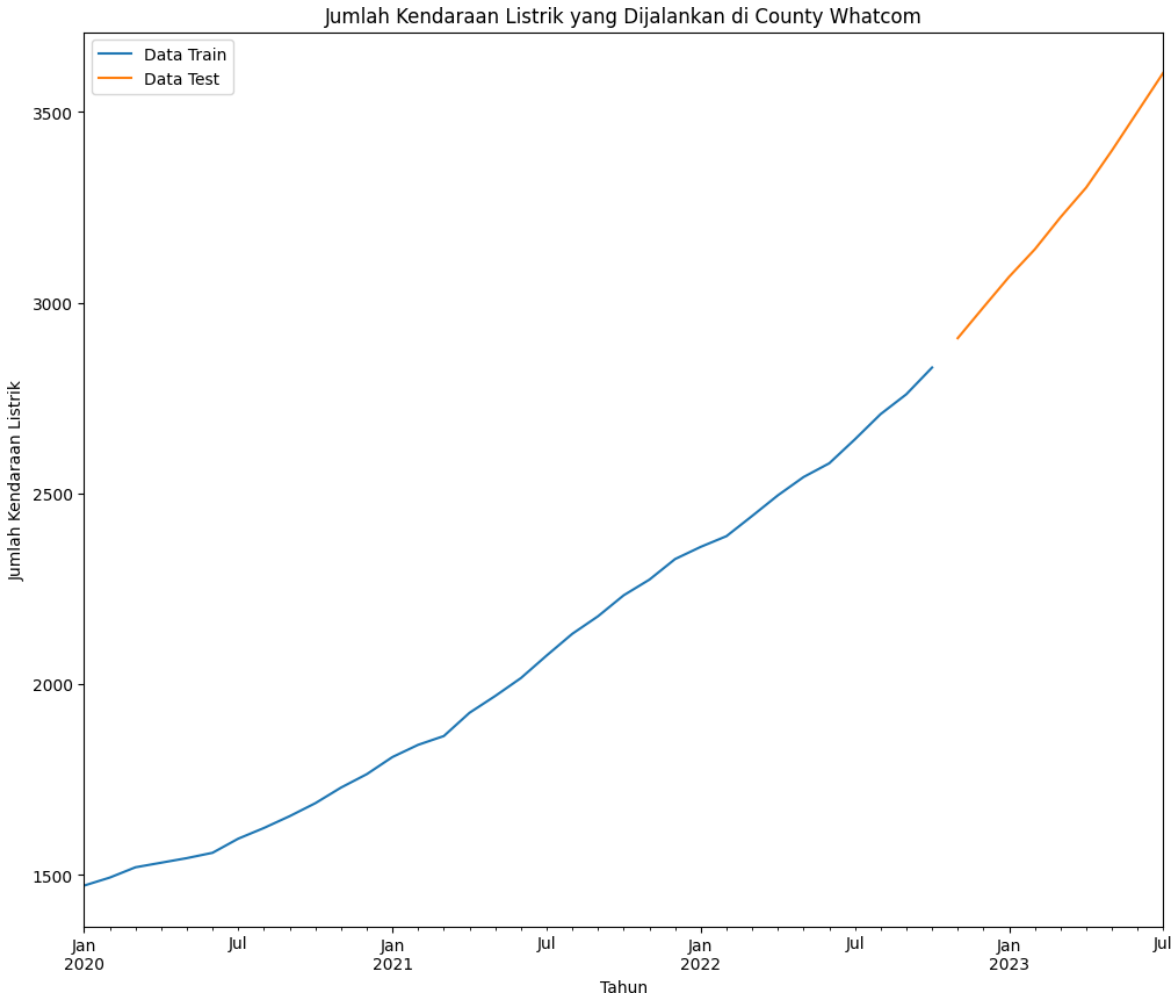


```
Mean Absolute Percentage Error: 0.10418470435157454

Mean Squared Error: 152136.06653066305

Root Mean Squared Error: 390.0462364011003

R-squared:  0.44919851681000045
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_whatcom, test_whatcom = train_test_split_ts(whatcom, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_whatcom, test_whatcom, 'Whatcom')
```



In [ ]:
```
auto_model = pm.auto_arima(train_whatcom, start_p = 0, start_d = 0, start_q = 0, m
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-123.010
Date:	Fri, 25 Aug 2023	**AIC**	252.021
Time:	19:57:17	**BIC**	256.418
Sample:	01-31-2020	**HQIC**	253.478
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	1.2599	0.387	3.255	0.001	0.501	2.019
ma.L1	-0.8439	0.129	-6.521	0.000	-1.098	-0.590
sigma2	122.8852	35.416	3.470	0.001	53.470	192.300

Ljung-Box (L1) (Q):	0.13	**Jarque-Bera (JB):**	0.71
Prob(Q):	0.72	**Prob(JB):**	0.70
Heteroskedasticity (H):	2.33	**Skew:**	-0.32
Prob(H) (two-sided):	0.18	**Kurtosis:**	2.67

Warnings:

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

In [ ]:

```
model = SARIMAX(train_whatcom, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

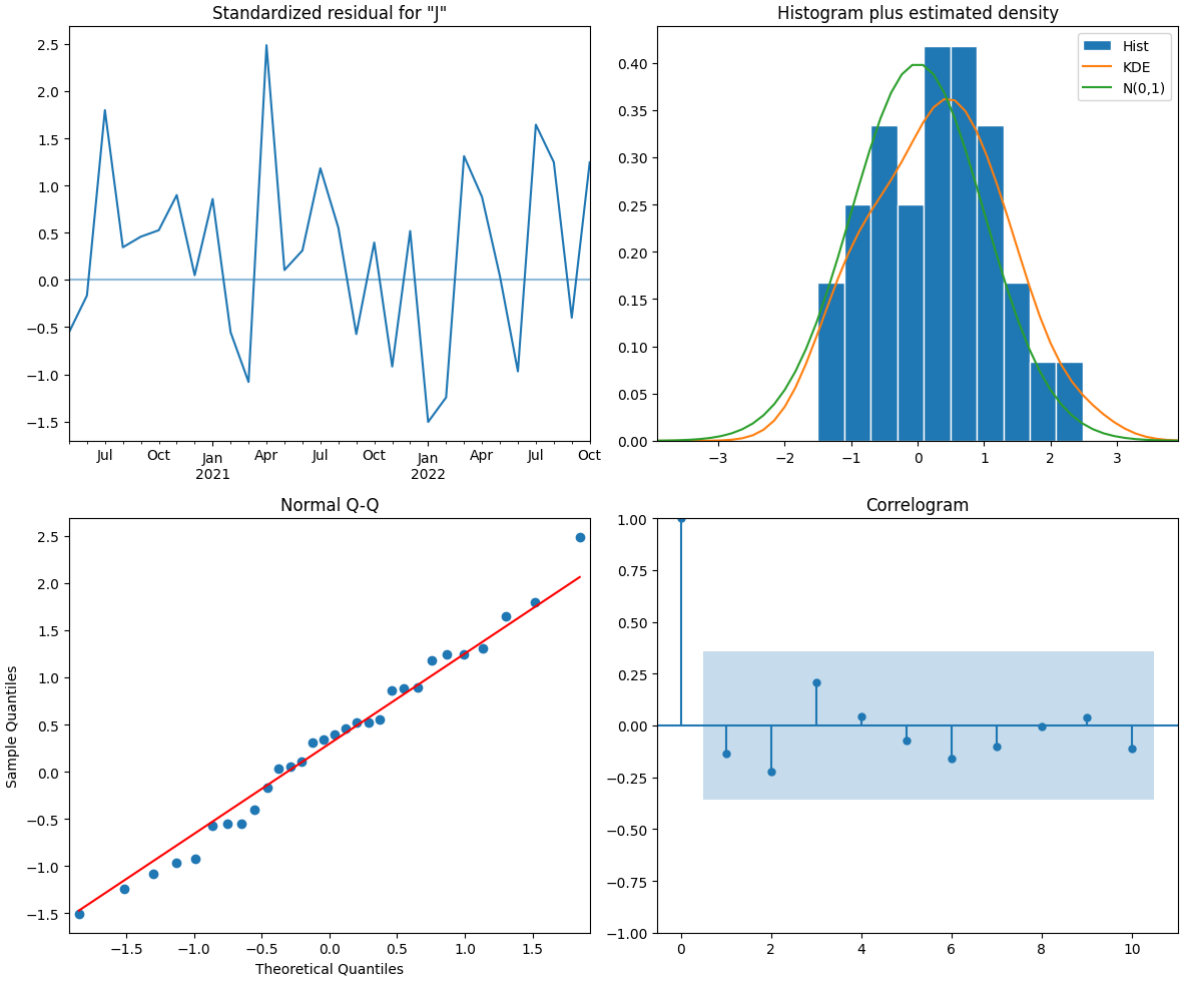
Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-117.368
Date:	Fri, 25 Aug 2023	**AIC**	238.736
Time:	19:56:39	**BIC**	241.539
Sample:	01-31-2020	**HQIC**	239.633
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.6076	0.201	-3.023	0.002	-1.001	-0.214
sigma2	146.1943	46.450	3.147	0.002	55.154	237.235

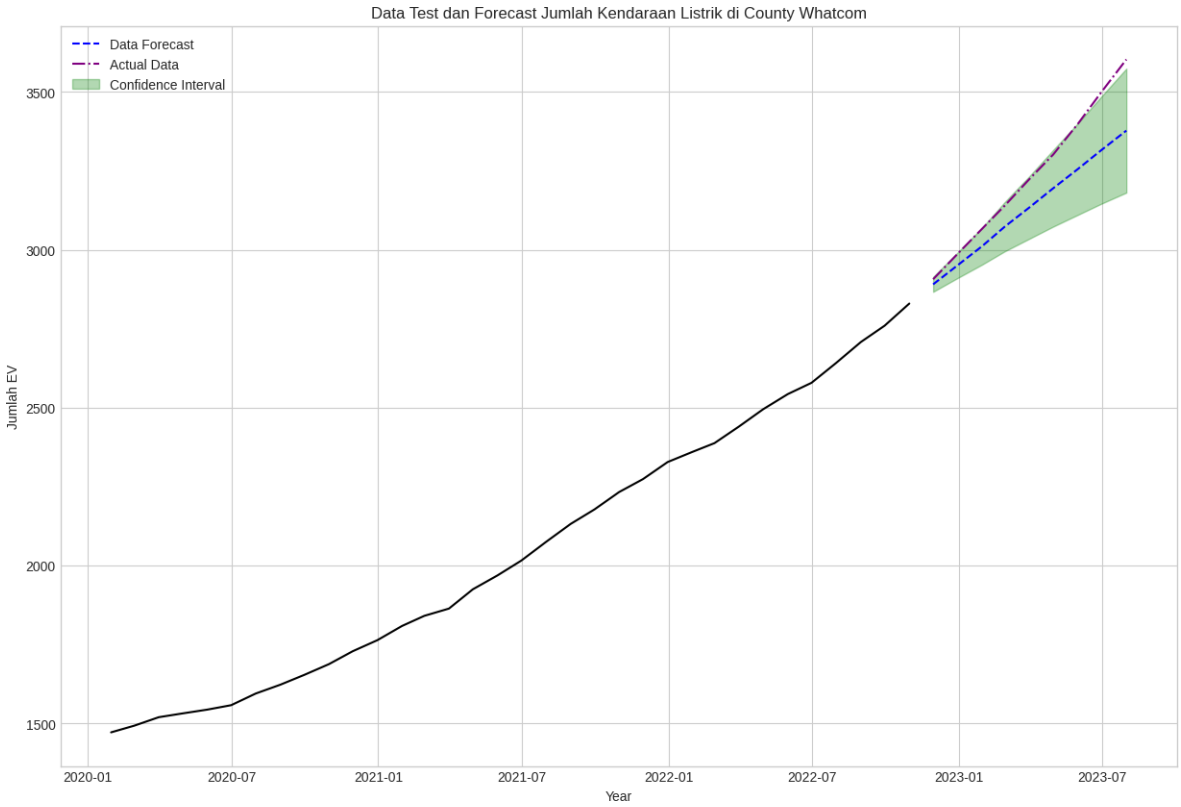
Ljung-Box (L1) (Q):	0.60	**Jarque-Bera (JB):**	0.40
Prob(Q):	0.44	**Prob(JB):**	0.82
Heteroskedasticity (H):	2.19	**Skew:**	0.08
Prob(H) (two-sided):	0.23	**Kurtosis:**	2.46

Warnings:

