generated_2dvar

April 8, 2021

[14]:

```
import numpy as np
import pandas as pd
import numpy.random as random
sys.path.insert(0, '../../Libraries')
import JacksonsTSPackage as jts
from statsmodels.tsa.api import VAR
```

[15]:

```
def mul_ten_and_mat(tensor, matrix):
    ten_shape = tensor.shape
    result = np.zeros((ten_shape[0], ten_shape[2]))
    for i in range(ten_shape[2]):
        result[:,i] = tensor[:,:,i].dot(matrix[:,i])
    return result

N = 2000
A = np.array([
    [
        [0.5, 0, 0],
        [0, 0.5, 0],
        [0, 0, 0.5]
    ],
    [
        [0, 0, 0],
        [0.4, 0, 0],
        [0, 0, 0]
    ],
    [
        [0, 0.5, 0],
        [0, 0, 0],
        [0, 0, 0]
    ]
    ])

T = np.array([
        [1, -1, 1],
        [-1, 1, 1],
        [1, 1, -1]
    ])
```

```
tmp = np.array(
    [
        [0.5, 0.5, 0.5],
        [0.5, 0.5, 0.5],
        [0.5, 0.5, 0.5]
    ])

data_tensor = np.zeros((N, 3, 3))
data_tensor[0] = tmp
for i in range(1, N):
    data_tensor[i] = mul_ten_and_mat(A, data_tensor[i-1]) + random.uniform(-1,␣
 ↪1, (3, 3)) + T * i**2 / 500000
data_tensor.shape
```

```
[15]: (2000, 3, 3)
```

```
[16]: vectorized = pd.DataFrame(jts.tensor_to_vector(data_tensor))
      vectorized
```

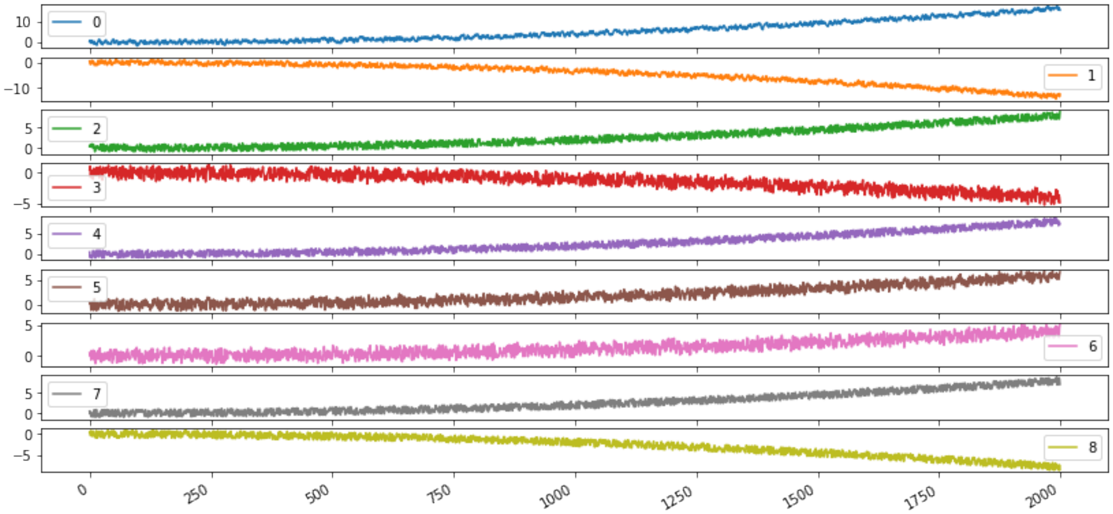
```
[16]:              0          1         2         3         4         5         6  \
      0     0.500000   0.500000  0.500000  0.500000  0.500000  0.500000  0.500000
      1     0.969847  -0.557478  0.773470  1.075439 -0.813949  0.173232 -0.009624
      2    -0.292416  -0.772558  0.297511 -0.706021 -0.276460  0.331214  0.345908
      3    -0.015859  -0.612576  0.894810  0.152768 -0.858028 -1.116022 -0.658394
      4     0.488870  -0.042765  0.973395  0.472074 -0.360042 -0.082752  0.856598
      …          …          …         …         …         …         …
      1995  15.435267 -12.509400  8.312082 -3.841305  8.295329  6.032100  3.440381
      1996  15.847569 -12.910540  7.903454 -4.782139  6.974089  6.137096  4.689907
      1997  16.431367 -12.224459  7.084579 -3.606179  7.868779  5.188021  3.016596
      1998  15.284617 -13.453360  7.339786 -3.976524  7.717211  6.127516  4.562244
      1999  15.278943 -12.473208  8.872794 -4.796703  7.390676  6.644333  5.182980

                    7         8
      0     0.500000  0.500000
      1    -0.194278  0.476712
      2     0.294244 -0.350889
      3    -0.001361  0.872239
      4    -0.879510  0.455359
      …         …         …
      1995  6.981897 -7.795731
      1996  8.621132 -8.249918
      1997  8.719709 -8.789664
      1998  8.374916 -7.457246
      1999  7.102077 -8.581773

      [2000 rows x 9 columns]
```

