timeserieslab4-rohramehak-251524

March 26, 2024

[43]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

[117]:
```
import pandas as pd
from matplotlib import pyplot as plt
import numpy as np
from statsmodels.tsa.holtwinters import ExponentialSmoothing
```

[118]:
```
data = pd.read_csv('/content/drive/MyDrive/TSA_BDA_2024/Lab4/
 ↪Retail_sales_of_electricity_United_States_monthly.csv', skiprows=4)
```

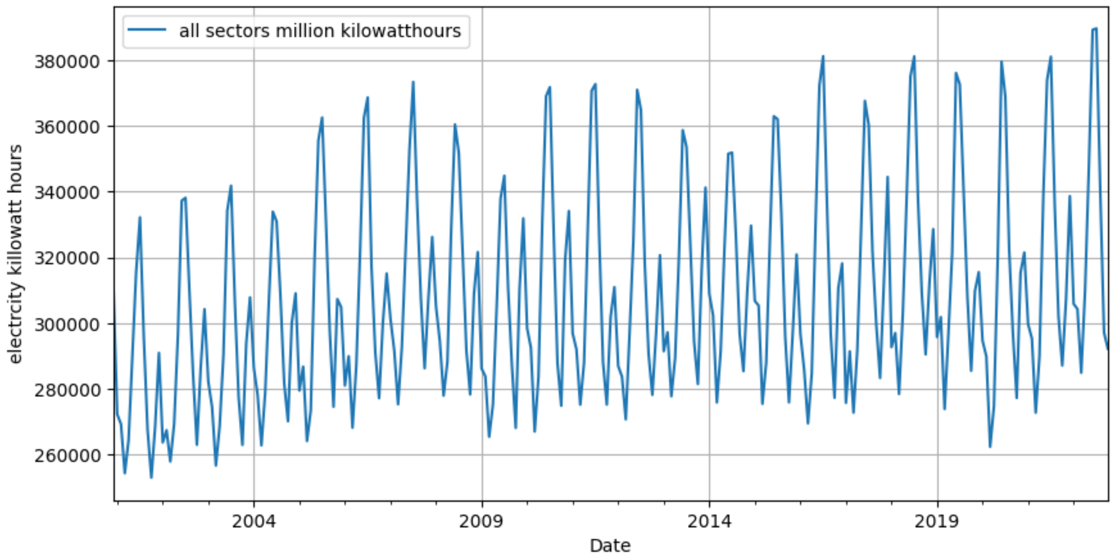
[119]:
```
data.dropna(inplace=True)
data['DatePart'] = pd.to_datetime(data['Month'], format='%b %Y',␣
 ↪errors='coerce')
data.rename(columns = {"DatePart" : "Date"}, inplace=True)
data.set_index("Date", inplace=True)
data.drop(columns=["Month"], inplace=True)
```

[120]:
```
data
```

[120]:
```
            all sectors million kilowatthours
Date
2022-10-01                       292257.74617
2022-09-01                       297195.94414
2022-08-01                       340543.84071
2022-07-01                       389626.28230
2022-06-01                       389214.17473
…                                         …
2001-04-01                       264490.49166
2001-03-01                       254390.93545
2001-02-01                       269298.40142
2001-01-01                       272334.73804
2000-12-01                       310816.06880
```

```
[263 rows x 1 columns]
```

[121]:
```
data.plot(figsize=(10,5), grid=True)
plt.ylabel("electrcity killowatt hours")
plt.show()
```



[122]:
```
data.sort_index(inplace=True)
data
```

[122]:
```
            all sectors million kilowatthours
Date
2000-12-01                     310816.06880
2001-01-01                     272334.73804
2001-02-01                     269298.40142
2001-03-01                     254390.93545
2001-04-01                     264490.49166
…                                       …
2022-06-01                     389214.17473
2022-07-01                     389626.28230
2022-08-01                     340543.84071
2022-09-01                     297195.94414
2022-10-01                     292257.74617

[263 rows x 1 columns]
```

Splitting data into training and testing 90% and 10% respectively.

[123]:
```
length = len(data)
test_size = 0.1
split_index = int(length * (1 - test_size))
X_train = data[:split_index+1]
X_test = data[split_index:]
```

[124]:
```
fcast_months = len(X_test)
```

creating various instances of Holt Winter's Exponentail Smoothing with : 1. fit1 -> additive trend with additive seasonal 2. fit2 -> additive trend with multiplicative seasonal 3. fit3 -> multiplicative trend with additive seasonal 4. fit4 -> multiplicative trend with multiplicative seasonal