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



In [ ]:
```
df_whatcom_forecast = get_forecast(model, train_whatcom, test_whatcom, 'Whatcom',
```




```
Mean Absolute Percentage Error: 0.030493507272570837

Mean Squared Error: 14860.436821399066

Root Mean Squared Error: 121.90339134494604

R-squared: 0.6982045691624099
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(whatcom, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

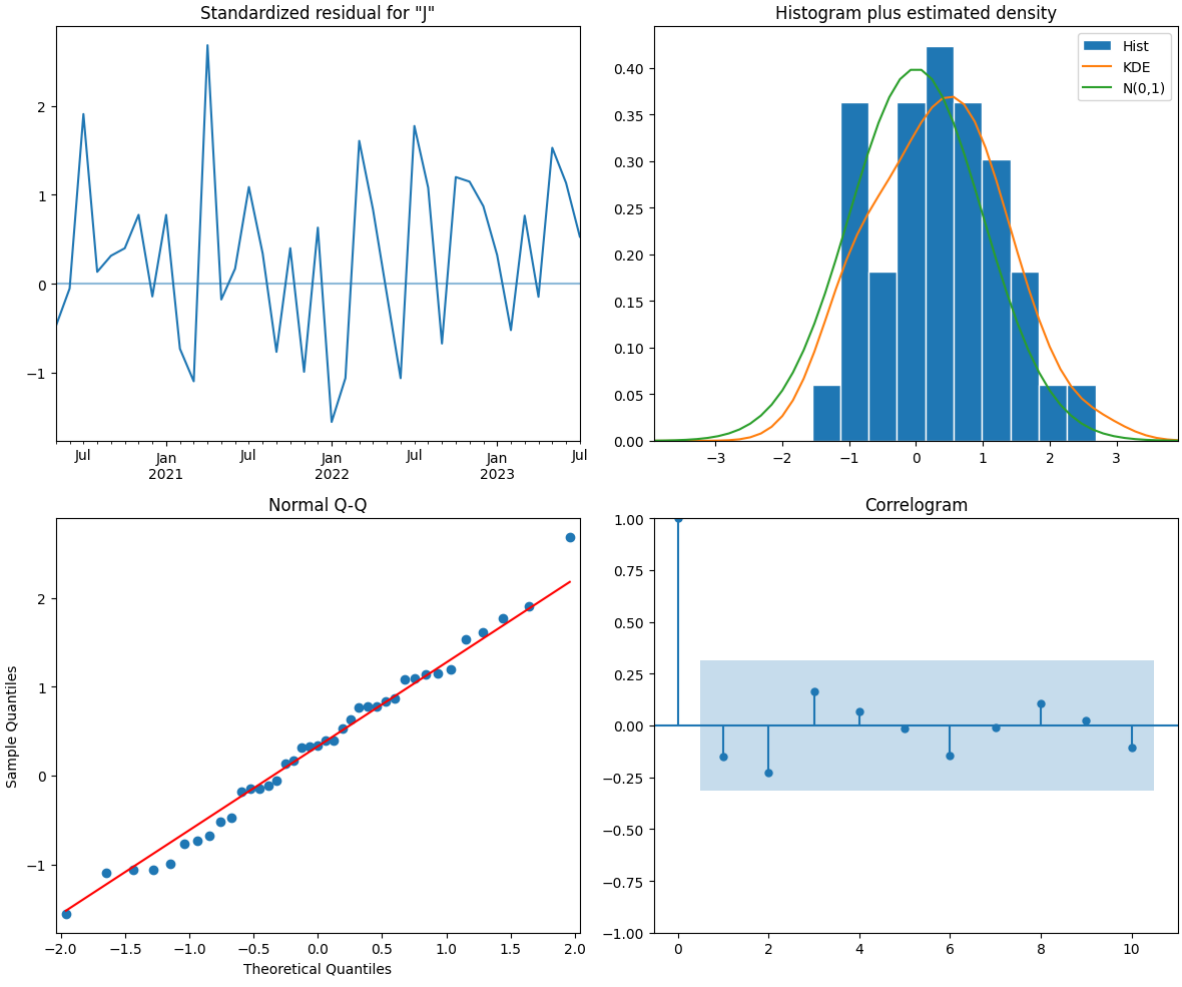
Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-151.872
Date:	Fri, 25 Aug 2023	**AIC**	307.745
Time:	19:59:59	**BIC**	311.072
Sample:	01-31-2020	**HQIC**	308.938
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.4665	0.187	-2.500	0.012	-0.832	-0.101
sigma2	141.2003	40.176	3.515	0.000	62.456	219.944

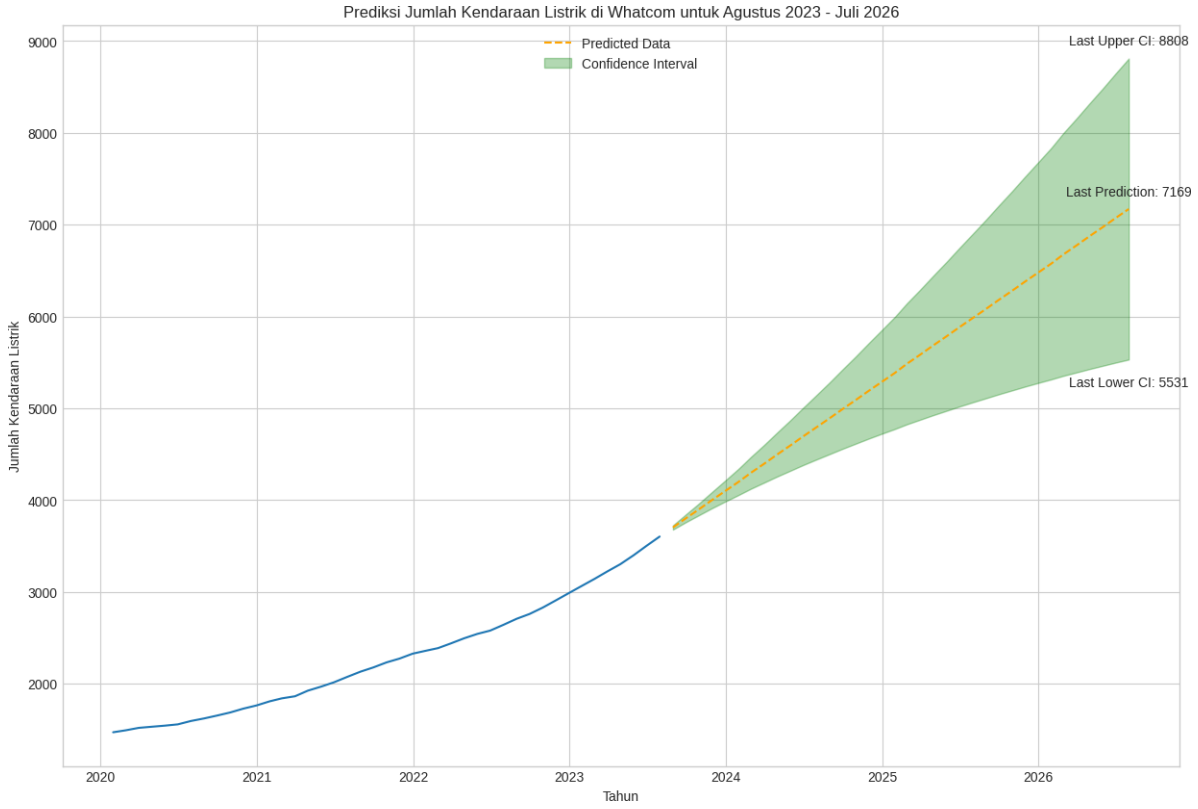
Ljung-Box (L1) (Q):	0.95	**Jarque-Bera (JB):**	0.38
Prob(Q):	0.33	**Prob(JB):**	0.83
Heteroskedasticity (H):	0.92	**Skew:**	0.14
Prob(H) (two-sided):	0.88	**Kurtosis:**	2.61

Warnings:

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



In [ ]:
```
df_whatcom_preds = get_prediction(model, whatcom['Jumlah EV'], test_whatcom, 'Whatc
```



In [ ]:
```
county_information['Whatcom']['Predictions'] = df_whatcom_preds
```

County Benton

Inisialisasi Dataset

In [ ]:
```
county_dfs['Benton']
```

Out[ ]:

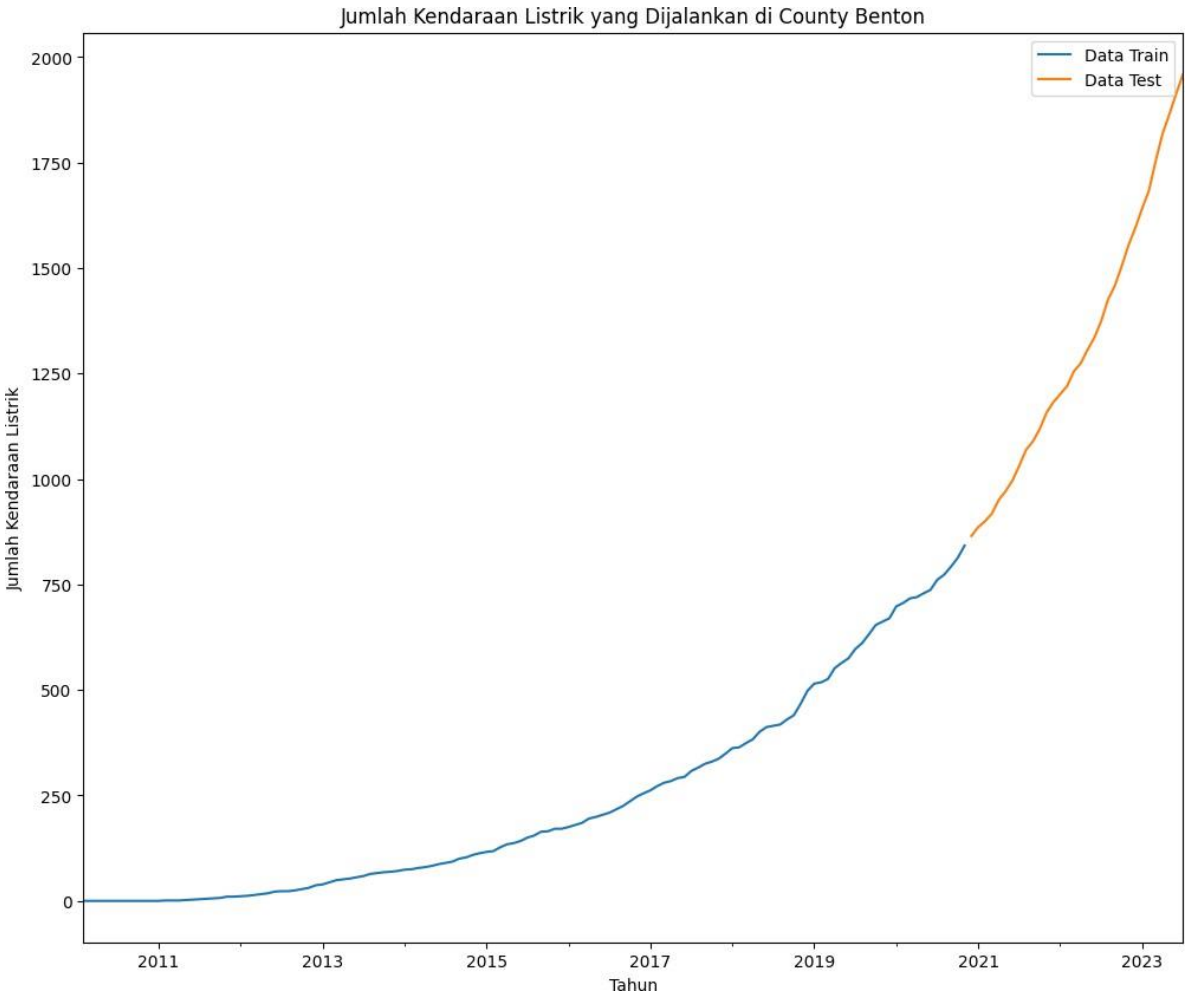
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	0.0
2010-05-31	0.0
2010-06-30	0.0
...	...
2023-03-31	1755.0
2023-04-30	1819.0
2023-05-31	1865.0
2023-06-30	1914.0
2023-07-31	1960.0

162 rows × 1 columns

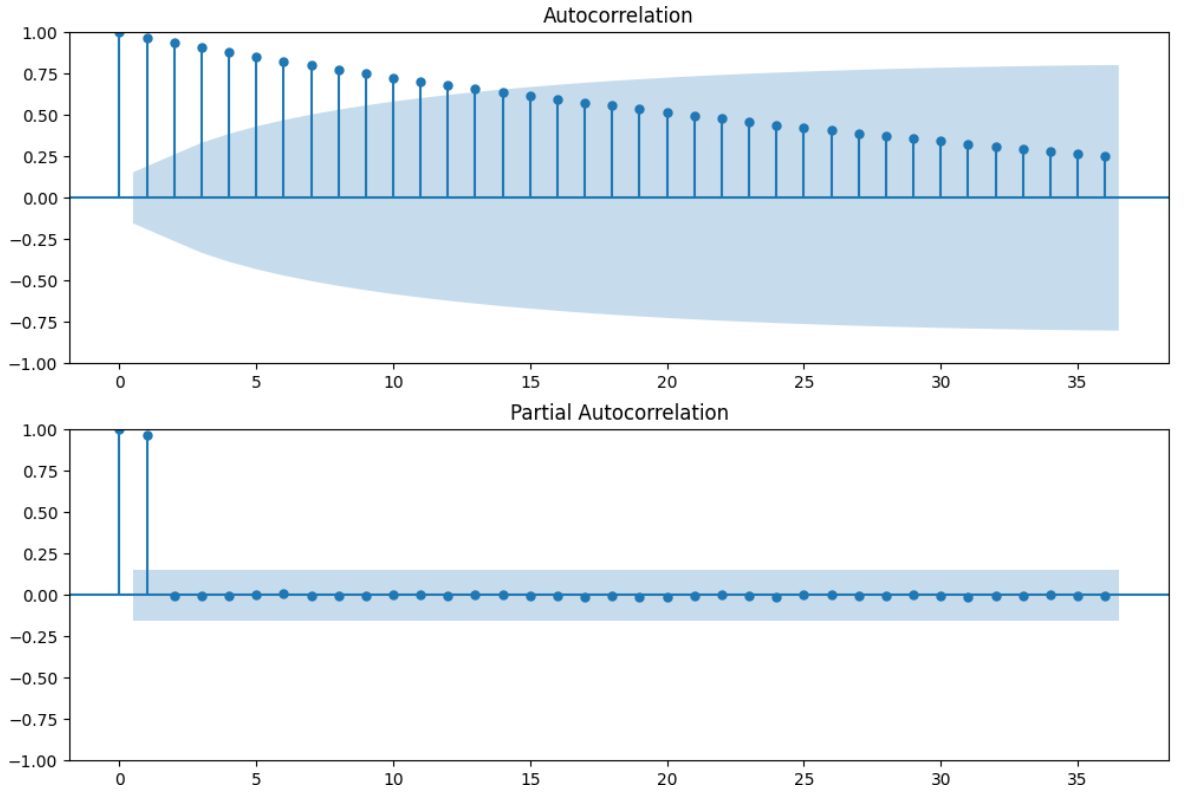
In [ ]:
```
benton = county_dfs['Benton'].copy()
benton.reset_index(inplace=True)
mask = benton['DOL Transaction Date'] >= '2020-01-31'
benton = benton[mask]