[17]:
```
vectorized.plot(figsize = (14, 7), subplots = True)
```

[17]:
```
array([<AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
       <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
       <AxesSubplot:>], dtype=object)
```



[18]:
```
N_train = 1800
N_test = N - N_train
print(f"N: {N}")
print(f"N_train: {N_train}")
print(f"N_test: {N_test}")
```

```
N: 2000
N_train: 1800
N_test: 200
```

[19]:
```
train_tensor = jts.extract_train_tensor(data_tensor, N_train)
test_tensor = jts.extract_test_tensor(data_tensor, N_train, N_test)
```

[20]:
```
train_tensor_rotated = np.empty((N_train, 3, 3))
for i in range(N_train):
    train_tensor_rotated[i] = np.rot90(train_tensor[i])
train_tensor_rotated
```

[20]:
```
array([[[ 5.00000000e-01,  5.00000000e-01,  5.00000000e-01],
        [ 5.00000000e-01,  5.00000000e-01,  5.00000000e-01],
        [ 5.00000000e-01,  5.00000000e-01,  5.00000000e-01]],

       [[-9.62353495e-03, -1.94278433e-01,  4.76711682e-01],
        [ 1.07543902e+00, -8.13948917e-01,  1.73231620e-01],
        [ 9.69847207e-01, -5.57478165e-01,  7.73469862e-01]],

       [[ 3.45907929e-01,  2.94243735e-01, -3.50888782e-01],
        [-7.06020573e-01, -2.76460372e-01,  3.31213549e-01],
        [-2.92415893e-01, -7.72557716e-01,  2.97511296e-01]],

       …,

       [[ 3.88996144e+00,  6.85065105e+00, -6.84637706e+00],
        [-3.82720699e+00,  6.60445646e+00,  4.09618385e+00],
        [ 1.35206124e+01, -1.16206379e+01,  7.24575469e+00]],

       [[ 3.28687237e+00,  7.16152900e+00, -7.13422925e+00],
        [-2.27345192e+00,  7.23343900e+00,  4.36472635e+00],
        [ 1.22642437e+01, -1.18963462e+01,  5.90999648e+00]],

       [[ 2.38371114e+00,  7.32461169e+00, -6.64188216e+00],
        [-2.31839091e+00,  7.21719332e+00,  4.56877495e+00],
        [ 1.18231875e+01, -1.05053876e+01,  7.06532184e+00]]])
```

[21]:

```
test_tensor_rotated = np.empty((N_test, 3, 3))
for i in range(N_test):
    test_tensor_rotated[i] = np.rot90(test_tensor[i])
test_tensor_rotated
```

