## **Probabilistic Models Final Project**

## Modeling and Inferring Airline Passenger Satisfaction

```
import numpy as np
In [1]:
         import pandas as pd
         from sklearn.preprocessing import OneHotEncoder
         %matplotlib inline
         import matplotlib.pyplot as plt
         import seaborn as sns
         import warnings
         warnings.filterwarnings("ignore")
         import zipfile
         import os
         # Plot settings
         plt.rcParams['figure.figsize'] = (12, 9)
         plt.rcParams['font.size'] = 12
In [2]:
         #loading the data
         data=pd.read csv("train.csv").drop('Unnamed: 0', axis=1)
         data raw=data.copy()
         data['Gender']=data['Gender'].map(dict({'Male': 0, 'Female': 1}))
In [3]:
         data['Customer Type']=data['Customer Type'].map(dict({'disloyal Customer': 0, 'Loyal Cus
         data['Type of Travel']=data['Type of Travel'].map(dict({'Personal Travel': 0, 'Business
         #data['Class']=data['Class'].map(dict({'Eco Plus': 0, 'Business': 1, 'Eco': 2}))
         data['satisfaction']=data['satisfaction'].map(dict({'neutral or dissatisfied': 0, 'satis
In [4]:
         data
Out[4]:
                                               Type
                                                                      Inflight
                                                                                               Ease of
                                                               Flight
                                                                              Departure/Arrival
                                Customer
                    id Gender
                                         Age
                                                 of
                                                       Class
                                                                         wifi
                                                                                               Online
                                                             Distance
                                    Type
                                                                               time convenient
                                              Travel
                                                                      service
                                                                                              booking
                 70172
              0
                             0
                                      1
                                           13
                                                  0 Eco Plus
                                                                 460
                                                                           3
                                                                                           4
                                                                                                    3
                             0
                                                                           3
                                                                                           2
                                                                                                    3
                  5047
                                      0
                                           25
                                                     Business
                                                                 235
                110028
                                                                           2
                                                                                           2
                                                                                                    2
                             1
                                       1
                                           26
                                                     Business
                                                                1142
                                                                           2
                 24026
                             1
                                       1
                                           25
                                                     Business
                                                                 562
                119299
                             0
                                       1
                                           61
                                                                           3
                                                                                           3
                                                                                                    3
                                                     Business
                                                                 214
                                                                           2
         103899
                 94171
                             1
                                      0
                                           23
                                                         Eco
                                                                 192
                                                                                           1
                                                                                                    2
         103900
                 73097
                                       1
                                           49
                                                     Business
                                                                2347
                                                                           1
                                                                                           1
         103901
                 68825
                             0
                                      0
                                           30
                                                     Business
                                                                 1995
```

103904 rows × 24 columns

54173

62567

0

103902

103903

```
In [5]: def oheColumn(oheData, columnName):
    oneHotEnc = OneHotEncoder(dtype=int, handle_unknown='ignore')
```

Eco

**Business** 

1000

1723

1

1

3

3

22

27

```
oheDataColumn = oneHotEnc.fit_transform(oheData[[columnName]]).toarray()
oheData[oneHotEnc.categories_[0]] = oheDataColumn

for catCol in oneHotEnc.categories_[0]:
    oheData.rename(columns = {catCol:columnName+'_'+catCol}, inplace = True)

return oheData
```

In [6]: data = oheColumn(data, 'Class').drop('Class', axis=1)

In [7]: data

Out[7]:

•		id	Gender	Customer Type	Age	Type of Travel	Flight Distance	Inflight wifi service	Departure/Arrival time convenient	Ease of Online booking	Gate location	•••	Ba ha
	0	70172	0	1	13	0	460	3	4	3	1		
	1	5047	0	0	25	1	235	3	2	3	3		
	2	110028	1	1	26	1	1142	2	2	2	2		
	3	24026	1	1	25	1	562	2	5	5	5		
	4	119299	0	1	61	1	214	3	3	3	3		
	•••												
	103899	94171	1	0	23	1	192	2	1	2	3		
	103900	73097	0	1	49	1	2347	4	4	4	4		
	103901	68825	0	0	30	1	1995	1	1	1	3		
	103902	54173	1	0	22	1	1000	1	1	1	5		
	103903	62567	0	1	27	1	1723	1	3	3	3		