benton.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_benton, test_benton = train_test_split_ts(county_information['Benton']['df'],
```

In [ ]:
```
plot_train_test_split(train_benton, test_benton, 'Benton')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig =  sm.graphics.tsa.plot_acf(county_information['Benton']['df'], lags = 36, ax =
ax2 = fig.add_subplot(212)
fig =  sm.graphics.tsa.plot_pacf(county_information['Benton']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_benton, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(1, 2, 4)x(1, 0, [], 12)	**Log Likelihood**	-370.807
Date:	Fri, 25 Aug 2023	**AIC**	757.615
Time:	09:54:16	**BIC**	780.431
Sample:	02-28-2010	**HQIC**	766.885
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	0.2978	0.077	3.892	0.000	0.148	0.448
ar.L1	-0.8700	0.075	-11.659	0.000	-1.016	-0.724
ma.L1	0.1714	0.097	1.764	0.078	-0.019	0.362
ma.L2	-0.9632	0.084	-11.403	0.000	-1.129	-0.798
ma.L3	-0.3186	0.059	-5.428	0.000	-0.434	-0.204
ma.L4	0.2557	0.066	3.874	0.000	0.126	0.385
ar.S.L12	-0.1488	0.080	-1.864	0.062	-0.305	0.008
sigma2	18.7877	1.789	10.501	0.000	15.281	22.294

Ljung-Box (L1) (Q):	0.03	**Jarque-Bera (JB):**	101.34
Prob(Q):	0.87	**Prob(JB):**	0.00
Heteroskedasticity (H):	32.78	**Skew:**	1.21
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.62

Warnings:

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

In [ ]:
```
model = SARIMAX(train_benton, order = (1, 2, 4), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

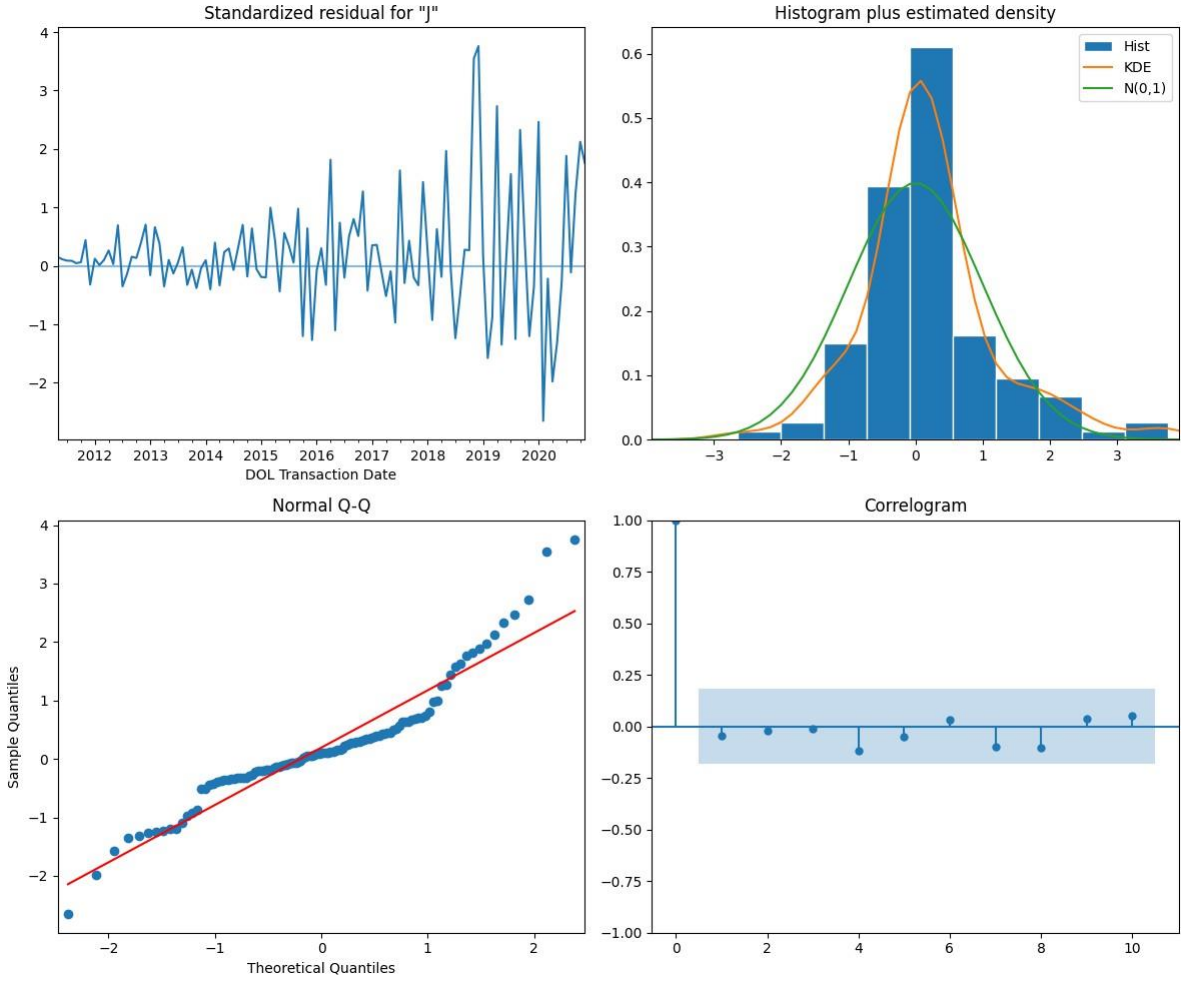
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(1, 2, 4)x(1, 0, [], 12)	**Log Likelihood**	-343.074
Date:	Fri, 25 Aug 2023	**AIC**	700.148
Time:	20:03:46	**BIC**	719.362
Sample:	02-28-2010	**HQIC**	707.947
	- 11-30-2020		
Covariance Type:	opg		

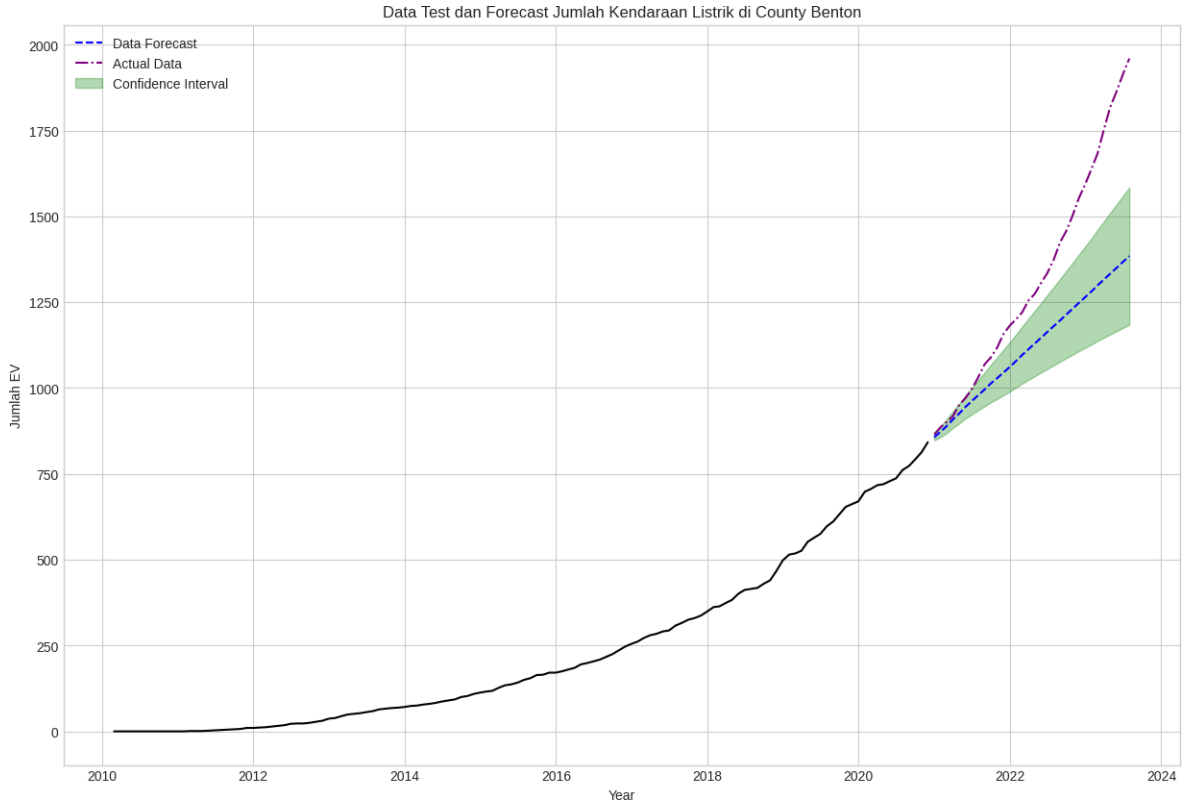
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.8564	0.079	-10.868	0.000	-1.011	-0.702
ma.L1	0.2234	0.101	2.215	0.027	0.026	0.421
ma.L2	-0.8706	0.090	-9.639	0.000	-1.048	-0.694
ma.L3	-0.2891	0.064	-4.500	0.000	-0.415	-0.163
ma.L4	0.2669	0.070	3.831	0.000	0.130	0.403
ar.S.L12	-0.1323	0.086	-1.544	0.123	-0.300	0.036
sigma2	22.4639	2.171	10.345	0.000	18.208	26.720

Ljung-Box (L1) (Q):	0.22	**Jarque-Bera (JB):**	40.36
Prob(Q):	0.64	**Prob(JB):**	0.00
Heteroskedasticity (H):	26.28	**Skew:**	0.81
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.40

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



In [ ]:
```
df_benton_forecast = get_forecast(model, train_benton, test_benton, 'Benton', plot
```

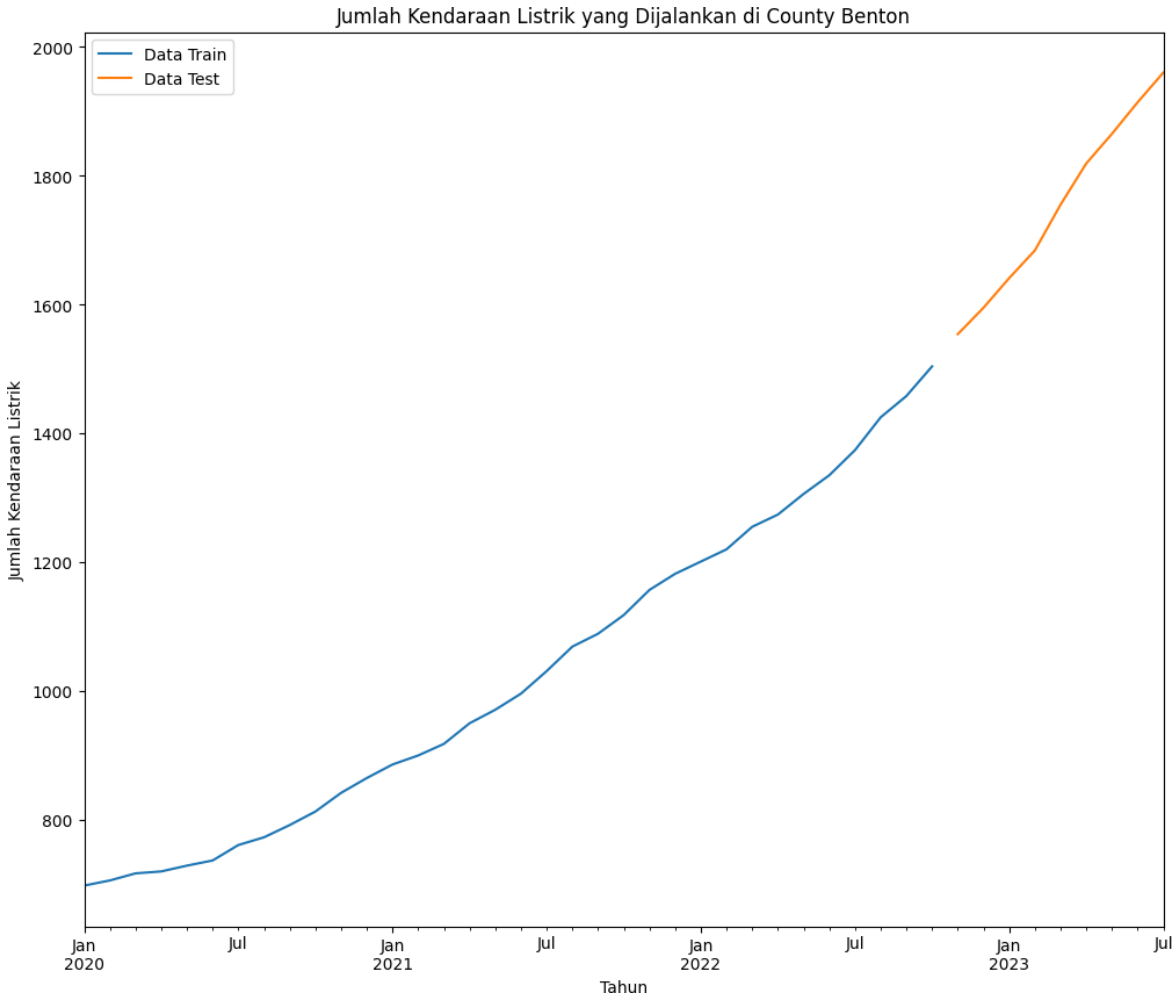


```
Mean Absolute Percentage Error: 0.129787488439577

Mean Squared Error: 68820.2024701758

Root Mean Squared Error: 262.33604874316416

R-squared: 0.3415714888650684
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_benton, test_benton = train_test_split_ts(benton, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_benton, test_benton, 'Benton')
```



In [ ]:
```
auto_model = pm.auto_arima(train_benton, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 1, 2)x(1, 1, [], 12)	**Log Likelihood**	-71.425
Date:	Fri, 25 Aug 2023	**AIC**	152.849
Time:	20:07:52	**BIC**	158.072
Sample:	01-31-2020	**HQIC**	153.983
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	18.5141	2.905	6.372	0.000	12.820	24.209
ma.L1	-0.5630	0.241	-2.334	0.020	-1.036	-0.090
ma.L2	0.6789	0.250	2.717	0.007	0.189	1.169
ar.S.L12	-0.7704	0.149	-5.169	0.000	-1.063	-0.478
sigma2	29.7320	14.329	2.075	0.038	1.649	57.815

Ljung-Box (L1) (Q):	1.40	**Jarque-Bera (JB):**	2.04
Prob(Q):	0.24	**Prob(JB):**	0.36
Heteroskedasticity (H):	0.85	**Skew:**	0.71
Prob(H) (two-sided):	0.84	**Kurtosis:**	2.46

Warnings:

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

In [ ]:

```
model = SARIMAX(train_benton, order = (0, 1, 2), seasonal_order = (1, 1, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 1, 2)x(1, 1, [], 12)	**Log Likelihood**	-33.788
Date:	Fri, 25 Aug 2023	**AIC**	75.576
Time:	20:06:19	**BIC**	76.364
Sample:	01-31-2020	**HQIC**	73.873
	- 10-31-2022		
Covariance Type:	opg		

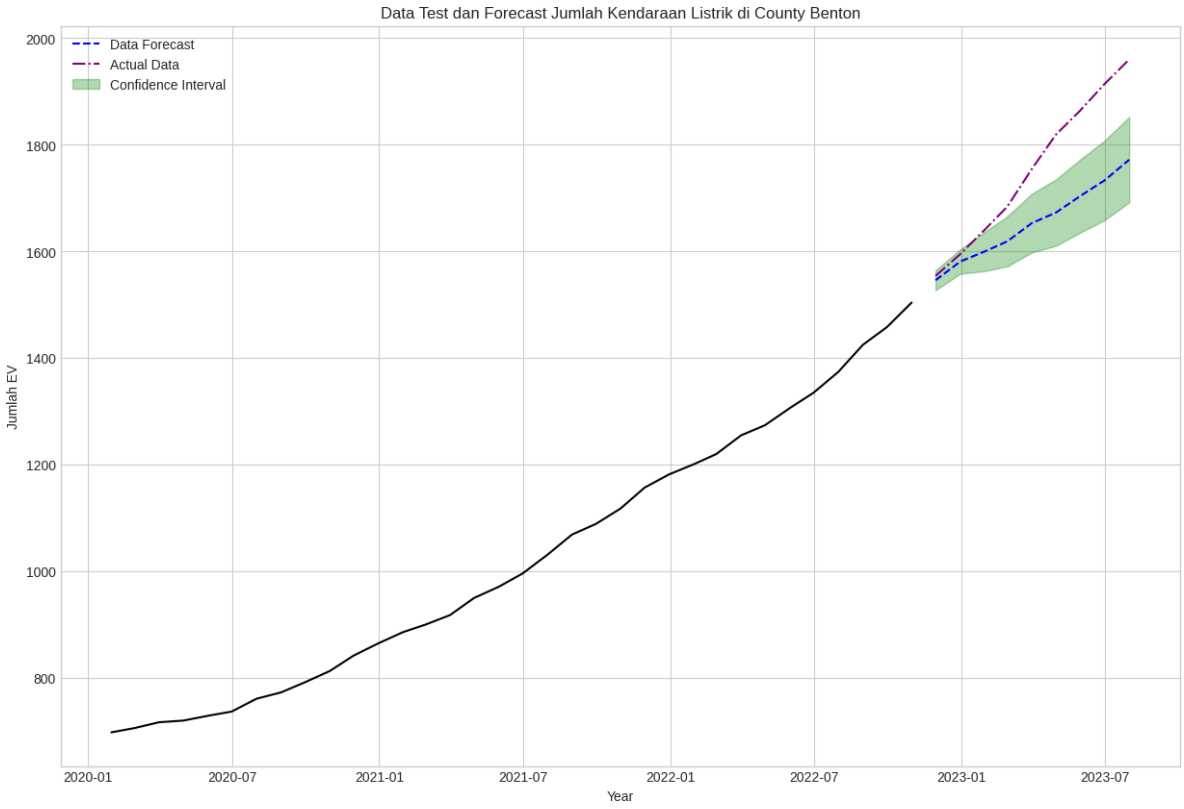
	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.3273	0.362	-0.903	0.366	-1.038	0.383
ma.L2	1.0000	0.965	1.036	0.300	-0.891	2.891
ar.S.L12	-0.0370	0.245	-0.151	0.880	-0.517	0.443
sigma2	78.2486	0.013	6181.742	0.000	78.224	78.273

Ljung-Box (L1) (Q):	0.11	**Jarque-Bera (JB):**	0.69
Prob(Q):	0.74	**Prob(JB):**	0.71
Heteroskedasticity (H):	0.83	**Skew:**	-0.63
Prob(H) (two-sided):	0.88	**Kurtosis:**	2.50

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number 6.07e+19. Standard errors may be unstable.

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-241-2a3141a64a00> in <cell line: 3>()
      1 model = SARIMAX(train_benton, order = (0, 1, 2), seasonal_order = (1, 1,
0, 12),
      2                 enforce_invertibility = False, enforce_stationarity = Fals
e).fit()
----> 3 evaluate_model(model)

<ipython-input-67-01bf108b49e8> in evaluate_model(model)
      1 def evaluate_model(model):
      2   display(model.summary())
----> 3   model.plot_diagnostics()
      4   plt.tight_layout()

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/statespace/mlemodel.py in
plot_diagnostics(self, variable, lags, fig, figsize, truncate_endog_names, auto_yl
ims, bartlett_confint, acf_kwargs)
   4611
   4612         if resid.shape[0] < max(d, lags):
-> 4613             raise ValueError(
   4614                 "Length of endogenous variable must be larger the the numb
er "
   4615                 "of lags used in the model and the number of observations
"

ValueError: Length of endogenous variable must be larger the the number of lags us
ed in the model and the number of observations burned in the log-likelihood calcul
ation.
<Figure size 1200x1000 with 0 Axes>
```

In [ ]:
```
df_benton_forecast = get_forecast(model, train_benton, test_benton, 'Benton', plot
```



```
Mean Absolute Percentage Error: 0.054728085423617165

Mean Squared Error: 14640.58984235711

Root Mean Squared Error: 120.99830512183676

R-squared:  0.2134958726306968
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(benton, order = (0, 1, 2), seasonal_order = (1, 1, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/t
ueWarning:

No frequency information was provided, so inferred frequency

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/t
ueWarning:

No frequency information was provided, so inferred frequency
```

SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 1, 2)x(1, 1, [], 12)	**Log Likelihood**	-71.941
Date:	Fri, 25 Aug 2023	**AIC**	151.881
Time:	20:08:09	**BIC**	155.443
Sample:	01-31-2020	**HQIC**	152.372
	- 07-31-2023		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	0.6050	0.258	2.345	0.019	0.099	1.111
ma.L2	0.7055	0.402	1.756	0.079	-0.082	1.493
ar.S.L12	-0.4335	0.283	-1.533	0.125	-0.988	0.121
sigma2	158.9824	93.633	1.698	0.090	-24.535	342.500

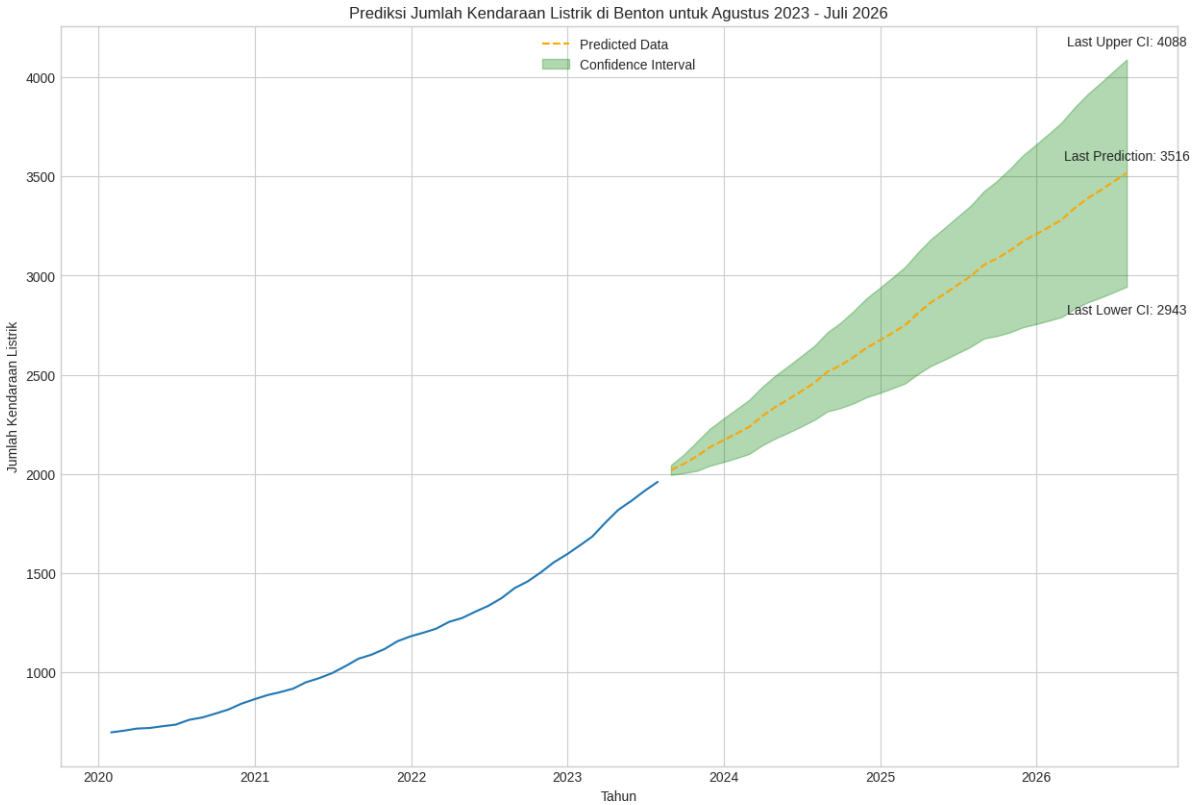
Ljung-Box (L1) (Q):	2.14	**Jarque-Bera (JB):**	0.50
Prob(Q):	0.14	**Prob(JB):**	0.78
Heteroskedasticity (H):	2.38	**Skew:**	-0.39
Prob(H) (two-sided):	0.32	**Kurtosis:**	2.78

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

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-244-96942f7ab4d2> in <cell line: 3>()
      1 model = SARIMAX(benton, order = (0, 1, 2), seasonal_order = (1, 1, 0, 12),
      2                 enforce_invertibility = False, enforce_stationarity = Fals
e).fit()
----> 3 evaluate_model(model)

<ipython-input-67-01bf108b49e8> in evaluate_model(model)
      1 def evaluate_model(model):
      2   display(model.summary())
----> 3   model.plot_diagnostics()
      4   plt.tight_layout()

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/statespace/mlemodel.py in
plot_diagnostics(self, variable, lags, fig, figsize, truncate_endog_names, auto_yl
ims, bartlett_confint, acf_kwargs)
   4611
   4612         if resid.shape[0] < max(d, lags):
-> 4613             raise ValueError(
   4614                 "Length of endogenous variable must be larger the the numb
er "
   4615                 "of lags used in the model and the number of observations
"

ValueError: Length of endogenous variable must be larger the the number of lags us
ed in the model and the number of observations burned in the log-likelihood calcul
ation.
```

<Figure size 1200x1000 with 0 Axes>

In [ ]:
```
df_benton_preds = get_prediction(model, benton['Jumlah EV'], test_benton, 'Benton',
```



In [ ]:
```
county_information['Benton']['Predictions'] = df_benton_preds
```

County Island

Inisialisasi Dataset

In [ ]:
```
county_dfs['Island']
```

Out[ ]:

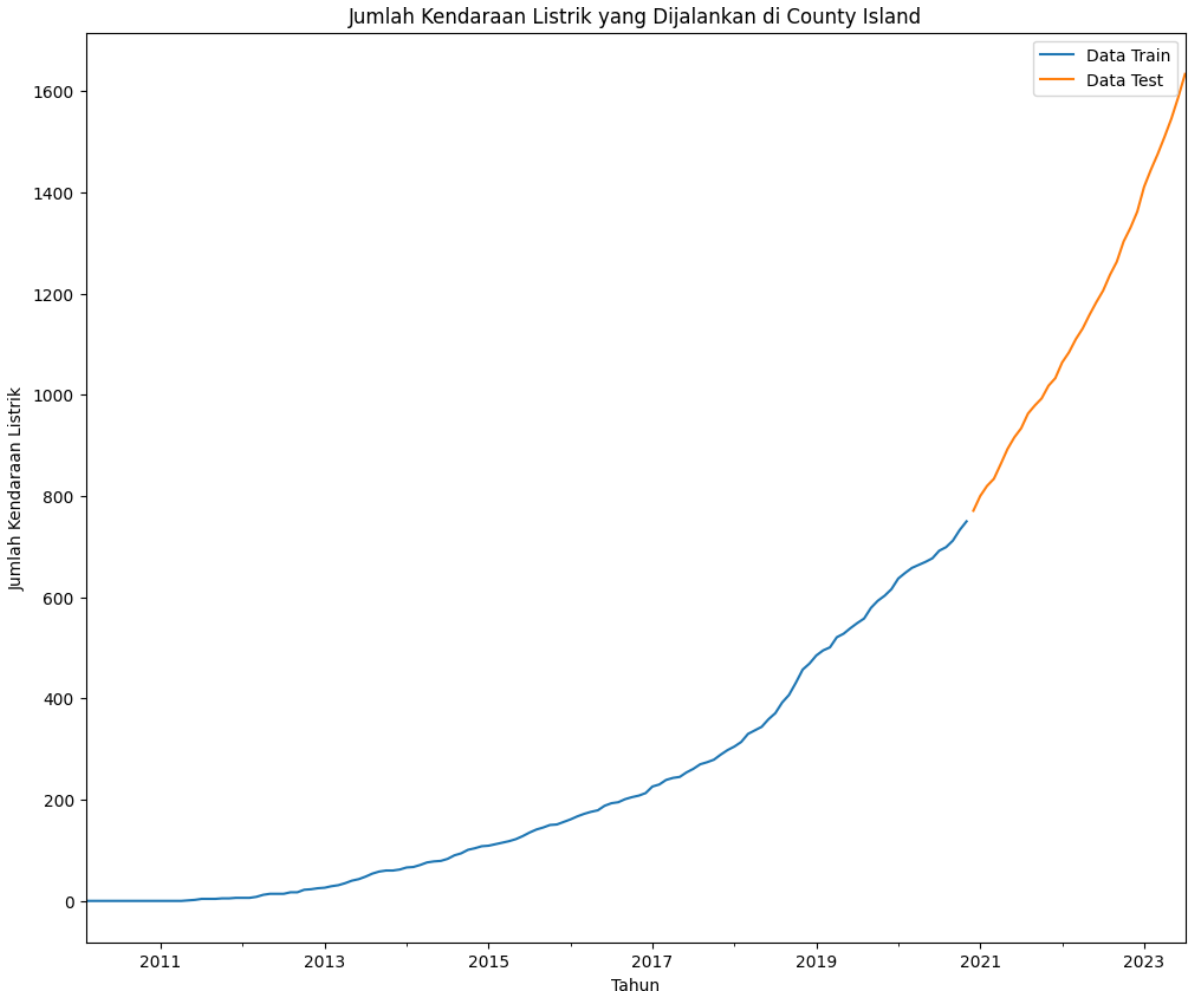
DOL Transaction Date	Jumlah EV
2010-02-28	0.0
2010-03-31	0.0
2010-04-30	0.0
2010-05-31	0.0
2010-06-30	0.0
...	...
2023-03-31	1476.0
2023-04-30	1510.0
2023-05-31	1546.0
2023-06-30	1588.0
2023-07-31	1634.0

162 rows × 1 columns

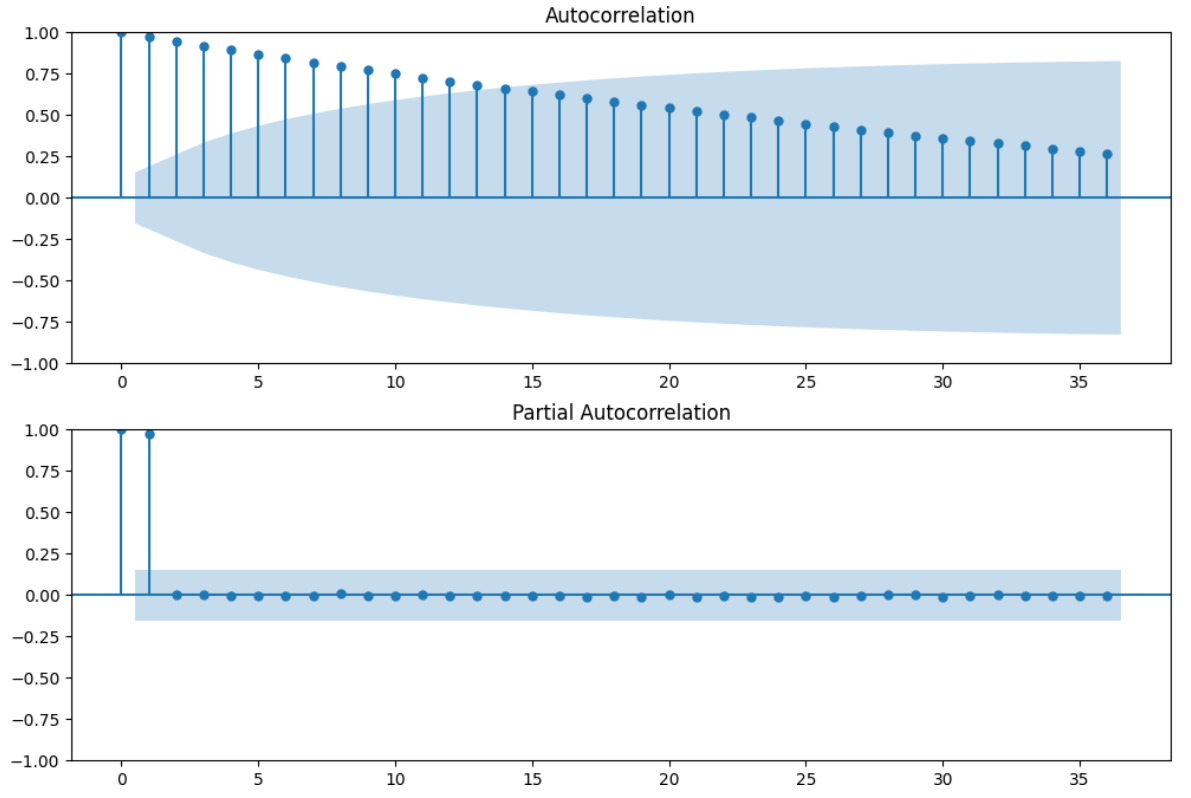
In [ ]:
```
island = county_dfs['Island'].copy()
island.reset_index(inplace=True)
mask = island['DOL Transaction Date'] >= '2020-01-31'
island = island[mask]

island.set_index('DOL Transaction Date', inplace = True)
```

In [ ]:
```
train_island, test_island = train_test_split_ts(county_information['Island']['df'],
```

In [ ]:
```
plot_train_test_split(train_island, test_island, 'Island')
```



In [ ]:
```
fig = plt.figure(figsize = (12, 8))
ax1 = fig.add_subplot(211)
fig =  sm.graphics.tsa.plot_acf(county_information['Island']['df'], lags = 36, ax =
ax2 = fig.add_subplot(212)
fig =  sm.graphics.tsa.plot_pacf(county_information['Island']['df'], lags = 36, ax
```



In [ ]:
```
auto_model = pm.auto_arima(train_island, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-344.158
Date:	Fri, 25 Aug 2023	**AIC**	692.317
Time:	09:55:34	**BIC**	698.021
Sample:	02-28-2010	**HQIC**	694.634
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7197	0.039	-18.575	0.000	-0.796	-0.644
sigma2	12.6025	1.180	10.676	0.000	10.289	14.916

Ljung-Box (L1) (Q):	0.06	**Jarque-Bera (JB):**	18.07
Prob(Q):	0.81	**Prob(JB):**	0.00
Heteroskedasticity (H):	17.23	**Skew:**	0.60
Prob(H) (two-sided):	0.00	**Kurtosis:**	4.39

Warnings:

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

In [ ]:
```
model = SARIMAX(train_island, order = (0, 2, 1),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

SARIMAX Results

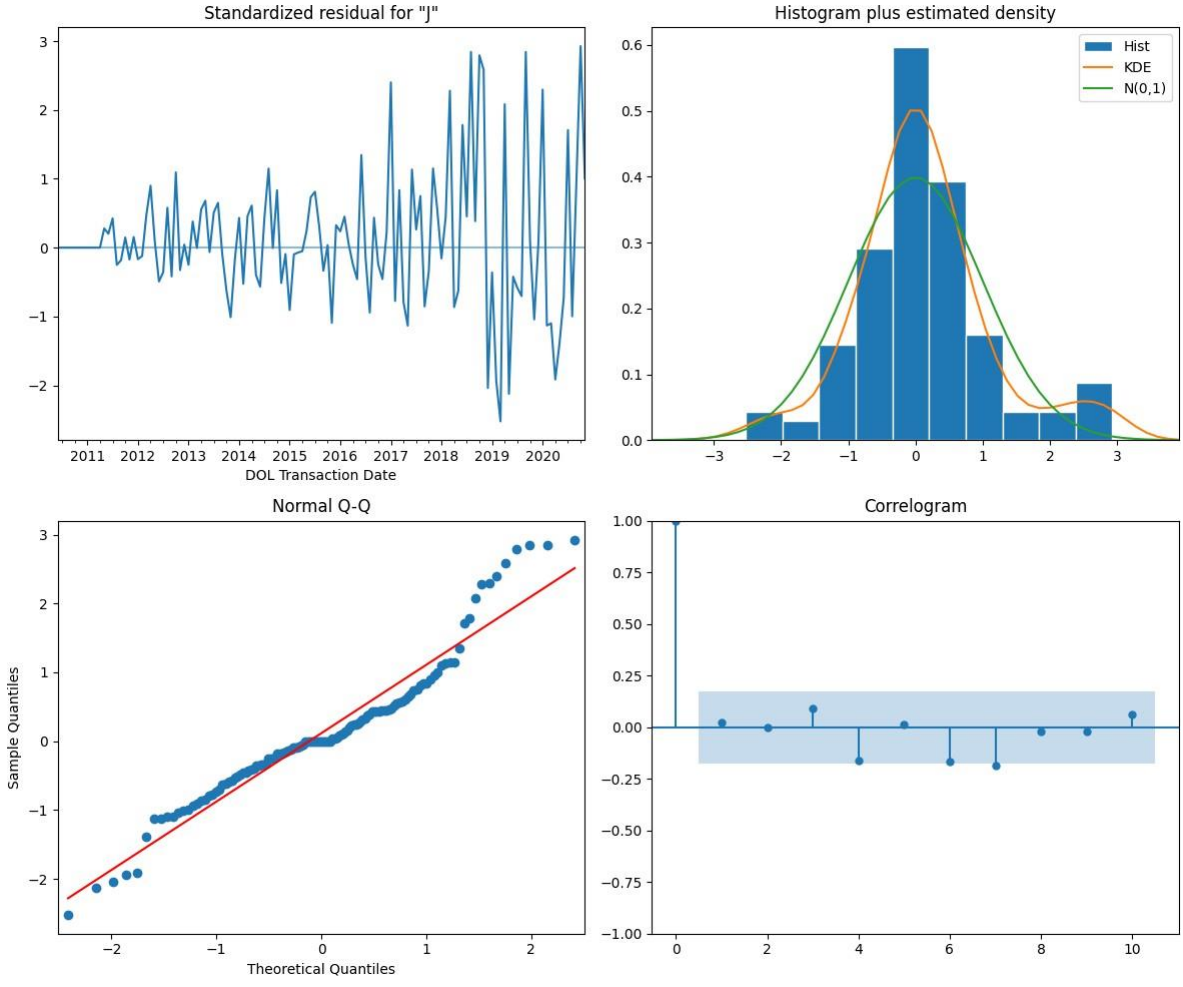
Dep. Variable:	Jumlah EV	**No. Observations:**	130
Model:	SARIMAX(0, 2, 1)	**Log Likelihood**	-339.487
Date:	Fri, 25 Aug 2023	**AIC**	682.973
Time:	20:09:01	**BIC**	688.646
Sample:	02-28-2010	**HQIC**	685.278
	- 11-30-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.7250	0.039	-18.653	0.000	-0.801	-0.649
sigma2	12.8014	1.221	10.484	0.000	10.408	15.194

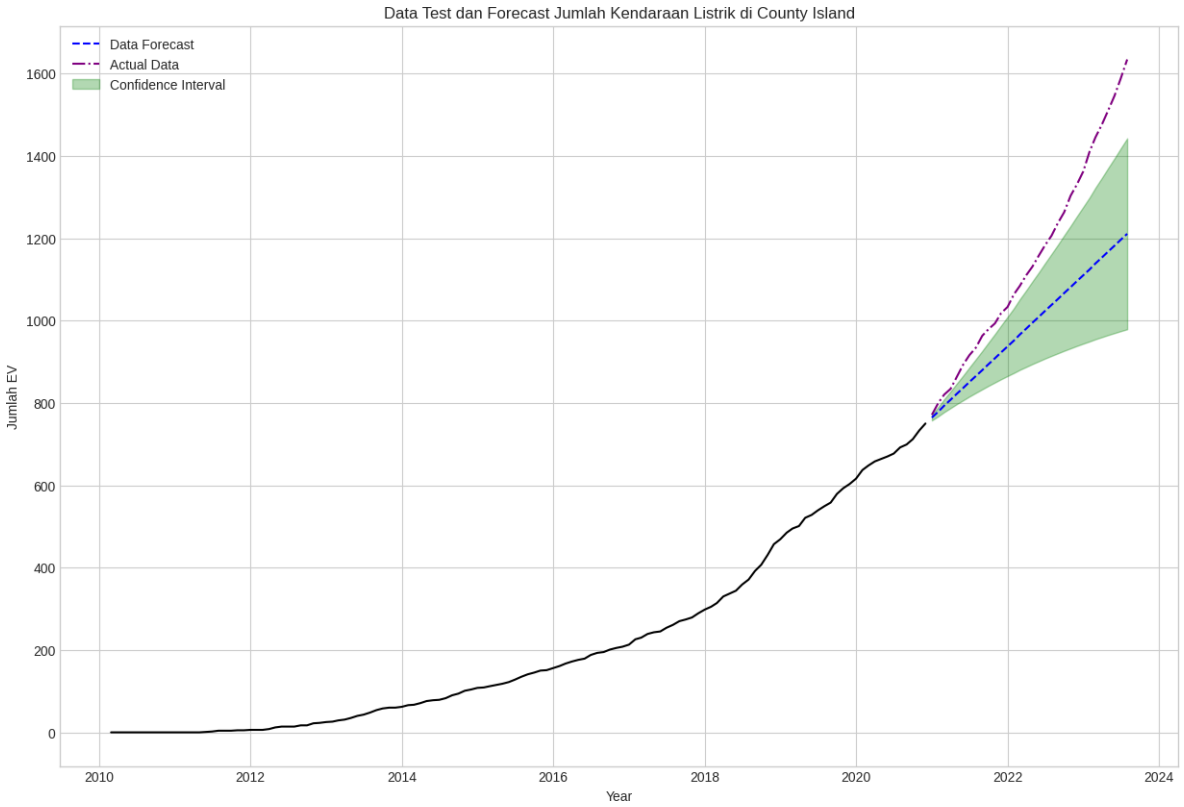
Ljung-Box (L1) (Q):	0.08	**Jarque-Bera (JB):**	16.76
Prob(Q):	0.78	**Prob(JB):**	0.00
Heteroskedasticity (H):	14.48	**Skew:**	0.60
Prob(H) (two-sided):	0.00	**Kurtosis:**	4.33

Warnings:

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



In [ ]:
```
df_island_forecast = get_forecast(model, train_island, test_island, 'Island', plot
```

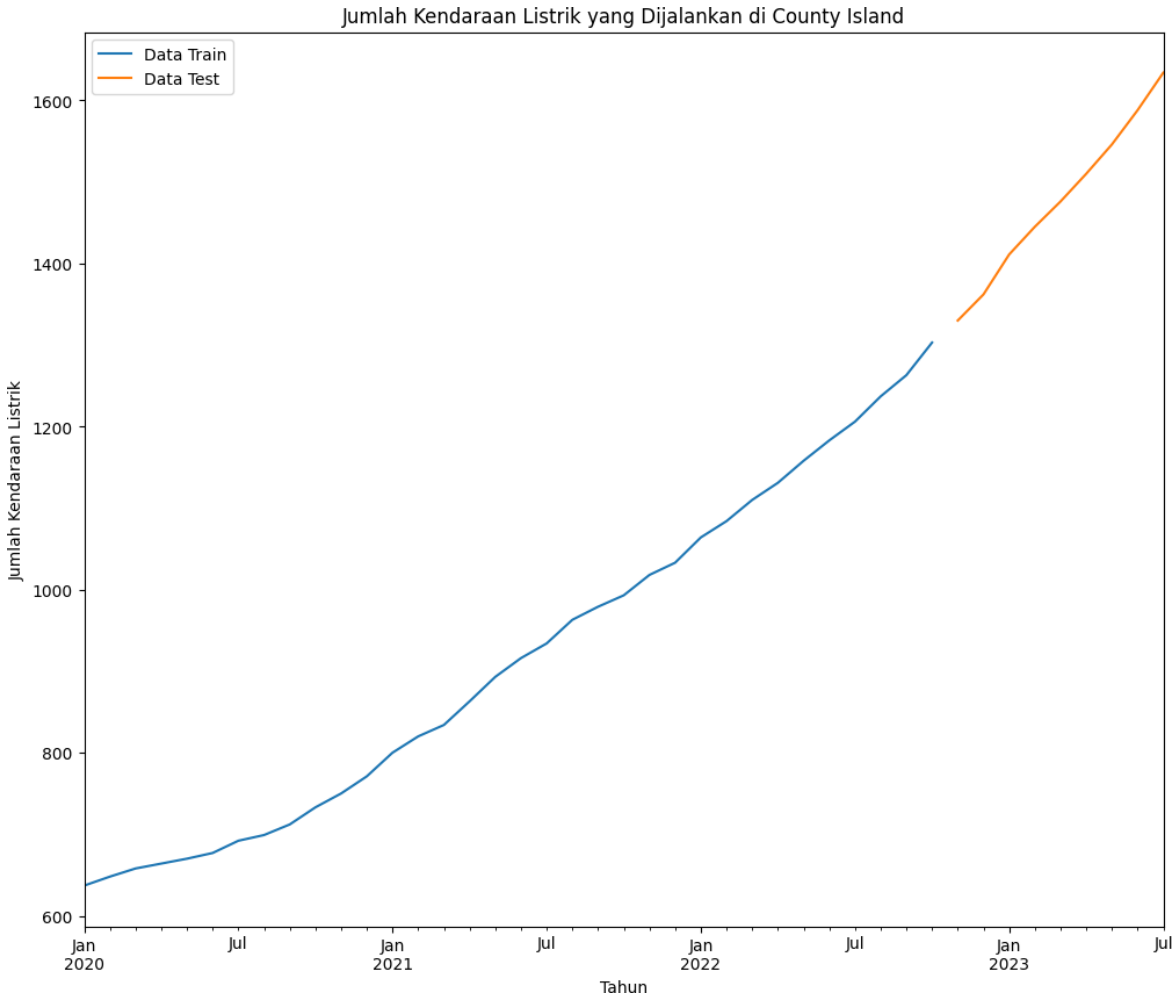



```
Mean Absolute Percentage Error: 0.12794473089930986

Mean Squared Error: 40528.2565204465

Root Mean Squared Error: 201.3163096235536

R-squared:  0.3375113765581427
```

Menggunakan Data dari Tahun 2020 Saja

In [ ]:
```
train_island, test_island = train_test_split_ts(island, 0.80, 0.20)
```

In [ ]:
```
plot_train_test_split(train_island, test_island, 'Island')
```



In [ ]:
```
auto_model = pm.auto_arima(train_island, start_p = 0, start_d = 0, start_q = 0, ma
                           max_d = 3, max_q = 4, start_P = 0, start_D = 0, start_Q
                           max_D = 3, max_Q = 3, m = 12)
auto_model.summary()
```

Out[ ]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	34
Model:	SARIMAX(0, 2, 2)x(1, 0, [], 12)	**Log Likelihood**	-101.788
Date:	Fri, 25 Aug 2023	**AIC**	213.576
Time:	09:55:53	**BIC**	220.904
Sample:	01-31-2020	**HQIC**	216.005
	- 10-31-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	0.9127	0.429	2.126	0.033	0.071	1.754
ma.L1	-0.9783	0.312	-3.137	0.002	-1.590	-0.367
ma.L2	0.2920	0.297	0.984	0.325	-0.289	0.873
ar.S.L12	-0.3362	0.167	-2.010	0.044	-0.664	-0.008
sigma2	31.3874	11.144	2.817	0.005	9.546	53.228

Ljung-Box (L1) (Q):	0.00	**Jarque-Bera (JB):**	0.79
Prob(Q):	0.98	**Prob(JB):**	0.67
Heteroskedasticity (H):	1.15	**Skew:**	0.22
Prob(H) (two-sided):	0.82	**Kurtosis:**	2.37

Warnings:

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

In [ ]:

```
model = SARIMAX(train_island, order = (0, 2, 2), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: Val
ueWarning:

No frequency information was provided, so inferred frequency M will be used.
```

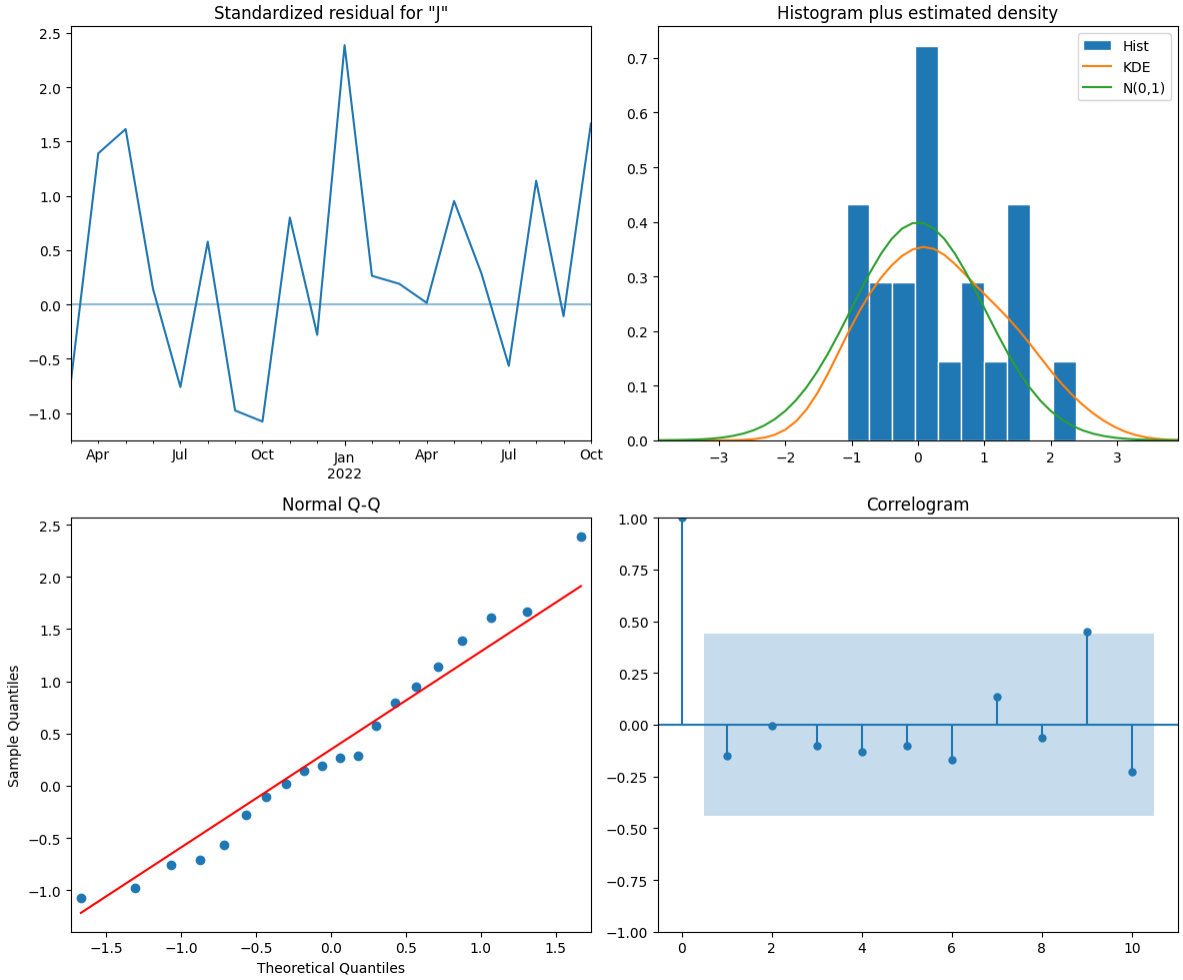
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	34
Model:	SARIMAX(0, 2, 2)x(1, 0, [], 12)	**Log Likelihood**	-65.749
Date:	Fri, 25 Aug 2023	**AIC**	139.499
Time:	20:09:54	**BIC**	143.482
Sample:	01-31-2020	**HQIC**	140.276
	- 10-31-2022		
Covariance Type:	opg		

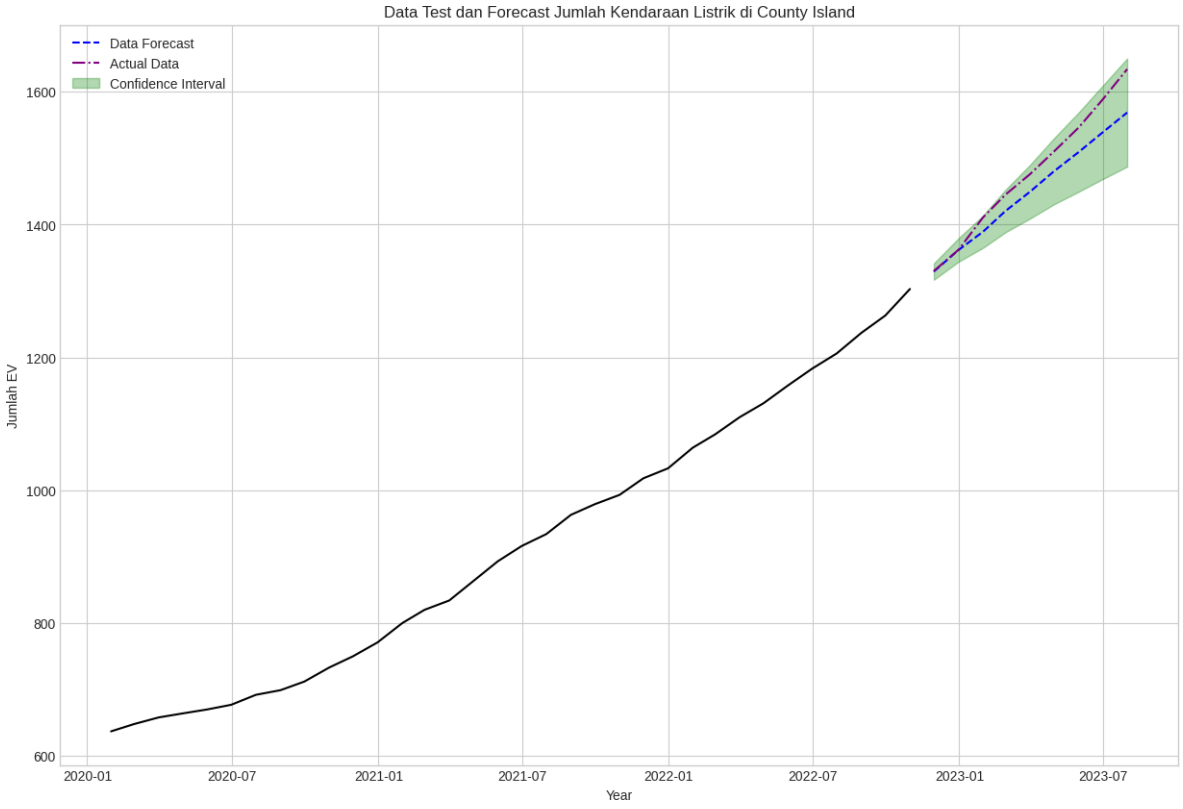
	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.9803	0.462	-2.121	0.034	-1.886	-0.074
ma.L2	0.3091	0.332	0.932	0.351	-0.341	0.959
ar.S.L12	-0.2954	0.186	-1.588	0.112	-0.660	0.069
sigma2	39.9056	15.000	2.660	0.008	10.506	69.305

Ljung-Box (L1) (Q):	0.53	**Jarque-Bera (JB):**	0.84
Prob(Q):	0.47	**Prob(JB):**	0.66
Heteroskedasticity (H):	0.78	**Skew:**	0.36
Prob(H) (two-sided):	0.75	**Kurtosis:**	2.30

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



In [ ]:
```
df_island_forecast = get_forecast(model, train_island, test_island, 'Island', plot
```



```
Mean Absolute Percentage Error: 0.018433867571239253

Mean Squared Error: 1193.9563958647745

Root Mean Squared Error: 34.5536741297474

R-squared:  0.8705753912896808
```

Prediksi Masa Depan

In [ ]:
```
model = SARIMAX(island, order = (0, 2, 2), seasonal_order = (1, 0, 0, 12),
                enforce_invertibility = False, enforce_stationarity = False).fit()
evaluate_model(model)
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/t
ueWarning:

No frequency information was provided, so inferred frequency

/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/t
ueWarning:

No frequency information was provided, so inferred frequency
```

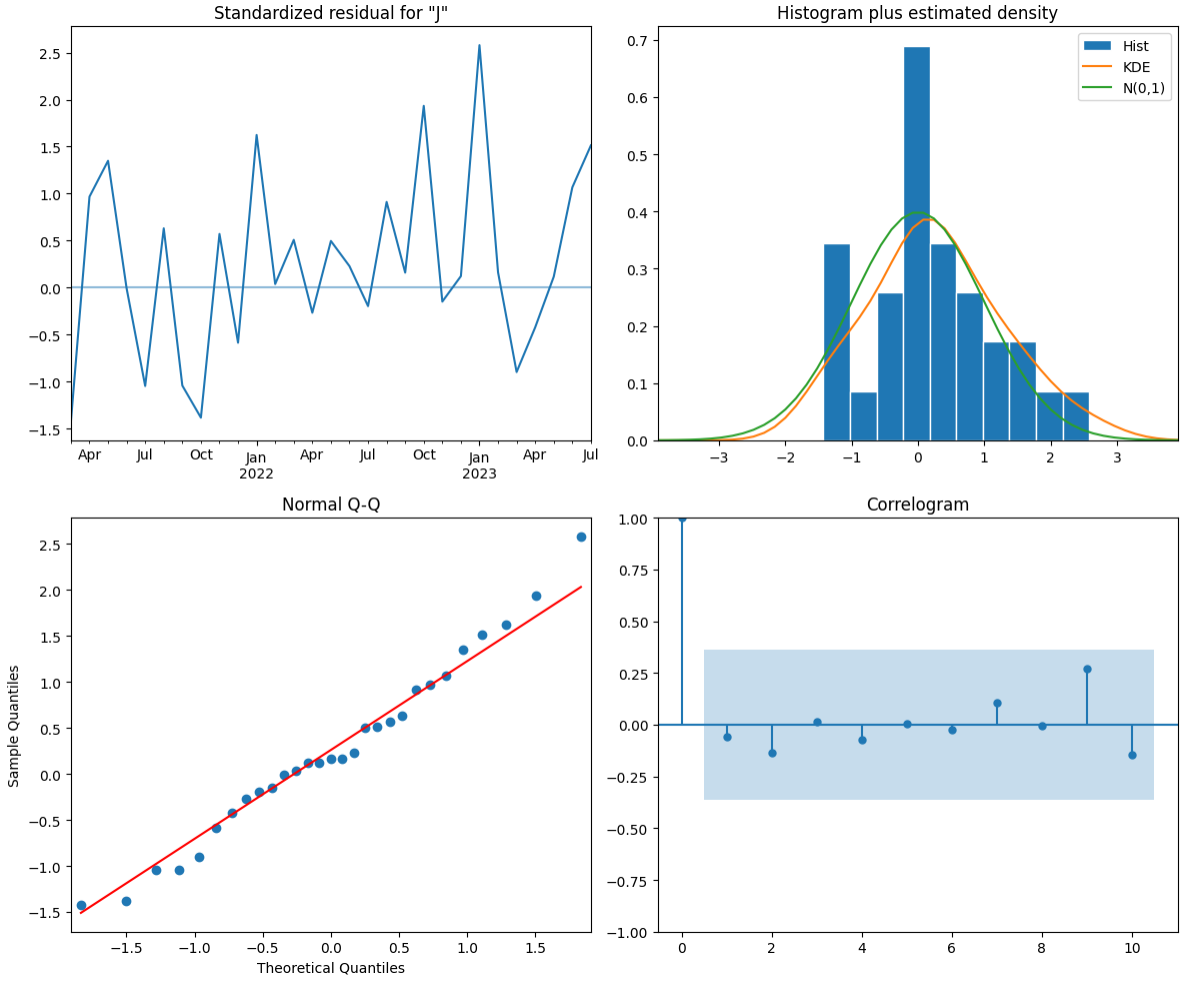
SARIMAX Results

Dep. Variable:	Jumlah EV	**No. Observations:**	43
Model:	SARIMAX(0, 2, 2)x(1, 0, [], 12)	**Log Likelihood**	-97.525
Date:	Fri, 25 Aug 2023	**AIC**	203.050
Time:	20:11:27	**BIC**	208.519
Sample:	01-31-2020	**HQIC**	204.763
	- 07-31-2023		
Covariance Type:	opg		

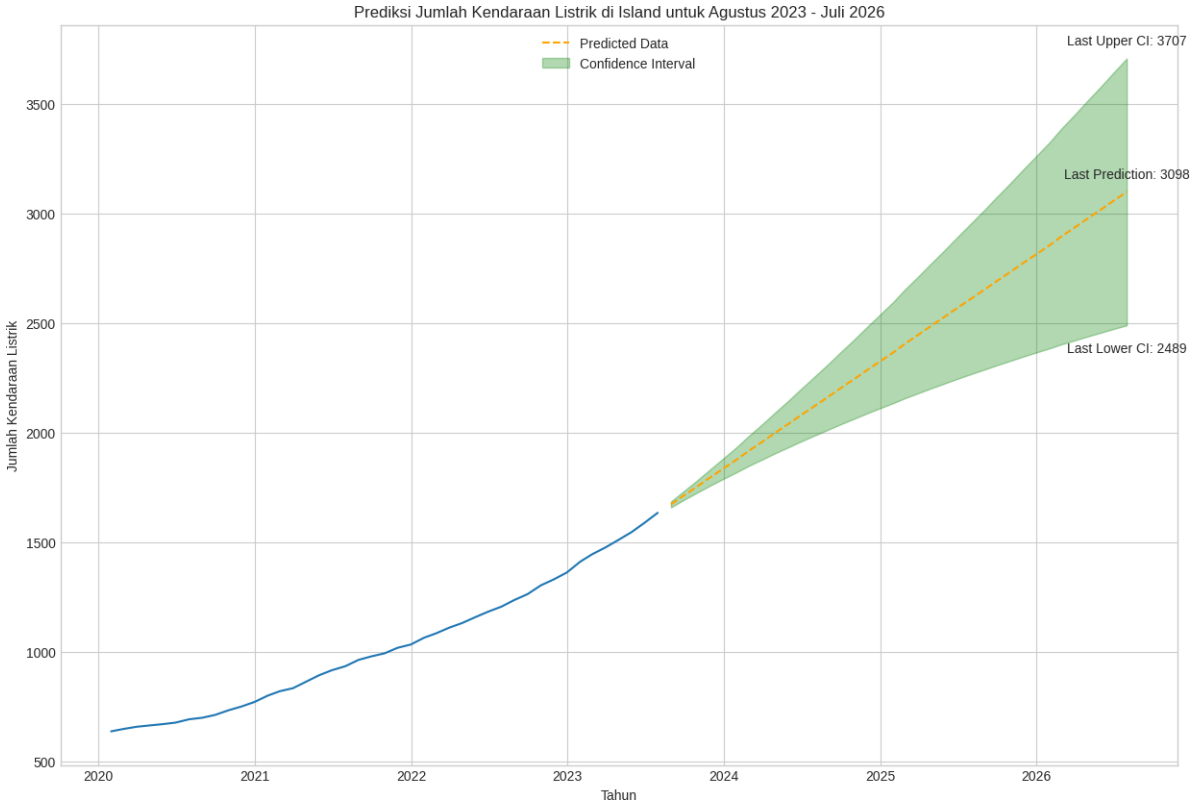
	coef	std err	z	P>|z|	[0.025	0.975]
ma.L1	-0.9069	0.327	-2.776	0.006	-1.547	-0.267
ma.L2	0.2385	0.254	0.940	0.347	-0.259	0.736
ar.S.L12	0.0012	0.019	0.062	0.951	-0.036	0.038
sigma2	48.6983	14.941	3.259	0.001	19.414	77.983

Ljung-Box (L1) (Q):	0.10	**Jarque-Bera (JB):**	0.51
Prob(Q):	0.75	**Prob(JB):**	0.78
Heteroskedasticity (H):	1.50	**Skew:**	0.30
Prob(H) (two-sided):	0.54	**Kurtosis:**	2.73

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



In [ ]:
```
df_island_preds = get_prediction(model, island['Jumlah EV'], test_island, 'Island',
```



In [ ]:
```
county_information['Island']['Predictions'] = df_island_preds
```

Penyimpanan Data

In [ ]:
```
drop_kolom = ['Lower Confidence Interval',      'Upper Confidence Interval']
top_10_county = ['King', 'Snohomish', 'Pierce', 'Clark', 'Thurston', 'Kitsap', 'Sp

df_pred = df_king_preds.drop(drop_kolom, axis=1)
df_pred.rename(columns = {'Predictions':'Jumlah EV - King'}, inplace = True)
df_pred.index.name = 'Date'
for x in top_10_county:
  if x == 'King':
    continue
  val = pd.DataFrame(county_information[x]['Predictions'])
  val = val.drop(drop_kolom, axis=1)
  val.rename(columns = {'Predictions':f'Jumlah EV - {x}'}, inplace = True)
  val.index.name = 'Date'
  df_pred = df_pred.merge(val, how='left', on='Date')
print(df_pred.head())
```

```
            Jumlah EV - King  Jumlah EV - Snohomish  Jumlah EV - Pierce  \
Date
2023-08-31      98120.058756           19698.458325        19698.458325
2023-09-30     100597.954185           20280.916760        20280.916760
2023-10-31     103817.839452           21002.334011        21002.334011
2023-11-30     106908.444803           21741.498820        21741.498820
2023-12-31     109862.225571           22463.122958        22463.122958

            Jumlah EV - Clark  Jumlah EV - Thurston  Jumlah EV - Kitsap  \
Date
2023-08-31       10836.912025           5696.216578         5533.874362
2023-09-30       11142.824050           5836.340754         5657.748723
2023-10-31       11448.736075           5978.207120         5781.623085
2023-11-30       11754.648100           6120.454294         5905.497447
2023-12-31       12060.560125           6262.075109         6029.371808

            Jumlah EV - Spokane  Jumlah EV - Whatcom  Jumlah EV - Benton  \
Date
2023-08-31          4185.492669          3702.065834         2020.015424
2023-09-30          4299.985338          3801.131668         2050.901220
2023-10-31          4414.478007          3900.197502         2089.531867
2023-11-30          4528.970676          3999.263336         2134.763462
2023-12-31          4643.463345          4098.329170         2168.827601

            Jumlah EV - Island
Date
2023-08-31         1672.208684
2023-09-30         1712.929362
2023-10-31         1753.666444
2023-11-30         1794.388294
2023-12-31         1835.116003
```

In [ ]:
```
top_10_county = ['King', 'Snohomish', 'Pierce', 'Clark', 'Thurston', 'Kitsap', 'Sp
df_ori = pd.DataFrame(county_information['King']['df'])
df_ori.rename(columns = {'Jumlah EV':'Jumlah EV - King'}, inplace = True)
for x in top_10_county:
  if x == 'King':
    continue
  val = pd.DataFrame(county_information[x]['df'])
  val.rename(columns = {'Jumlah EV':f'Jumlah EV - {x}'}, inplace = True)
  df_ori = df_ori.merge(val, how='left', on='DOL Transaction Date')
print(df_ori.head())
```

DOL Transaction Date	Jumlah EV - King	Jumlah EV - Snohomish
2010-02-28	0.0	0.0
2010-03-31	1.0	0.0
2010-04-30	2.0	0.0
2010-05-31	2.0	1.0
2010-06-30	3.0	1.0

DOL Transaction Date	Jumlah EV - Pierce	Jumlah EV - Clark
2010-02-28	0.0	0.0
2010-03-31	0.0	1.0
2010-04-30	0.0	1.0
2010-05-31	0.0	1.0
2010-06-30	0.0	1.0

DOL Transaction Date	Jumlah EV - Thurston	Jumlah EV - Kitsap
2010-02-28	0.0	1
2010-03-31	0.0	1
2010-04-30	0.0	1
2010-05-31	1.0	1
2010-06-30	1.0	1

DOL Transaction Date	Jumlah EV - Spokane	Jumlah EV - Whatcom
2010-02-28	0.0	0.0
2010-03-31	0.0	0.0
2010-04-30	1.0	1.0
2010-05-31	1.0	1.0
2010-06-30	1.0	1.0

DOL Transaction Date	Jumlah EV - Benton	Jumlah EV - Island
2010-02-28	0.0	0.0
2010-03-31	0.0	0.0
2010-04-30	0.0	0.0
2010-05-31	0.0	0.0
2010-06-30	0.0	0.0

In [ ]:
```
df_final = pd.concat([df_ori, df_pred])
print(df_final)
```

```
            Jumlah EV - King  Jumlah EV - Snohomish  Jumlah EV - Pierce  \
2010-02-28          0.000000               0.000000           0.000000
2010-03-31          1.000000               0.000000           0.000000
2010-04-30          2.000000               0.000000           0.000000
2010-05-31          2.000000               1.000000           0.000000
2010-06-30          3.000000               1.000000           0.000000
...                      ...                    ...                ...
2026-03-31     208023.590423           50156.430199       50156.430199
2026-04-30     212153.358888           51545.176451       51545.176451
2026-05-31     216257.131839           52920.693961       52920.693961
2026-06-30     220448.880262           54354.614909       54354.614909
2026-07-31     224552.182515           55869.283575       55869.283575

            Jumlah EV - Clark  Jumlah EV - Thurston  Jumlah EV - Kitsap  \
2010-02-28          0.000000               0.000000           1.000000
2010-03-31          1.000000               0.000000           1.000000
2010-04-30          1.000000               0.000000           1.000000
2010-05-31          1.000000               1.000000           1.000000
2010-06-30          1.000000               1.000000           1.000000
...                      ...                    ...                ...
2026-03-31      20320.184802           10092.956655        9373.979573
2026-04-30      20626.096827           10234.837953        9497.853935
2026-05-31      20932.008852           10376.719250        9621.728297
2026-06-30      21237.920877           10518.600548        9745.602659
2026-07-31      21543.832902           10660.481846        9869.477020

            Jumlah EV - Spokane  Jumlah EV - Whatcom  Jumlah EV - Benton  \
2010-02-28             0.000000              0.000000           0.000000
2010-03-31             0.000000              0.000000           0.000000
2010-04-30             1.000000              1.000000           0.000000
2010-05-31             1.000000              1.000000           0.000000
2010-06-30             1.000000              1.000000           0.000000
...                         ...                   ...                ...
2026-03-31          7734.765405           6773.106689        3338.817803
2026-04-30          7849.258074           6872.172523        3388.101182
2026-05-31          7963.750743           6971.238357        3429.522678
2026-06-30          8078.243412           7070.304191        3471.981958
2026-07-31          8192.736081           7169.370025        3515.692706

            Jumlah EV - Island
2010-02-28           0.000000
2010-03-31           0.000000
2010-04-30           0.000000
2010-05-31           0.000000
2010-06-30           0.000000
...                       ...
2026-03-31        2935.022100
2026-04-30        2975.760046
2026-05-31        3016.497993
2026-06-30        3057.235939
2026-07-31        3097.973886

[198 rows x 10 columns]
```

In [ ]:
```
df_final = df_final.rename_axis('Date').reset_index()
df_final.head()
```

Out[ ]:

	Date	Jumlah EV - King	Jumlah EV - Snohomish	Jumlah EV - Pierce	Jumlah EV - Clark	Jumlah EV - Thurston	Jumlah EV - Kitsap	Jumlah EV - Spokane	Jumlah EV - Whatcom	Jumlah EV - Benton
0	2010-02-28	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
1	2010-03-31	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
2	2010-04-30	2.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0
3	2010-05-31	2.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0
4	2010-06-30	3.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0

In [ ]:
```
# Menyimpan df_cumsum untuk pembuatan dashboard
df_final.to_csv('jumlah_kendaraan_ori_dan_prediksi.csv', index = False)
```

In [ ]:
```

```