

```
In [95]: import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

```
In [96]: df = pd.read_csv("ICNSA.csv")
```

```
In [97]: df.head()
```

Out[97]:

	DATE	ICNSA
0	1/7/1967	208000
1	1/14/1967	207000
2	1/21/1967	217000
3	1/28/1967	204000
4	2/4/1967	216000

```
In [98]: df.shape
```

Out[98]: (2981, 2)

```
In [99]: df.describe
```

Out[99]: <bound method NDFrame.describe of

	DATE	ICNSA
0	1/7/1967	208000
1	1/14/1967	207000
2	1/21/1967	217000
3	1/28/1967	204000
4	2/4/1967	216000
...
2976	1/20/2024	215000
2977	1/27/2024	227000
2978	2/3/2024	220000
2979	2/10/2024	213000
2980	2/17/2024	201000

[2981 rows x 2 columns]>



```
In [100]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 2981 entries, 0 to 2980  
Data columns (total 2 columns):  
#   Column  Non-Null Count  Dtype    
---  ---      -  
0   DATE     2981 non-null   object   
1   ICNSA    2981 non-null   int64    
dtypes: int64(1), object(1)  
memory usage: 46.7+ KB
```

```
In [101]: df.isnull().sum()
```

```
Out[101]: DATE      0  
          ICNSA     0  
          dtype: int64
```

```
In [102]: df['DATE'] = pd.to_datetime(df['DATE'])  
          df.corr()
```

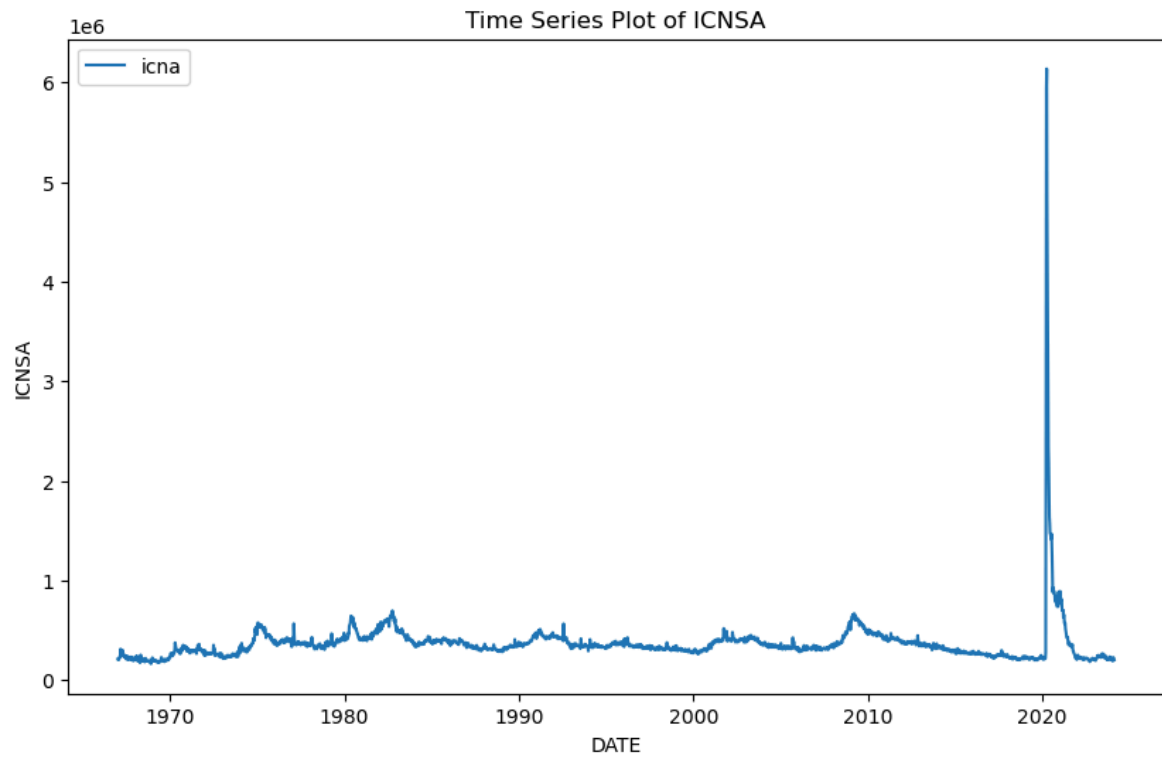
```
Out[102]:
```

	DATE	ICNSA
DATE	1.000000	0.086549
ICNSA	0.086549	1.000000