103904 rows × 26 columns

```
In [8]: print(data.iloc[:,0:27].isna().sum())
```

id	0
Gender	0
Customer Type	0
Age	0
Type of Travel	0
Flight Distance	0
Inflight wifi service	0
Departure/Arrival time convenient	0
Ease of Online booking	0
Gate location	0
Food and drink	0
Online boarding	0
Seat comfort	0
Inflight entertainment	0
On-board service	0
Leg room service	0
Baggage handling	0
Checkin service	0
Inflight service	0
Cleanliness	0
Departure Delay in Minutes	0
Arrival Delay in Minutes	310

```
0
          Class Business
                                                      0
          Class Eco
                                                      0
          Class Eco Plus
          dtype: int64
 In [9]: #Filling in nan values
          data['Arrival Delay in Minutes']=data['Arrival Delay in Minutes'].fillna(0)
In [10]:
          print(data.iloc[:,0:27].isna().sum())
                                                    0
          id
                                                    0
          Gender
          Customer Type
                                                    0
                                                    0
          Age
          Type of Travel
                                                    0
          Flight Distance
                                                    0
          Inflight wifi service
                                                    0
          Departure/Arrival time convenient
                                                    0
          Ease of Online booking
                                                    0
          Gate location
                                                    0
          Food and drink
                                                    0
                                                    0
          Online boarding
                                                    0
          Seat comfort
          Inflight entertainment
                                                    0
          On-board service
                                                    0
                                                    0
          Leg room service
                                                    0
          Baggage handling
                                                    0
          Checkin service
          Inflight service
                                                    0
          Cleanliness
                                                    0
                                                    0
          Departure Delay in Minutes
         Arrival Delay in Minutes
                                                    0
                                                    0
          satisfaction
          Class Business
                                                    0
          Class Eco
                                                    0
                                                    0
          Class Eco Plus
          dtype: int64
          data=data.drop duplicates()
In [11]:
          data
In [12]:
Out[12]:
                                                 Type
                                                                Inflight
                                                                                         Ease of
                                                         Flight
                                                                        Departure/Arrival
                                                                                                    Gate
                                                                                                             Ba
                                 Customer
                      id Gender
                                                   of
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                                                                                          Online
                                     Type
                                                       Distance
                                                                         time convenient
                                                                                                 location
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                                                                                        booking
                                                Travel
               0
                   70172
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                                                           460
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                                                                                     4
                                                                                              3
                                                                                                       1
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                    5047
                                        0
                                            25
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                                                           235
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                                                                                                       3
               2 110028
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                                                                     2
                                                                                     2
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                                                                                                       2
                              1
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                   24026
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                                                                                     5
                                                                                              5
                                                                                                       5
                              1
                                        1
                                                    1
                                                           562
                                                                     2
                                                                                     3
               4 119299
                              0
                                        1
                                            61
                                                    1
                                                                     3
                                                                                              3
                                                                                                       3 ...
                                                           214
```

satisfaction

**103903** 62567 0 1 27 1 1723 1 3 3 3

```
103904 rows × 26 columns
```

travel

```
In [13]:
                            corrMatrix = data.corr()
                             #print(corrMatrix)
                             sns.heatmap(corrMatrix, annot=True,)
                            <AxesSubplot:>
Out[13]:
                                                                                                                                                                                                                                                                                                      - 1.00
                                                                                            id - 1, 090 6 0 0 155 8 0 0 485 6 92 10 02 91 4 00 600 10 550 5 50 45 0 75 0 75 0 75 0 70 0 2 6 . 92 . 0 6 . 0 1 4 . 1 0 . 93 0 4
                                                                                 Gender 200 1).03.20.8916965.800.909.000900.000000.000580.0066108.2-320-370-0103.90650.290-035020110.5300
                                                                 Customer Type -0.001053 1 0.280.30.20007052 D.0200000059.19.16.10.0 570 428 02.50 32.0 02.50 34 900.40 048.0 086.12006
                                                                                                  .02300<mark>8928 10</mark>.0499099901893889250001G2G.210.16607660589401.0489305.0499549.901.0102140.140.140.01
                                                                                                                                                                                                                                                                                                      - 0.75
                                                                    Type of Travel -0.0004869330.04 1 0.270.130.26.16.0301063.220.120.16.0507.14.030.00.7023007.90540599450.55-0.5-0.1
                                                                  Flight Distance -
                                                                                                   09600623.099.27<mark>1</mark>0070L00206.604.8507.210.160.130.110.133.0630733053809.8990220020530.470.40.1
                                                          Inflight wifi service -).0/21(0)90/7.51& D100 7 1 0.3-0.720.3-0.130.4-6.120.2 D.120.16.10.046.1 D.1-6.0-070 1992& 0-3806.00
                                                                                                                                                                                                                                                                                                     -0.50
                           Departure/Arrival time convenient -0002009.120.038.26.00.34 1 0.440.4400 49007.0100049690 120 1020 1020 1030 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1040110 1
                                                  Food and drink -0.01.005659023063057.13004.9B200 1 0.25.50.60.059032055087030.660.03.03220.087.07990
                                                                                                                                                                                                                                                                                                      -0.25
                                                                Online boarding -.055042.19.20.20.20.20.46.070.40.00072.210.40.20.16.10.083.20.076.38.0409020.50.330.29.07
                                                                      Seat comfort - .053020.16.16.16.16.12.010.0300 575 70.42 1 0.6.0.130.10.075.19.060.60.028.08.35.230.20.05
                                                   Inflight entertainment -0002006110.076.15.15.21.00494.003;60.29.61.1 0.420.30.38.120.40.60.027030.4 0.20.18.04
                                                                                                                                                                                                                                                                                                      -0.00
                                                              On-board service -. 0-0-050 0082 0570 0580 507.1 D. 102.0 0690 329.0 250 50.1 0.1 0.42 1 0.3 0.5 20.2 4.5 50.1 0.0 0820 3053 20.2 20.1 08.0 7
                                                              Leg room service -.045.062048040.14.130.166.0102.101.0059302.120.110.30.36 1 0.370.150.307.0960.D40102.3.D.2.10.108.06
                                                            Baggage handling -.0750-2504.8 310 60. 10.0 7203.900.9 350 830 75.38.52.3 1 0.23.60.0960 0560 662 5.170.104.06
                                                                Checkin service -.073001.03203500.073043098030.005987.20.19.120.24.15.23 1).24.18.018.00.224.160.18.00
                                                                                                                                                                                                                                                                                                        -0.25
                                                                 Inflight service -.070.0390.20304.9.203058.1d.070308.500.70304.505069.40.553.30.650.24 1 .0809.055050924.170.140.0
                                                                         Cleanliness - .025006584054052079096.16.01400600 0.60.3 0.688.6 0.10.096096.18.08 1 0.0140 163 10.140 102.03
                                         Departure Delay in Minutes 0.42092.093.0.1 05300 201.0.100.000 955 93.0.100.000 955 93.0.100.000 955 93.0.100.000 955 93.0.100.000 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 93.0.100 955 
                                                                                                                                                                                                                                                                                                         -0.50
                                                Arrival Delay in Minutes 4.0307900.8504.601295.992.5010900.907.009.520.920.202.903.030106.50020.08692.059010.96 10.05700.850.1006
                                                                         satisfaction -.0304010219.140.450.30.26.05020.0006.210.50.350.40.320.310.250.240.240.340.95.05 1 0.50.450.1
                                                                 Class Business -0.20.00.D86.140.550.40.03B097D1004.587.330.230.20.220.2D.170.160.170.140.00.016.5 1 0.870.2
                                                                            Class_Eco 0.0.805381-20.130.50.40.06.7082.69.893.579.249.2-10.1-80.1-80.1-40.1-30.1-40.02.043.21-10.45.87 1 0.2
                                                                  Flight Distance
                                                                                                                                                                     Food and drink
                                                                                                                                                                             Online boarding
                                                                                                                                                                                                                      Checkin service
                                                                                                                Customer Type
                                                                                                                              Type of Travel
                                                                                                                                           Inflight wifi service
                                                                                                                                                         Ease of Online booking
                                                                                                                                                               Gate location
                                                                                                                                                                                           Inflight entertainment
                                                                                                                                                                                                 On-board service
                                                                                                                                                                                                         Leg room service
                                                                                                                                                                                                               Baggage handling
                                                                                                                                                                                                                            Inflight service
                                                                                                                                                                                                                                   Cleanliness
                                                                                                                                                                                                                                          Departure Delay in Minutes
                                                                                                                                                                                                                                                 Arrival Delay in Minutes
                                                                                                         Gender
                                                                                                                                                  Departure/Arrival time convenient
                                                                                                                                                                                    Seat comfort
                            datal=data raw.loc[:, ['Type of Travel', 'Inflight wifi service',
                                                   'Ease of Online booking', 'Food and drink', 'Online boarding',
                                                                                                                                                                                                                                                           'On-board service
                                                   'Baggage handling', 'Inflight service', 'Cleanliness',
                                                   'Departure Delay in Minutes', 'Arrival Delay in Minutes',
                                                   'satisfaction', 'Class', 'Inflight entertainment', 'Seat comfort']] #data.drop("id"
                            data1
In [16]:
                                                                         Inflight
                                                                                                                                                                                                                                                                       Departure
Out[16]:
                                                                                                   Ease of
                                                                                                                        Food
                                                                                                                                                                           On-
                                                                                                                                                                                                                                                                                                      Arrival
                                                   Type of
                                                                                                                                               Online
                                                                                                                                                                                        Baggage Inflight
                                                                                                   Online
                                                                                                                                                                                                                                                                            Delay in
                                                                                                                                                                                                                                                                                                   Delay in
                                                                                  wifi
                                                                                                                           and
                                                                                                                                                                      board
                                                                                                                                                                                                                                        Cleanliness
                                                      Travel
                                                                                                                                         boarding
                                                                                                                                                                                        handling
                                                                                                                                                                                                                  service
                                                                          service
                                                                                               booking
                                                                                                                       drink
                                                                                                                                                                   service
                                                                                                                                                                                                                                                                            Minutes
                                                                                                                                                                                                                                                                                                   Minutes
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                                                                                                                                                                                                                                                                                           1
                                                                                                                                                                                                                                                                                                                6.0
                                                  Business
```

2	Business travel	2	2	5	5	4	4	4	5	0	0.0
3	Business travel	2	5	2	2	2	3	4	2	11	9.0
4	Business travel	3	3	4	5	3	4	3	3	0	0.0
103899	Business travel	2	2	2	2	3	4	3	2	3	0.0
103900	Business travel	4	4	2	4	5	5	5	4	0	0.0
103901	Business travel	1	1	4	1	3	4	5	4	7	14.0
103902	Business travel	1	1	1	1	4	1	4	1	0	0.0
103903	Business travel	1	3	1	1	1	4	3	1	0	0.0

103904 rows × 15 columns

```
In [17]: from pgmpy.estimators import PC
         from pgmpy.estimators.CITests import chi square
         est = PC(data1)
         print(est.estimate(significance level=0.01).edges())
                       | 0/5 [00:00<?, ?it/s]
        ValueError
                                                   Traceback (most recent call last)
        ~\anaconda3\lib\site-packages\pgmpy\estimators\CITests.py in power divergence(X, Y, Z, d
        ata, boolean, lambda_, **kwargs)
            549
                             try:
         --> 550
                                 c, _, d, _ = stats.chi2_contingency(
            551
                                     df.groupby([X, Y]).size().unstack(Y, fill value=0), lambda =
        lambda
        ~\anaconda3\lib\site-packages\scipy\stats\contingency.py in chi2 contingency(observed, c
        orrection, lambda )
            268
                    if observed.size == 0:
         --> 269
                        raise ValueError("No data; `observed` has size 0.")
            270
        ValueError: No data; `observed` has size 0.
        During handling of the above exception, another exception occurred:
        TypeError
                                                   Traceback (most recent call last)
         ~\AppData\Local\Temp\ipykernel 25332\1097962197.py in <module>
              2 from pgmpy.estimators.CITests import chi square
              3 \text{ est} = PC(\text{data1})
         ---> 4 print(est.estimate(significance level=0.01).edges())
        ~\anaconda3\lib\site-packages\pgmpy\estimators\PC.py in estimate(self, variant, ci_test,
         max_cond_vars, return_type, significance_level, n_jobs, show_progress, **kwargs)
            167
            168
                         # Step 1: Run the PC algorithm to build the skeleton and get the separat
        ing sets.
         --> 169
                         skel, separating sets = self.build skeleton(
             170
                             ci test=ci test,
```

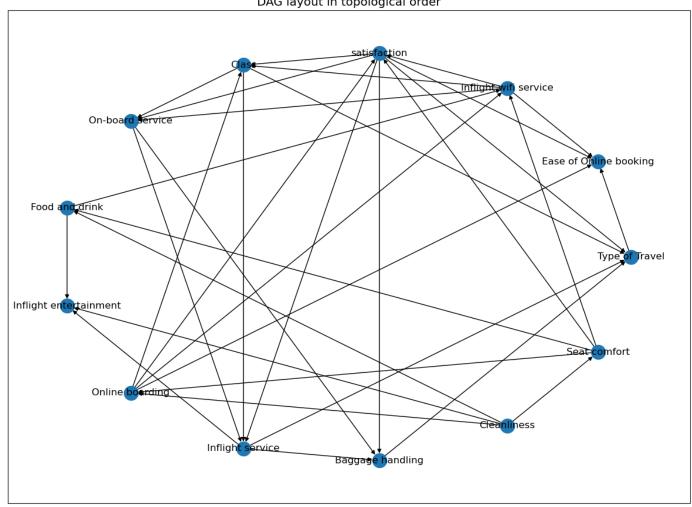
```
~\anaconda3\lib\site-packages\pgmpy\estimators\PC.py in build skeleton(self, ci test, ma
        x cond vars, significance level, variant, n jobs, show progress, **kwargs)
                                         # If a conditioning set exists remove the edge, store th
             317
            318
                                         # separating set and move on to finding conditioning set
         for next edge.
         --> 319
                                         if ci test(
             320
                                             u,
             321
                                             v,
        ~\anaconda3\lib\site-packages\pgmpy\estimators\CITests.py in chi square(X, Y, Z, data, b
        oolean, **kwarqs)
              93
                    False
                    11 11 11
              94
         ---> 95
                   return power divergence (
             96
                        X=X, Y=Y, Z=Z, data=data, boolean=boolean, lambda ="pearson", **kwargs
              97
         ~\anaconda3\lib\site-packages\pgmpy\estimators\CITests.py in power divergence(X, Y, Z, d
        ata, boolean, lambda_, **kwargs)
             562
                                     z str = ", ".join(
         --> 563
                                         [f"{var}={state}" for var, state in zip(Z, z state)]
             564
             565
                                     logging.info(
        TypeError: 'int' object is not iterable
In [18]: from pgmpy.estimators import HillClimbSearch
         from pgmpy.estimators import BDeuScore, K2Score, BicScore
         from pgmpy.models import BayesianModel
         hc = HillClimbSearch(data1)
         best model = hc.estimate(scoring method=BicScore(data1))
        print(best model.edges())
                        | 0/1000000 [00:00<?, ?it/s]
        [('Type of Travel', 'Ease of Online booking'), ('Inflight wifi service', 'Ease of Online
        booking'), ('Inflight wifi service', 'satisfaction'), ('Inflight wifi service', 'Clas
        s'), ('Inflight wifi service', 'On-board service'), ('Food and drink', 'Inflight enterta
        inment'), ('Food and drink', 'Inflight wifi service'), ('Online boarding', 'Inflight wif
        i service'), ('Online boarding', 'satisfaction'), ('Online boarding', 'Ease of Online bo
        oking'), ('Online boarding', 'Class'), ('On-board service', 'Inflight service'), ('On-bo
        ard service', 'Baggage handling'), ('Baggage handling', 'Type of Travel'), ('Inflight se
        rvice', 'Inflight entertainment'), ('Inflight service', 'Baggage handling'), ('Inflight
        service', 'Type of Travel'), ('Cleanliness', 'Inflight entertainment'), ('Cleanliness',
         'Food and drink'), ('Cleanliness', 'Seat comfort'), ('Cleanliness', 'Online boarding'),
         ('satisfaction', 'Class'), ('satisfaction', 'On-board service'), ('satisfaction', 'Type
        of Travel'), ('satisfaction', 'Baggage handling'), ('satisfaction', 'Inflight service'),
         ('satisfaction', 'Ease of Online booking'), ('Class', 'Type of Travel'), ('Class', 'Infl
        ight service'), ('Class', 'On-board service'), ('Seat comfort', 'Online boarding'), ('Se
        at comfort', 'Food and drink'), ('Seat comfort', 'Inflight wifi service'), ('Seat comfor
        t', 'satisfaction')]
In [19]: import networkx as nx
         import matplotlib.pyplot as plt
         G = nx.DiGraph(best model.edges())
         for layer, nodes in enumerate(nx.topological generations(G)):
             # `multipartite layout` expects the layer as a node attribute, so add the
             # numeric layer value as a node attribute
             for node in nodes:
                 G.nodes[node]["layer"] = layer
```

max cond vars=max cond vars,

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```
# Compute the multipartite layout using the "layer" node attribute
# pos = nx.multipartite layout(G, subset key="layer")
pos=nx.circular layout(G, scale=1, center=None, dim=2)
# nx.spring layout(G) #nx.nx pydot.graphviz layout(G)
fig, ax = plt.subplots()
nx.draw networkx(G, pos=pos, ax=ax)
ax.set title("DAG layout in topological order")
fig.tight layout()
plt.show()
```

DAG layout in topological order



the features which we are inferring are\

1)Satisfaction\ 2)Type of Travel

```
#Maximum likelihood estimator
In [20]:
        from pgmpy.models import BayesianModel
In [21]:
        model = BayesianModel(best model.edges())
        from pgmpy.estimators import MaximumLikelihoodEstimator
In [22]:
        mle = MaximumLikelihoodEstimator(model, data1)
        print(mle.estimate cpd('satisfaction')) # unconditional
        mle.estimate cpd('satisfaction')
         | Inflight wifi service
                                                 | ... | Inflight wifi service(5) | Inflight wifi
        service(5) |
```

Online boarding												
Seat comfort	Online boarding ng(5)		1 1	Online boarding(5)	Online boardi							
satisfaction(neutral or dissatisfied)     0.0	Seat comfort (5)		1 1	Seat comfort(4)	Seat comfort							
satisfaction(satisfied)	satisfaction(neutral or 07656066	dissatisfied)	1 1	0.0	0.00058892815							
<pre>+ <tabularcpd 0x23f15507ac0="" at="" boarding:="" comfort:6)="" inflight="" online="" p(satisfaction:2="" representing="" seat="" service:6,="" wifi=""  ="">  print(mle.estimate_cpd('Class'))  +</tabularcpd></pre>	satisfaction(satisfied)		1 1	1.0	0.99941107184							
Inflight wifi service     Inflight wifi service(5)	+ <tabularcpd representing<="" td=""><td>P(satisfaction:</td><td></td><td></td><td></td></tabularcpd>	P(satisfaction:										
Inflight wifi service     Inflight wifi service(5)	<pre>print(mle.estimate_cpd('Class'))</pre>											
Online boarding	Inflight wifi service	Inflight	wifi s	ervice(5)								
satisfaction	Online boarding	Online b	boarding(5)									
Class(Business)     0.524873398868037   +	satisfaction	satisfac	tion(sa	on(satisfied)								
Class(Eco)	Class(Business)	0.524873	3988680	37								
Class(Eco Plus)     0.08772713732499256	Class(Eco)	0.387399	4638069	705								
++	Class(Eco Plus)	0.087727	1373249	9256								