lab7

May 5, 2024

1 Comparison of classical forecasting methods

[25]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
```

[26]:
```
df = pd.read_csv('electricity.csv', index_col='Month', parse_dates=True)
df.drop_duplicates(inplace=True)
df.dropna(inplace=True)
df = df.iloc[::-1]
df
```

```
C:\Users\Marcin\AppData\Local\Temp\ipykernel_396\1188158003.py:1: UserWarning:
Could not infer format, so each element will be parsed individually, falling
back to `dateutil`. To ensure parsing is consistent and as-expected, please
specify a format.
  df = pd.read_csv('electricity.csv', index_col='Month', parse_dates=True)
```

[26]:

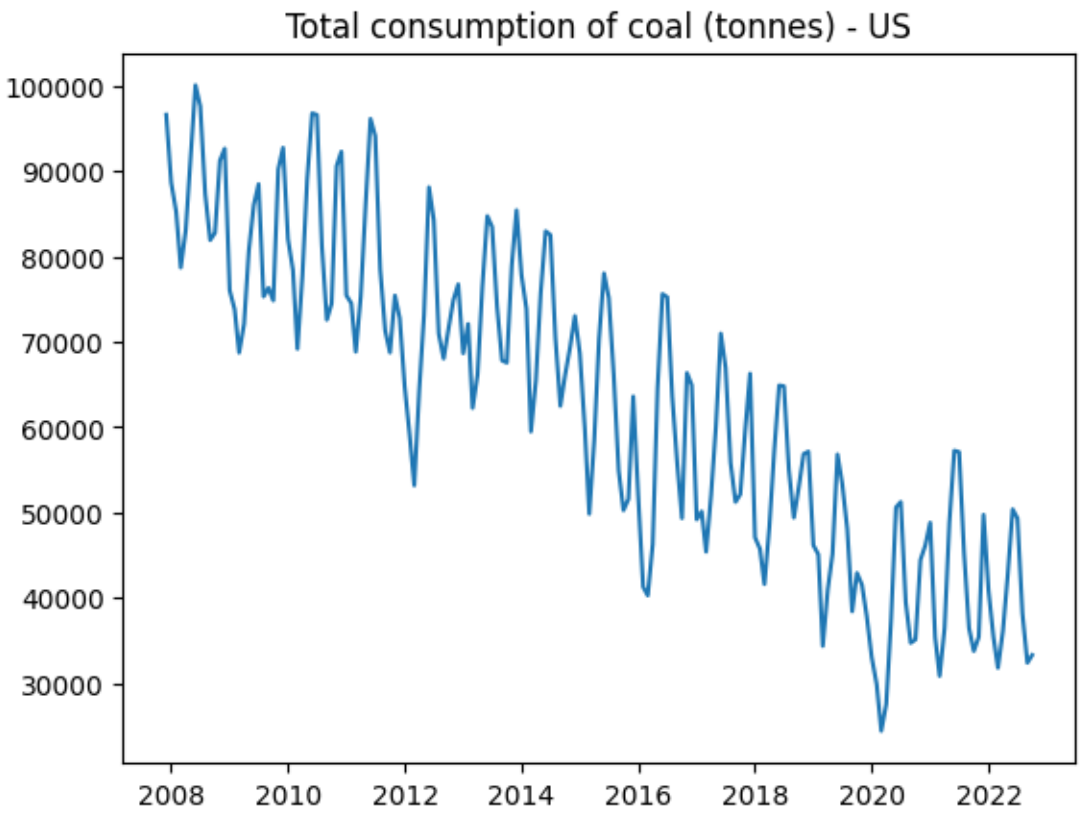
Month	Coal thousand tons
2007-12-01	96610.08500
2008-01-01	88657.02500
2008-02-01	85270.25400
2008-03-01	78700.16800
2008-04-01	83057.81600
…	…
2022-06-01	50386.76376
2022-07-01	49318.31997
2022-08-01	38207.03492
2022-09-01	32390.58403
2022-10-01	33301.18205

[179 rows x 1 columns]

Timeseries plot

[27]:
```
plt.title('Total consumption of coal (tonnes) - US')
plt.plot(df)
```

[27]: [<matplotlib.lines.Line2D at 0x236b63362d0>]



Train and test data split

[28]:
```
train_data = df.iloc[:int(len(df)*0.8)]
test_data = df.iloc[int(len(df)*0.8):]
```

2 Holt-Winters method

[29]:
```
from statsmodels.tsa.holtwinters import ExponentialSmoothing

fitHoltWinter = ExponentialSmoothing(train_data, trend='add', seasonal='add',␣
 ↪seasonal_periods=12).fit()
fcastHoltWinter = fitHoltWinter.forecast(len(test_data)).rename('Holt-Winters␣
 ↪Predict')
fcastHoltWinter
```

```
C:\Users\Marcin\Desktop\studia\Time-Series-Analysis\Lab7v2\.venv\Lib\site-
packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency
information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
```

```
C:\Users\Marcin\Desktop\studia\Time-Series-Analysis\Lab7v2\.venv\Lib\site-
packages\statsmodels\tsa\holtwinters\model.py:918: ConvergenceWarning:
Optimization failed to converge. Check mle_retvals.
  warnings.warn(
```

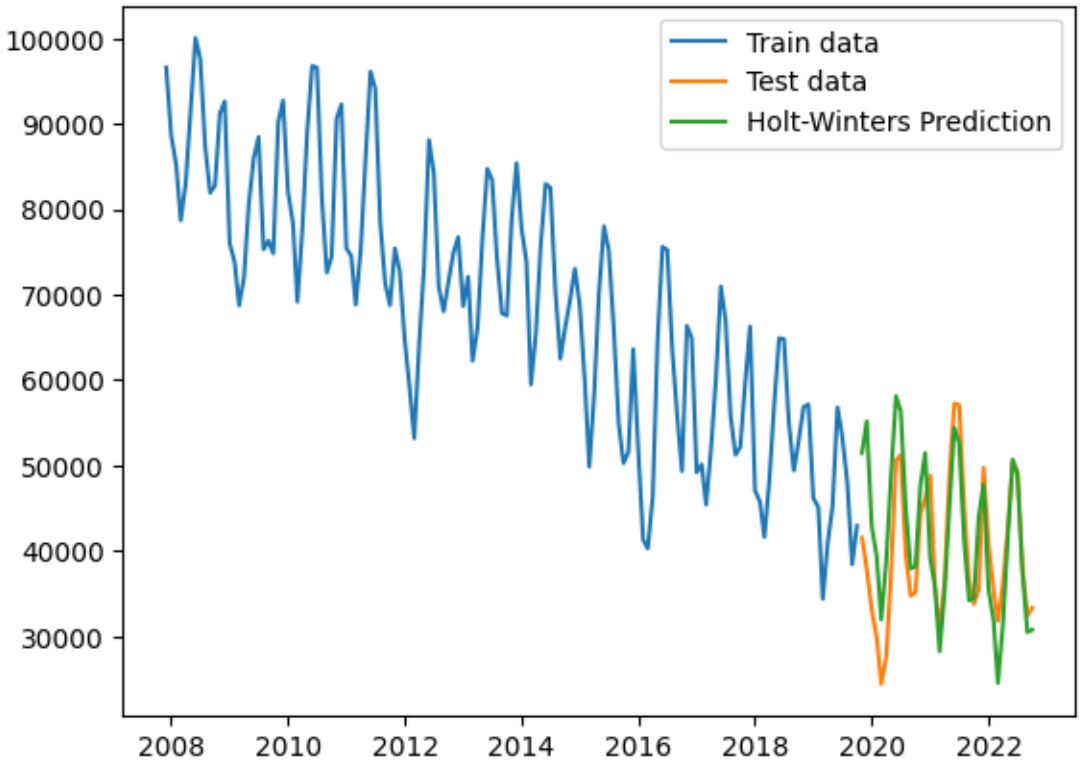
[29]:
```
2019-11-01    51459.287204
2019-12-01    55166.653654
2020-01-01    42863.437794
2020-02-01    39414.040075
2020-03-01    31946.439319
2020-04-01    38770.742579
2020-05-01    48756.787872
2020-06-01    58130.809606
2020-07-01    56361.649773
2020-08-01    45022.820076
2020-09-01    37905.026093
2020-10-01    38185.756293
2020-11-01    47745.842465
2020-12-01    51453.208916
2021-01-01    39149.993055
2021-02-01    35700.595336
2021-03-01    28232.994581
2021-04-01    35057.297841
2021-05-01    45043.343133
2021-06-01    54417.364867
2021-07-01    52648.205034
2021-08-01    41309.375337
2021-09-01    34191.581355
2021-10-01    34472.311554
2021-11-01    44032.397727
2021-12-01    47739.764177
2022-01-01    35436.548316
2022-02-01    31987.150598
2022-03-01    24519.549842
2022-04-01    31343.853102
2022-05-01    41329.898395
2022-06-01    50703.920129
2022-07-01    48934.760296
2022-08-01    37595.930598
2022-09-01    30478.136616
2022-10-01    30758.866816
Freq: MS, Name: Holt-Winters Predict, dtype: float64
```

Plot of the timeseries with forecast

[30]:
```
plt.plot(train_data, label='Train data')
plt.plot(test_data, label='Test data')
plt.plot(fcastHoltWinter, label='Holt-Winters Prediction')
```

```
plt.legend()
```

[30]: <matplotlib.legend.Legend at 0x236b634dc40>



3 SARIMA method

[32]:
```
from statsmodels.tsa.statespace.sarimax import SARIMAX
from pmdarima.arima import auto_arima

auto_arima(df, seasonal=True, m=12, trace=True).summary()
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(1,0,1)[12] intercept   : AIC=inf, Time=1.08 sec
 ARIMA(0,1,0)(0,0,0)[12] intercept   : AIC=3711.553, Time=0.02 sec
 ARIMA(1,1,0)(1,0,0)[12] intercept   : AIC=3648.425, Time=0.09 sec
 ARIMA(0,1,1)(0,0,1)[12] intercept   : AIC=3669.088, Time=0.07 sec
 ARIMA(0,1,0)(0,0,0)[12]             : AIC=3709.902, Time=0.01 sec
 ARIMA(1,1,0)(0,0,0)[12] intercept   : AIC=3709.678, Time=0.03 sec
 ARIMA(1,1,0)(2,0,0)[12] intercept   : AIC=3639.620, Time=0.27 sec
 ARIMA(1,1,0)(2,0,1)[12] intercept   : AIC=3626.304, Time=0.29 sec
 ARIMA(1,1,0)(1,0,1)[12] intercept   : AIC=3624.305, Time=0.12 sec
```

```
ARIMA(1,1,0)(0,0,1)[12] intercept   : AIC=3666.668, Time=0.08 sec
ARIMA(1,1,0)(1,0,2)[12] intercept   : AIC=3626.272, Time=0.31 sec
ARIMA(1,1,0)(0,0,2)[12] intercept   : AIC=3653.985, Time=0.16 sec
ARIMA(1,1,0)(2,0,2)[12] intercept   : AIC=inf, Time=1.09 sec
ARIMA(0,1,0)(1,0,1)[12] intercept   : AIC=inf, Time=0.40 sec
ARIMA(2,1,0)(1,0,1)[12] intercept   : AIC=3615.554, Time=0.16 sec
ARIMA(2,1,0)(0,0,1)[12] intercept   : AIC=3658.393, Time=0.10 sec
ARIMA(2,1,0)(1,0,0)[12] intercept   : AIC=3640.293, Time=0.14 sec
ARIMA(2,1,0)(2,0,1)[12] intercept   : AIC=3617.417, Time=0.46 sec
ARIMA(2,1,0)(1,0,2)[12] intercept   : AIC=3617.553, Time=0.41 sec
ARIMA(2,1,0)(0,0,0)[12] intercept   : AIC=3699.073, Time=0.05 sec
ARIMA(2,1,0)(0,0,2)[12] intercept   : AIC=3645.313, Time=0.24 sec
ARIMA(2,1,0)(2,0,0)[12] intercept   : AIC=3630.091, Time=0.31 sec
ARIMA(2,1,0)(2,0,2)[12] intercept   : AIC=inf, Time=1.69 sec
ARIMA(3,1,0)(1,0,1)[12] intercept   : AIC=3596.694, Time=0.25 sec
ARIMA(3,1,0)(0,0,1)[12] intercept   : AIC=3628.976, Time=0.11 sec
ARIMA(3,1,0)(1,0,0)[12] intercept   : AIC=3616.833, Time=0.19 sec
ARIMA(3,1,0)(2,0,1)[12] intercept   : AIC=3598.152, Time=0.42 sec
ARIMA(3,1,0)(1,0,2)[12] intercept   : AIC=3598.650, Time=0.48 sec
ARIMA(3,1,0)(0,0,0)[12] intercept   : AIC=3660.155, Time=0.07 sec
ARIMA(3,1,0)(0,0,2)[12] intercept   : AIC=3619.572, Time=0.25 sec
ARIMA(3,1,0)(2,0,0)[12] intercept   : AIC=3607.717, Time=0.35 sec
ARIMA(3,1,0)(2,0,2)[12] intercept   : AIC=inf, Time=1.46 sec
ARIMA(4,1,0)(1,0,1)[12] intercept   : AIC=3600.471, Time=0.30 sec
ARIMA(3,1,1)(1,0,1)[12] intercept   : AIC=3598.029, Time=0.34 sec
ARIMA(2,1,1)(1,0,1)[12] intercept   : AIC=3592.760, Time=0.72 sec
ARIMA(2,1,1)(0,0,1)[12] intercept   : AIC=3645.777, Time=0.28 sec
ARIMA(2,1,1)(1,0,0)[12] intercept   : AIC=3629.450, Time=0.30 sec
ARIMA(2,1,1)(2,0,1)[12] intercept   : AIC=3599.069, Time=1.34 sec
ARIMA(2,1,1)(1,0,2)[12] intercept   : AIC=3599.051, Time=1.64 sec
ARIMA(2,1,1)(0,0,0)[12] intercept   : AIC=3686.791, Time=0.12 sec
ARIMA(2,1,1)(0,0,2)[12] intercept   : AIC=3631.307, Time=0.61 sec
ARIMA(2,1,1)(2,0,0)[12] intercept   : AIC=3616.192, Time=0.66 sec
ARIMA(2,1,1)(2,0,2)[12] intercept   : AIC=inf, Time=1.68 sec
ARIMA(1,1,1)(1,0,1)[12] intercept   : AIC=inf, Time=0.64 sec
ARIMA(1,1,2)(1,0,1)[12] intercept   : AIC=inf, Time=0.68 sec
ARIMA(3,1,2)(1,0,1)[12] intercept   : AIC=inf, Time=0.84 sec
ARIMA(2,1,1)(1,0,1)[12]             : AIC=3587.188, Time=0.43 sec
ARIMA(2,1,1)(0,0,1)[12]             : AIC=3641.878, Time=0.27 sec
ARIMA(2,1,1)(1,0,0)[12]             : AIC=3625.017, Time=0.32 sec
ARIMA(2,1,1)(2,0,1)[12]             : AIC=inf, Time=1.32 sec
ARIMA(2,1,1)(1,0,2)[12]             : AIC=inf, Time=1.19 sec
ARIMA(2,1,1)(0,0,0)[12]             : AIC=3669.212, Time=0.20 sec
ARIMA(2,1,1)(0,0,2)[12]             : AIC=3628.213, Time=0.79 sec
ARIMA(2,1,1)(2,0,0)[12]             : AIC=3612.388, Time=0.97 sec
ARIMA(2,1,1)(2,0,2)[12]             : AIC=3590.917, Time=1.11 sec
ARIMA(1,1,1)(1,0,1)[12]             : AIC=inf, Time=0.75 sec
ARIMA(2,1,0)(1,0,1)[12]             : AIC=3610.472, Time=0.20 sec
```

```
ARIMA(3,1,1)(1,0,1)[12]             : AIC=3584.734, Time=0.32 sec
ARIMA(3,1,1)(0,0,1)[12]             : AIC=3626.693, Time=0.16 sec
ARIMA(3,1,1)(1,0,0)[12]             : AIC=3615.484, Time=0.27 sec
ARIMA(3,1,1)(2,0,1)[12]             : AIC=inf, Time=0.82 sec
ARIMA(3,1,1)(1,0,2)[12]             : AIC=inf, Time=1.06 sec
ARIMA(3,1,1)(0,0,0)[12]             : AIC=3654.003, Time=0.08 sec
ARIMA(3,1,1)(0,0,2)[12]             : AIC=3617.613, Time=0.40 sec
ARIMA(3,1,1)(2,0,0)[12]             : AIC=3606.623, Time=0.48 sec
ARIMA(3,1,1)(2,0,2)[12]             : AIC=inf, Time=0.79 sec
ARIMA(3,1,0)(1,0,1)[12]             : AIC=3583.970, Time=0.22 sec
ARIMA(3,1,0)(0,0,1)[12]             : AIC=3627.148, Time=0.10 sec
ARIMA(3,1,0)(1,0,0)[12]             : AIC=3615.030, Time=0.16 sec
ARIMA(3,1,0)(2,0,1)[12]             : AIC=inf, Time=0.55 sec
ARIMA(3,1,0)(1,0,2)[12]             : AIC=inf, Time=0.56 sec
ARIMA(3,1,0)(0,0,0)[12]             : AIC=3658.012, Time=0.05 sec
ARIMA(3,1,0)(0,0,2)[12]             : AIC=3617.887, Time=0.22 sec
ARIMA(3,1,0)(2,0,0)[12]             : AIC=3606.169, Time=0.31 sec
ARIMA(3,1,0)(2,0,2)[12]             : AIC=inf, Time=0.67 sec
ARIMA(4,1,0)(1,0,1)[12]             : AIC=3581.283, Time=0.34 sec
ARIMA(4,1,0)(0,0,1)[12]             : AIC=3626.123, Time=0.12 sec
ARIMA(4,1,0)(1,0,0)[12]             : AIC=3614.658, Time=0.19 sec
ARIMA(4,1,0)(2,0,1)[12]             : AIC=inf, Time=1.41 sec
ARIMA(4,1,0)(1,0,2)[12]             : AIC=inf, Time=0.64 sec
ARIMA(4,1,0)(0,0,0)[12]             : AIC=3652.719, Time=0.07 sec
ARIMA(4,1,0)(0,0,2)[12]             : AIC=3616.101, Time=0.26 sec
ARIMA(4,1,0)(2,0,0)[12]             : AIC=3604.819, Time=0.38 sec
ARIMA(4,1,0)(2,0,2)[12]             : AIC=inf, Time=0.90 sec
ARIMA(5,1,0)(1,0,1)[12]             : AIC=3582.856, Time=0.40 sec
ARIMA(4,1,1)(1,0,1)[12]             : AIC=3583.339, Time=0.50 sec
ARIMA(5,1,1)(1,0,1)[12]             : AIC=3584.222, Time=0.61 sec

Best model:  ARIMA(4,1,0)(1,0,1)[12]
Total fit time: 41.951 seconds
```

[32]:

Dep. Variable:	y	**No. Observations:**	179
Model:	SARIMAX(4, 1, 0)x(1, 0, [1], 12)	**Log Likelihood**	-1783.642
Date:	Sun, 05 May 2024	**AIC**	3581.283
Time:	16:55:36	**BIC**	3603.556
Sample:	12-01-2007	**HQIC**	3590.316
	- 10-01-2022		
Covariance Type:	opg		

	coef	std err	z	P> |z|	[0.025	0.975]
ar.L1	-0.0385	0.053	-0.722	0.471	-0.143	0.066
ar.L2	-0.0997	0.065	-1.541	0.123	-0.227	0.027
ar.L3	-0.1728	0.041	-4.216	0.000	-0.253	-0.092
ar.L4	-0.0888	0.034	-2.583	0.010	-0.156	-0.021
ar.S.L12	0.9674	0.027	35.617	0.000	0.914	1.021
ma.S.L12	-0.8791	0.056	-15.804	0.000	-0.988	-0.770
sigma2	3.321e+07	1.4e-10	2.37e+17	0.000	3.32e+07	3.32e+07

Ljung-Box (L1) (Q):	0.50	**Jarque-Bera (JB):**	1.36
Prob(Q):	0.48	**Prob(JB):**	0.51
Heteroskedasticity (H):	0.39	**Skew:**	-0.20
Prob(H) (two-sided):	0.00	**Kurtosis:**	3.14

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number 2.43e+33. Standard errors may be unstable.

Split to train / test

[33]:
```
train = df.iloc[:-int(len(df) * 0.8)]
test = df.iloc[-int(len(df) * 0.8):]
```

[43]:
```
model = SARIMAX(train, order=(4,1,0), seasonal_order=(1, 0, 1, 12))
result = model.fit()
```

```
C:\Users\Marcin\Desktop\studia\Time-Series-Analysis\Lab7v2\.venv\Lib\site-
packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency
information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\Marcin\Desktop\studia\Time-Series-Analysis\Lab7v2\.venv\Lib\site-
packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency
information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\Marcin\Desktop\studia\Time-Series-Analysis\Lab7v2\.venv\Lib\site-
packages\statsmodels\tsa\statespace\sarimax.py:866: UserWarning: Too few
observations to estimate starting parameters for seasonal ARMA. All parameters
except for variances will be set to zeros.
  warn('Too few observations to estimate starting parameters%s.'
```

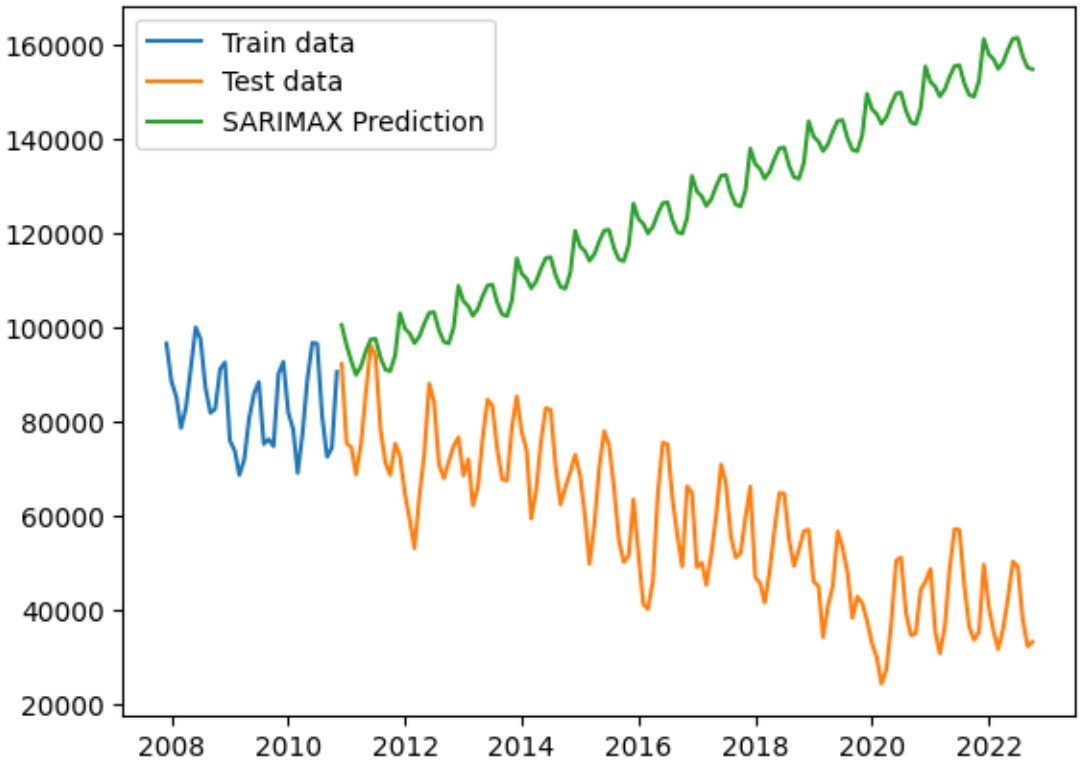
[48]:
```
fcastSARIMAX = result.forecast(len(test))
fcastSARIMAX = fcastSARIMAX.rename('SARIMAX Predict')
fcastSARIMAX
```

[48]:
```
2010-12-01    100564.856655
2011-01-01     96295.414550
2011-02-01     92790.652415
2011-03-01     89978.106563
```

```
2011-04-01     91757.591815
                   …
2022-06-01    161306.218643
2022-07-01    161483.033978
2022-08-01    157641.484603
2022-09-01    155180.538687
2022-10-01    154839.124399
Freq: MS, Name: SARIMAX Predict, Length: 143, dtype: float64
```

[49]:
```
plt.plot(train, label='Train data')
plt.plot(test, label='Test data')
plt.plot(fcastSARIMAX, label='SARIMAX Prediction')
plt.legend()
```

[49]: <matplotlib.legend.Legend at 0x236b6375d90>



4 Conclusions

- As we can see the Holt-Winters prediction was much more accurate, this might be the result of some mistake or error while performing the SARIMAX method analysis
- The issued might be found in incosistency of the data, missing values or other issue