[21]:

```
array([[[  2.663901  ,   6.25759746,  -6.35291021],
        [ -3.47550511,   5.7699389 ,   5.06885495],
        [ 11.85058215, -10.97576484,   6.50750901]],

       [[  3.15039452,   7.20211113,  -7.16327137],
        [ -4.06450512,   6.89161067,   4.8936176 ],
        [ 12.86248741, -11.01528007,   6.91799534]],

       [[  3.17907749,   5.82210693,  -6.99621471],
        [ -3.2852304 ,   6.75201309,   3.99096919],
        [ 13.38689561, -10.51207882,   6.78058918]],

       …,

       [[  3.01659551,   8.71970949,  -8.7896642 ],
        [ -3.6061789 ,   7.86877861,   5.18802057],
        [ 16.4313671 , -12.22445903,   7.0845791 ]],

       [[  4.56224373,   8.37491558,  -7.45724633],
        [ -3.97652379,   7.71721107,   6.12751552],
        [ 15.28461657, -13.45336039,   7.33978613]],
       [[  5.18297957,   7.10207694,  -8.58177314],
        [ -4.79670251,   7.39067631,   6.64433252],
        [ 15.27894291, -12.47320842,   8.87279384]]])
```

[22]:

```
train_model_sets_col = jts.split_cols_into_model_sets(train_tensor, N_train)
train_model_sets_row = jts.split_cols_into_model_sets(train_tensor_rotated,␣
 ↪N_train)
test_model_sets_col = jts.split_cols_into_model_sets(test_tensor, N_test)
test_model_sets_row = jts.split_cols_into_model_sets(test_tensor_rotated,␣
 ↪N_test)
```

[23]:

```
result_model_sets_col = np.empty((3, N_test, 3))

for i in range(3):
    train_df = pd.DataFrame(train_model_sets_col[i])
    test_df = pd.DataFrame(test_model_sets_col[i])
    train_df.index = pd.DatetimeIndex(train_df.index).to_period('M')
    train_diff = train_df.diff().dropna()
    model = VAR(train_diff)
    fit = model.fit(3)

    test_df.columns = test_df.columns[:].astype(str)
    results_diff = jts.forecast(fit, train_diff, test_df, N_test, calc_conf =␣
 ↪False)
    result_model_sets_col[i] = jts.invert_diff_transformation(results_diff,␣
 ↪train_df)
result_tensor_col = jts.collect_result_cols_into_tensor(result_model_sets_col,␣
 ↪N_test)
```

[24]:

```
result_model_sets_row_rotated = np.empty((3, N_test, 3))

for i in range(3):
    train_df = pd.DataFrame(train_model_sets_row[i])
    test_df = pd.DataFrame(test_model_sets_row[i])
    train_df.index = pd.DatetimeIndex(train_df.index).to_period('M')
    train_diff = train_df.diff().dropna()
    model = VAR(train_diff)
    fit = model.fit(3)

    test_df.columns = test_df.columns[:].astype(str)
    results_diff = jts.forecast(fit, train_diff, test_df, N_test, calc_conf =␣
 ↪False)
    result_model_sets_row_rotated[i] = jts.
 ↪invert_diff_transformation(results_diff, train_df)
```

[25]:

```
result_tensor_row_rotated = jts.
 ↪collect_result_cols_into_tensor(result_model_sets_row_rotated, N_test)
```

```
result_tensor_row = np.empty((N_test, 3, 3))
for i in range(N_test):
    result_tensor_row[i] = np.rot90(result_tensor_row_rotated[i], 3)
```

```
[26]: result_tensor_col.shape
```

```
[26]: (200, 3, 3)
```