```
In [103]: plt.figure(figsize=(10, 6))
plt.plot(df['DATE'], df['ICNSA'], label='icna')

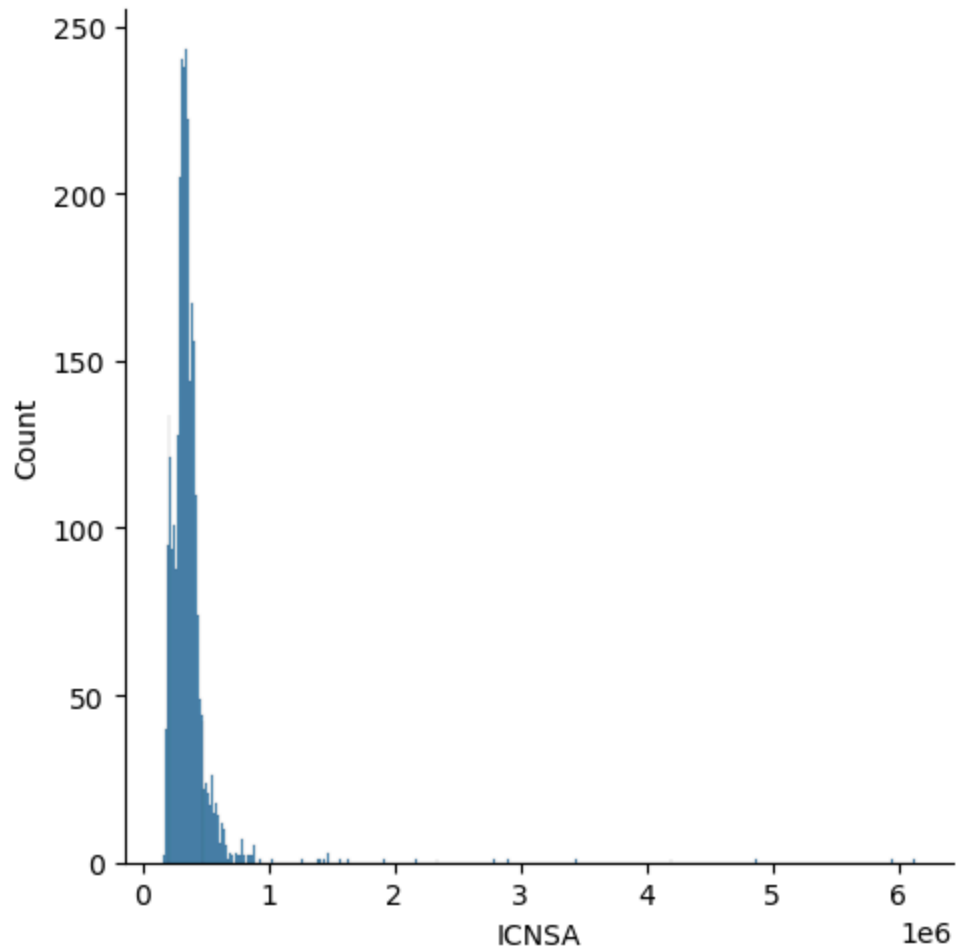
plt.xlabel('DATE')
plt.ylabel('ICNSA')
plt.title('Time Series Plot of ICNSA')
plt.legend()
plt.show()
```