[125]:
```
fit1 = ExponentialSmoothing(
    X_train,
    seasonal_periods=12,
    trend="add",
    seasonal="add",
    initialization_method="estimated",
).fit()
fit2 = ExponentialSmoothing(
    X_train,
    seasonal_periods=12,
    trend="add",
    seasonal="mul",
    initialization_method="estimated",
).fit()
fit3 = ExponentialSmoothing(
    X_train,
    seasonal_periods=12,
    trend="mul",
    seasonal="add",
    initialization_method="estimated",
).fit()
fit4 = ExponentialSmoothing(
    X_train,
    seasonal_periods=12,
    trend="mul",
    seasonal="mul",
    initialization_method="estimated",
).fit()
```

```
/usr/local/lib/python3.10/dist-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)
/usr/local/lib/python3.10/dist-
packages/statsmodels/tsa/holtwinters/model.py:917: ConvergenceWarning:
Optimization failed to converge. Check mle_retvals.
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-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)
/usr/local/lib/python3.10/dist-
packages/statsmodels/tsa/holtwinters/model.py:917: ConvergenceWarning:
Optimization failed to converge. Check mle_retvals.
  warnings.warn(
/usr/local/lib/python3.10/dist-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)
/usr/local/lib/python3.10/dist-
packages/statsmodels/tsa/holtwinters/model.py:917: ConvergenceWarning:
Optimization failed to converge. Check mle_retvals.
  warnings.warn(
/usr/local/lib/python3.10/dist-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)
/usr/local/lib/python3.10/dist-
packages/statsmodels/tsa/holtwinters/model.py:917: ConvergenceWarning:
Optimization failed to converge. Check mle_retvals.
  warnings.warn(
```

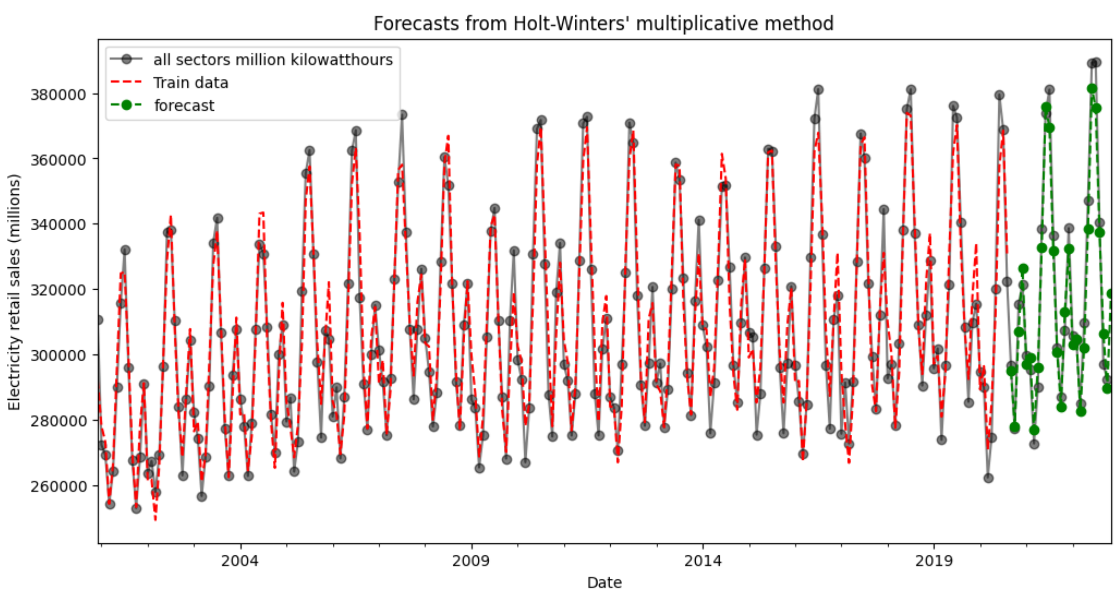
[132]:

```
results = pd.DataFrame(
    index=[r"$\alpha$", r"$\beta$", r"$\phi$", r"$\gamma$", r"$l_0$", "$b_0$",␣
 ↪"SSE"]
)
params = [
    "smoothing_level",
    "smoothing_trend",
    "damping_trend",
    "smoothing_seasonal",
    "initial_level",
    "initial_trend",
]
results["Both Additive"] = [fit1.params[p] for p in params] + [fit1.sse]
results["Additive (t) ,Multiplicative (s)"] = [fit2.params[p] for p in params]␣
 ↪+ [fit2.sse]
results["Multiplicative (t) ,Additive (s)"] = [fit3.params[p] for p in params]␣
 ↪+ [fit3.sse]
results["Both Multiplicative"] = [fit4.params[p] for p in params] + [fit4.sse]
```

Fitting Forecating for months in the future and plotting resutls.

FIT 1 with additive trend with additive seasonal

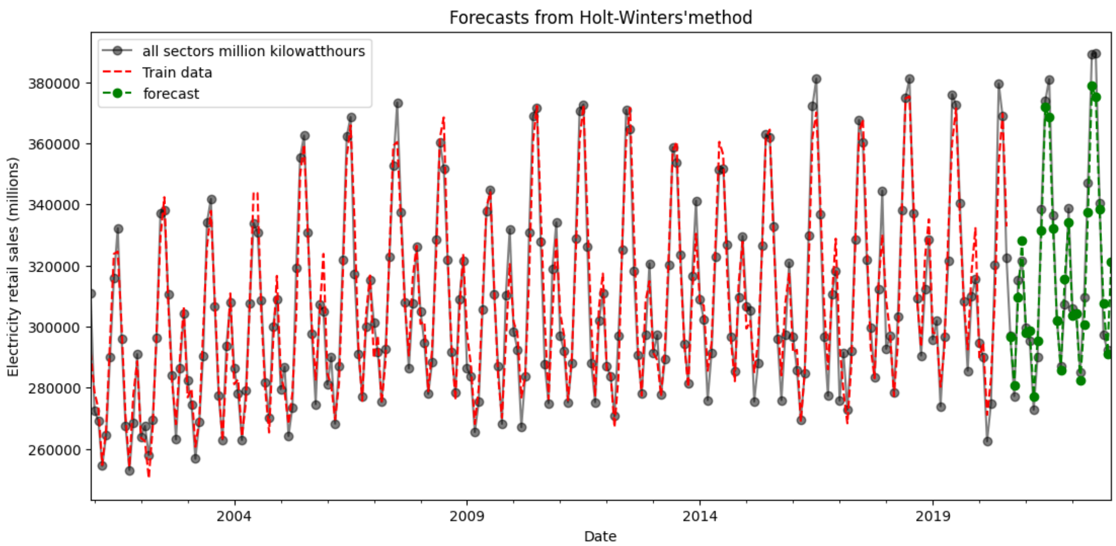
[127]:
```python
ax = data.plot(
    figsize=(12, 6),
    marker="o",
    color="black",
    alpha=0.5,
    title="Forecasts from Holt-Winters' multiplicative method",
    label="actual values"
)
ax.set_ylabel("Electricity retail sales (millions)")
fit1.fittedvalues.plot(ax=ax, style="--", color="red", label="Train data")
fit1.forecast(fcast_months).rename("forecast").plot(
    ax=ax, style="--", marker="o", color="green", legend=True
)
plt.legend()
plt.show()
```



FIT 2 with additive trend with multiplicative seasonal

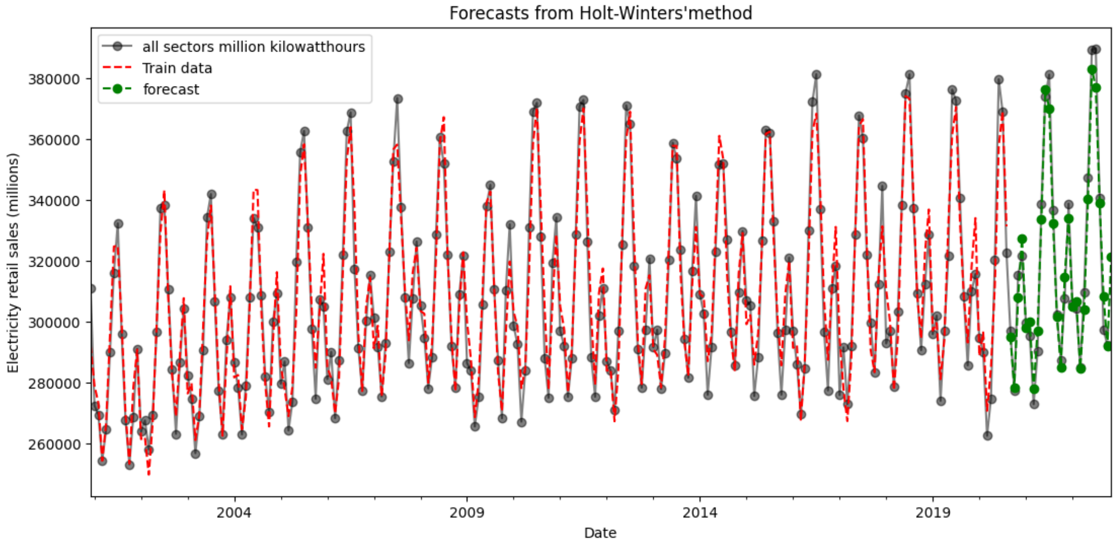
[128]:
```python
ax = data.plot(
    figsize=(13, 6),
    marker="o",
    color="black",
    alpha=0.5,
    title="Forecasts from Holt-Winters'method",
    label="actual values"
)
ax.set_ylabel("Electricity retail sales (millions)")
fit2.fittedvalues.plot(ax=ax, style="--", color="red", label="Train data")
```

```
fit2.forecast(fcast_months).rename("forecast").plot(
    ax=ax, style="--", marker="o", color="green", legend=True
)
plt.legend()
plt.show()
```



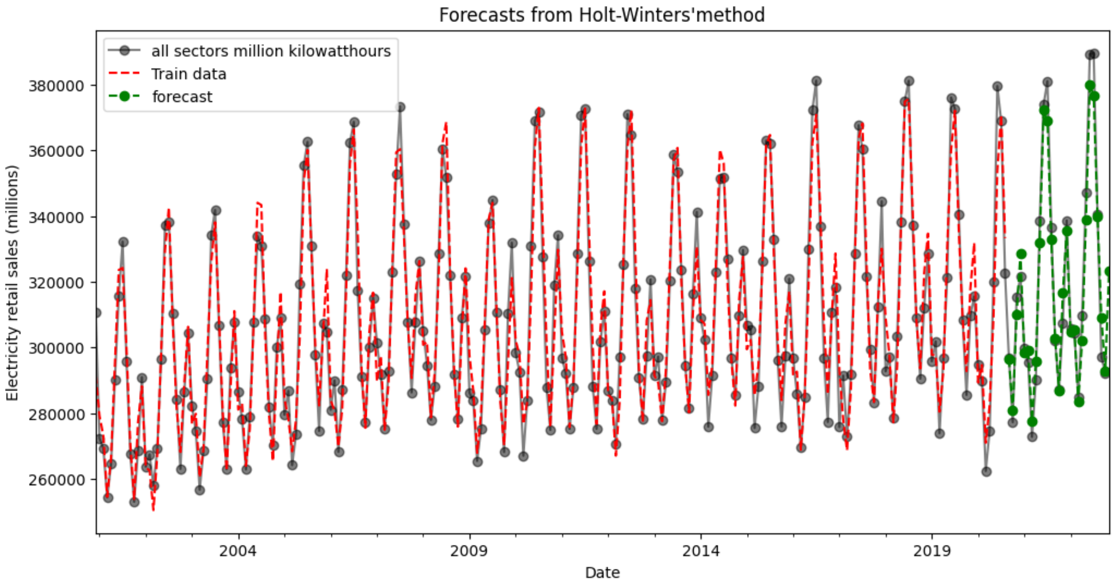
FIT 3 multiplicative trend with additive seasonal

[134]:
```
ax = data.plot(
    figsize=(13, 6),
    marker="o",
    color="black",
    alpha=0.5,
    title="Forecasts from Holt-Winters'method",
    label="actual values"
)
ax.set_ylabel("Electricity retail sales (millions)")
fit3.fittedvalues.plot(ax=ax, style="--", color="red", label="Train data")
fit3.forecast(fcast_months).rename("forecast").plot(
    ax=ax, style="--", marker="o", color="green", legend=True
)
plt.legend()
plt.show()
```



FIT 4 with multiplicative trend and multiplicative seasonal

[130]:
```
ax = data.plot(
    figsize=(12, 6),
    marker="o",
    color="black",
    title="Forecasts from Holt-Winters'method",
    alpha=0.5,
    label="actual values"
)
ax.set_ylabel("Electricity retail sales (millions)")
fit4.fittedvalues.plot(ax=ax, style="--", color="red", label="Train data")
fit4.forecast(fcast_months).rename("forecast").plot(
    ax=ax, style="--",  marker="o", color="green", legend=True
)
plt.legend()
plt.show()
```



Comparison of fitted parameters and SSE value

[133]:
```
results
```

[133]:
```
            Both Additive  Additive (t) ,Multiplicative (s)  \
$\alpha$     6.060714e-01                      6.414286e-01
$\beta$      1.000000e-04                      1.000000e-04
$\phi$                NaN                               NaN
$\gamma$     1.750794e-01                      1.054622e-01
$l_0$        2.795231e+05                      2.795231e+05
$b_0$        4.928005e+02                      4.928005e+02
SSE          1.282116e+10                      1.196271e+10

            Multiplicative (t) ,Additive (s)  Both Multiplicative
$\alpha$                        6.414286e-01         6.767857e-01
$\beta$                         1.000000e-04         1.000000e-04
$\phi$                                   NaN                  NaN
$\gamma$                        1.687395e-01         1.010045e-01
$l_0$                           2.795231e+05         2.795231e+05
$b_0$                           1.001763e+00         1.001763e+00
SSE                             1.286957e+10         1.199945e+10
```

A smaller SSE value inidicates a better fit which is obtained by using a different combination of trend and seasonal components, with a strong emphasis on the multiplicative seasonal component an we can see taht multiplicaitve seasonal component, we have a relatively smaller sse value.