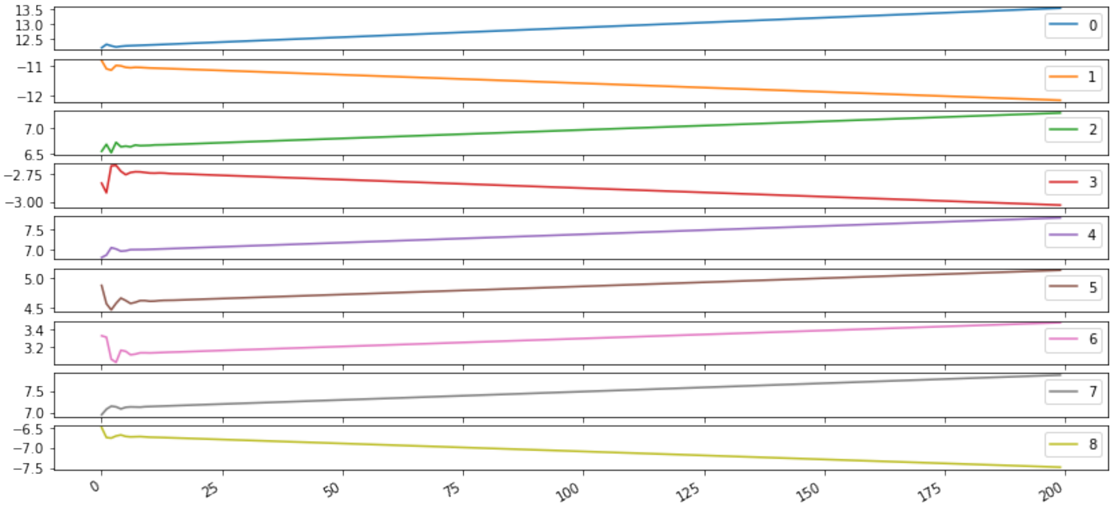
```
[27]: result_tensor_row.shape
```

```
[27]: (200, 3, 3)
```

```
[29]: result_tensor = np.empty((N_test, 3, 3))
      for i in range(N_test):
          for j in range(3):
              for k in range(3):
                  result_tensor[i][j][k] = np.mean([result_tensor_col[i][j][k],␣
       ↪result_tensor_row[i][j][k]])
```

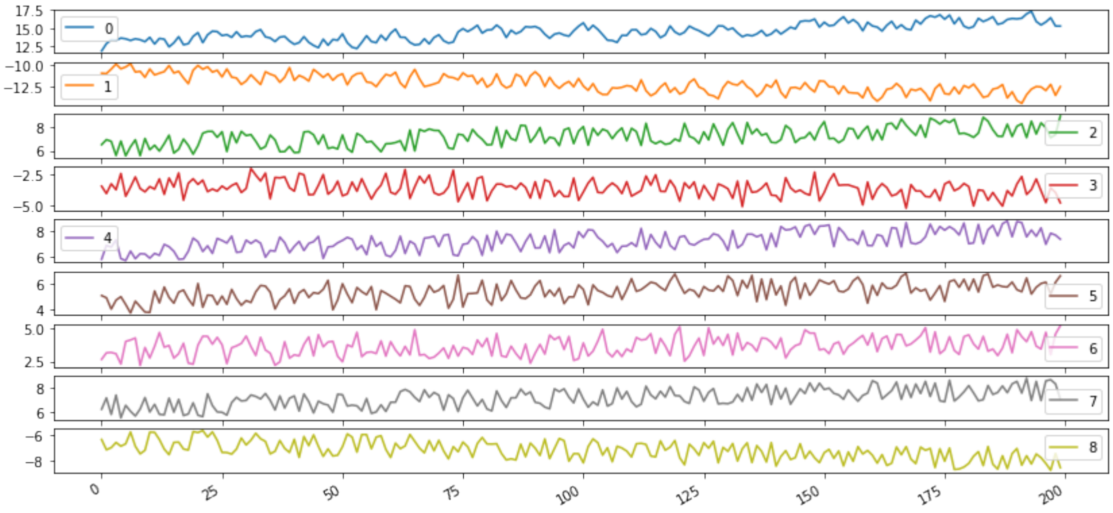
```
[33]: result_vectorized = pd.DataFrame(jts.tensor_to_vector(result_tensor))
      result_vectorized.plot(figsize = (14, 7), subplots = True)
```

```
[33]: array([<AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
             <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
             <AxesSubplot:>], dtype=object)
```



```
[34]: test_vectorized = pd.DataFrame(jts.tensor_to_vector(test_tensor))
      test_vectorized.plot(figsize = (14, 7), subplots = True)
```

```
[34]: array([<AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
              <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>, <AxesSubplot:>,
              <AxesSubplot:>], dtype=object)
```