```
In [104]: sns.displot(df['ICNSA'])
```

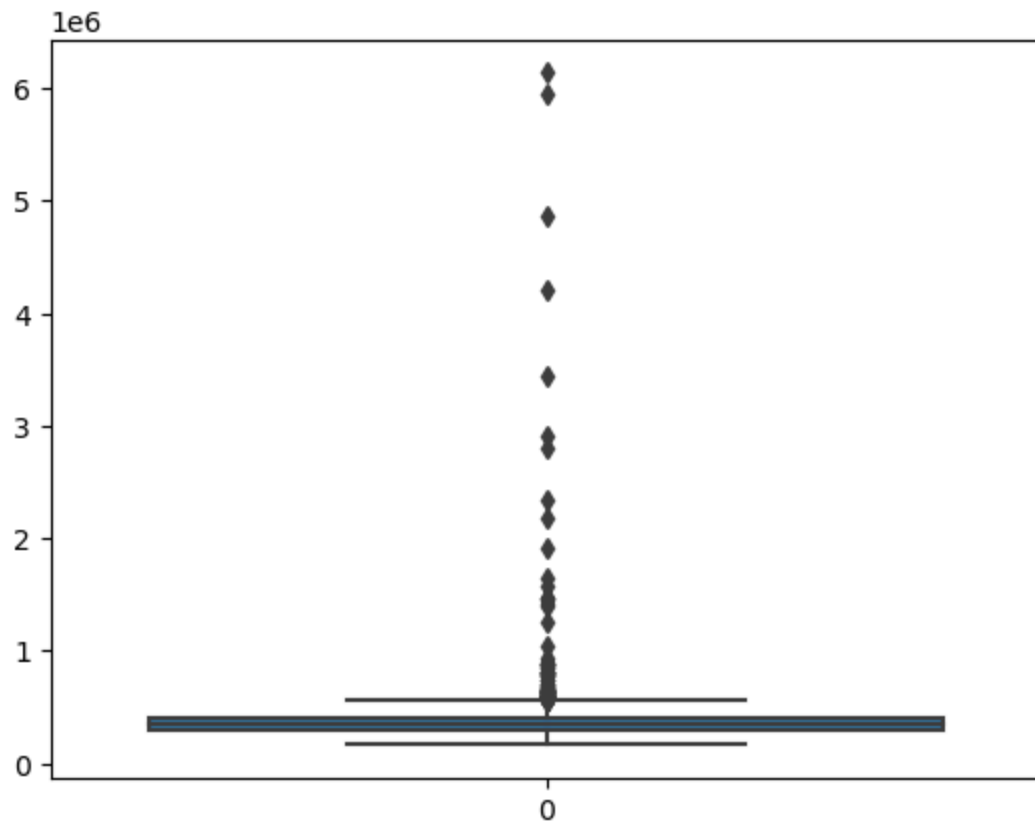
```
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to tight  
self._figure.tight_layout(*args, **kwargs)
```

```
Out[104]: <seaborn.axisgrid.FacetGrid at 0x232b5a93f10>
```



```
In [105]: sns.boxplot(df['ICNSA'])
```

```
Out[105]: <Axes: >
```



```

In [106]: import pandas as pd
import numpy as np
from scipy.interpolate import CubicSpline
import matplotlib.pyplot as plt
start_date = '2020-03-01'
end_date = '2020-12-31'
covid_period_data = df[(df['DATE'] >= start_date) & (df['DATE'] <= end_date)]

covid_period_indices = df.index[(df['DATE'] >= start_date) & (df['DATE'] <= end_date)]

cubic_spline = CubicSpline(covid_period_indices, covid_period_data['ICNSA'], k=3)

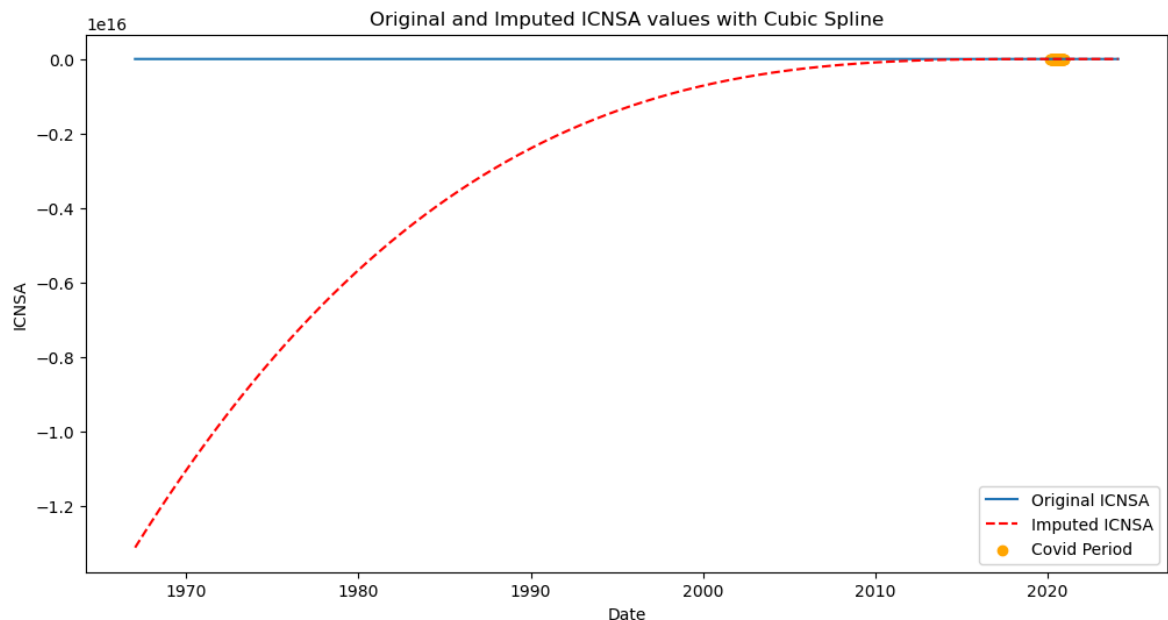
imputation_indices = np.arange(df.index.min(), df.index.max() + 1)

imputed_values = cubic_spline(imputation_indices)

df.loc[imputation_indices, 'ICNSA_imputed'] = imputed_values

plt.figure(figsize=(12, 6))
plt.plot(df['DATE'], df['ICNSA'], label='Original ICNSA')
plt.plot(df['DATE'], df['ICNSA_imputed'], label='Imputed ICNSA', linestyle='--')
plt.scatter(covid_period_data['DATE'], covid_period_data['ICNSA'], color='orange')
plt.xlabel('Date')
plt.ylabel('ICNSA')
plt.title('Original and Imputed ICNSA values with Cubic Spline')
plt.legend()
plt.show()

```



```
In [107]: import pandas as pd
import numpy as np
import statsmodels.api as sm
import matplotlib.pyplot as plt
from statsmodels.tsa.holtwinters import ExponentialSmoothing

df.index = pd.to_datetime(df.index)

train_size = int(len(df) * 0.8)
train, test = df.iloc[:train_size]['ICNSA'], df.iloc[train_size:]['ICNSA']

model_multi = ExponentialSmoothing(train, trend='add', seasonal='mul', seasonality=4)
fit_multi = model_multi.fit()
forecast_multi = fit_multi.forecast(steps=len(test))
print(forecast_multi)
```

```
C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency N will be used.
```

```
self._init_dates(dates, freq)

1970-01-01 00:00:00.000002384    381517.322834
1970-01-01 00:00:00.000002385    380363.549761
1970-01-01 00:00:00.000002386    378633.717165
1970-01-01 00:00:00.000002387    378830.593453
1970-01-01 00:00:00.000002388    381842.351201
...
1970-01-01 00:00:00.000002976    276505.562531
1970-01-01 00:00:00.000002977    279166.599745
1970-01-01 00:00:00.000002978    279175.131920
1970-01-01 00:00:00.000002979    281382.441249
1970-01-01 00:00:00.000002980    279634.581158
Freq: N, Length: 597, dtype: float64
```

```
C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\holtwinters\model.py:917: ConvergenceWarning: Optimization failed to converge. Check mle_retvals.
```

```
warnings.warn(
```



In [108]:

```

model_add = ExponentialSmoothing(train, trend='add', seasonal='add', seasonal_
fit_add = model_add.fit()
forecast_add = fit_add.forecast(steps=len(test))
print(forecast_add)

```

```

C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.p
y:473: ValueWarning: No frequency information was provided, so inferred freq
uency N will be used.

```

```

self._init_dates(dates, freq)

```

```

1970-01-01 00:00:00.000002384    384018.016148
1970-01-01 00:00:00.000002385    383453.564607
1970-01-01 00:00:00.000002386    382414.404511
1970-01-01 00:00:00.000002387    382362.326657
1970-01-01 00:00:00.000002388    386211.686758

```

```

...

```

```

1970-01-01 00:00:00.000002976    303835.104726
1970-01-01 00:00:00.000002977    306358.297952
1970-01-01 00:00:00.000002978    305296.519269
1970-01-01 00:00:00.000002979    305725.788561
1970-01-01 00:00:00.000002980    302394.957176

```

```

Freq: N, Length: 597, dtype: float64

```

```

C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\holtwinters\mode
l.py:917: ConvergenceWarning: Optimization failed to converge. Check mle_ret
vals.

```

```

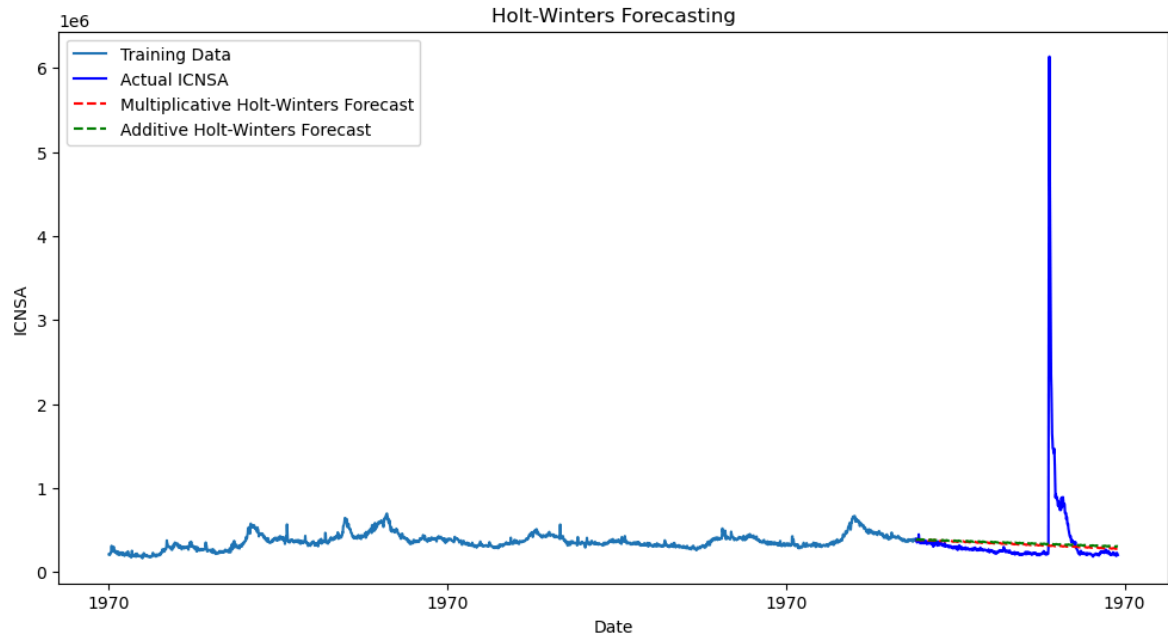
warnings.warn(

```




```
In [109]: plt.figure(figsize=(12, 6))
plt.plot(train.index, train, label='Training Data')
plt.plot(test.index, test, label='Actual ICNSA', color='blue')
plt.plot(test.index, forecast_multi, label='Multiplicative Holt-Winters Forecast')
plt.plot(test.index, forecast_add, label='Additive Holt-Winters Forecast', li

plt.xlabel('Date')
plt.ylabel('ICNSA')
plt.title('Holt-Winters Forecasting')
plt.legend()
plt.show()
```



```
In [110]: print("Multiplicative Holt-Winters Last Forecast Value:")
print(forecast_multi.iloc[-1])

print("\nAdditive Holt-Winters Last Forecast Value:")
print(forecast_add.iloc[-1])
```

Multiplicative Holt-Winters Last Forecast Value:
279634.5811576433

Additive Holt-Winters Last Forecast Value:
302394.9571756705