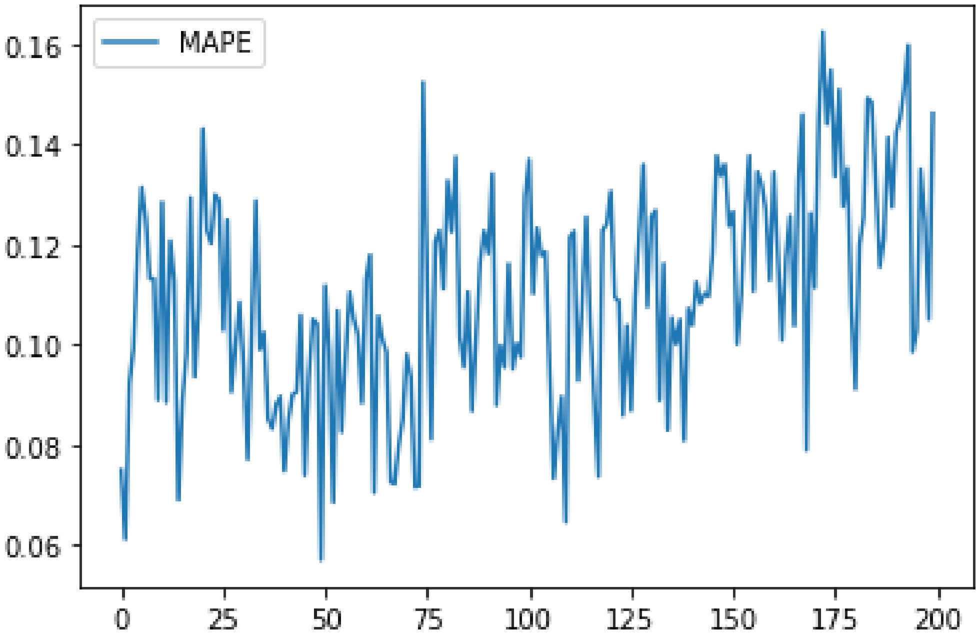
```
[31]: error = jts.calc_mape_per_matrix(test_tensor, result_tensor)
      error
```

```
[31]:          MAPE
      0    0.0750596
      1    0.0611786
      2    0.0923734
      3    0.0992954
      4     0.118409
      ..         …
      195   0.102832
      196   0.135119
      197   0.124757
      198   0.105108
      199   0.146253

      [200 rows x 1 columns]
```

```
[32]: error.plot()
```

```
[32]: <AxesSubplot:>
```



[35]:

```
jts.forecast_accuracy(result_vectorized, test_vectorized)
```

```
Results
----------------------------------------------------------------------
             ME            MSE            MAE            MAPE
0        -1.601          3.293          1.612          10.770%
1         0.517          0.799          0.727          5.809%
2        -0.213          0.463          0.567          7.778%
3         0.762          0.974          0.834          21.303%
4         0.146          0.415          0.544          7.795%
5        -0.531          0.685          0.688          12.193%
6        -0.343          0.557          0.610          16.060%
7         0.288          0.492          0.586          8.624%
8         0.104          0.402          0.532          7.386%
```

[ ]: