Initial(2)

January 20, 2024

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, classification_report
import pymc3 as pm
```

```
WARN: Could not locate executable g77
WARN: Could not locate executable f77
WARN: Could not locate executable ifort
WARN: Could not locate executable ifl
WARN: Could not locate executable f90
WARN: Could not locate executable DF
WARN: Could not locate executable efl
WARN: Could not locate executable gfortran
WARN: Could not locate executable f95
WARN: Could not locate executable g95
WARN: Could not locate executable efort
WARN: Could not locate executable efc
WARN: Could not locate executable flang
WARN: don't know how to compile Fortran code on platform 'nt'

WARNING (theano.configdefaults): g++ not available, if using conda: `conda
install m2w64-toolchain`
WARNING (theano.configdefaults): g++ not detected ! Theano will be unable to
execute optimized C-implementations (for both CPU and GPU) and will default to
Python implementations. Performance will be severely degraded. To remove this
warning, set Theano flags cxx to an empty string.
WARNING (theano.tensor.blas): Using NumPy C-API based implementation for BLAS
functions.
```

[3]:
```
df = pd.read_csv('C:/Users/sriva/OneDrive/Desktop/TU Dortmund/4) WiSe-2023-24/
↪4) Case Studies results/booking.csv')
```

[4]:
```
df.head(3)
```

[4]:
```
  Booking_ID  number of adults  number of children  number of weekend nights  \
0   INN00001                 1                   1                         2
1   INN00002                 1                   0                         1
2   INN00003                 2                   1                         1

   number of week nights  type of meal  car parking space   room type  \
0                      5   Meal Plan 1                  0  Room_Type 1
1                      3  Not Selected                  0  Room_Type 1
2                      3   Meal Plan 1                  0  Room_Type 1

   lead time market segment type  repeated  P-C  P-not-C  average price  \
0        224                Offline         0    0        0          88.00
1          5                 Online         0    0        0         106.68
2          1                 Online         0    0        0          50.00

   special requests date of reservation booking status
0                 0           10/2/2015   Not_Canceled
1                 1           11/6/2018   Not_Canceled
2                 0           2/28/2018       Canceled
```

[5]:
```python
# Perform random sampling of 10,000 observations
df1 = df.sample(n=10000, random_state=42)  # Use a specific random_state for␣
↪reproducibility

# Display the resulting DataFrame
print(df1)
```

```
      Booking_ID  number of adults  number of children  \
36238   INN36239                 1                   0
83      INN00084                 2                   0
23449   INN23450                 1                   0
14981   INN14982                 1                   0
18392   INN18393                 2                   0
…            …                 …                   …
6755    INN06756                 2                   0
26612   INN26613                 2                   0
8696    INN08697                 2                   0
35211   INN35212                 2                   0
20777   INN20778                 3                   0

       number of weekend nights  number of week nights  type of meal  \
36238                         0                      1  Not Selected
83                            1                      4   Meal Plan 1
23449                         0                      1   Meal Plan 1
14981                         2                      1   Meal Plan 1
18392                         1                      0   Meal Plan 1
…                           …                      …           …
```

```
6755                        0                      2   Meal Plan 1
26612                       0                      2   Meal Plan 1
8696                        0                      1  Not Selected
35211                       0                      1   Meal Plan 1
20777                       0                      1   Meal Plan 1

       car parking space    room type  lead time market segment type  \
36238                  0  Room_Type 1        117              Online
83                     0  Room_Type 4         40              Online
23449                  1  Room_Type 1          7           Corporate
14981                  0  Room_Type 1        116              Online
18392                  0  Room_Type 1        141             Offline
…                    …          …        …                   …
6755                   0  Room_Type 1          8              Online
26612                  0  Room_Type 1        211             Offline
8696                   1  Room_Type 1        153              Online
35211                  0  Room_Type 1         43             Offline
20777                  0  Room_Type 1         72              Online

       repeated  P-C  P-not-C  average price  special requests  \
36238         0    0        0         161.10                 1
83            0    0        0          98.82                 0
23449         1    0        7          98.00                 1
14981         0    0        0           1.00                 0
18392         0    0        0          90.00                 0
…           …  …      …            …                …
6755          0    0        0         111.35                 1
26612         0    0        0         100.00                 0
8696          0    0        0         103.50                 1
35211         0    0        0          85.00                 0
20777         0    0        0         159.30                 0

      date of reservation booking status
36238          11/10/2018       Canceled
83              3/14/2018   Not_Canceled
23449           6/22/2018   Not_Canceled
14981           2/28/2018   Not_Canceled
18392           9/20/2017   Not_Canceled
…                     …            …
6755            5/31/2018   Not_Canceled
26612           5/20/2018       Canceled
8696            7/29/2018       Canceled
35211          10/13/2017   Not_Canceled
20777           5/13/2018       Canceled

[10000 rows x 17 columns]
```

```
[6]: df1.rename(columns={'Booking_ID':'Booking_ID','number of adults':
      ↪'number_of_adults', 'number of children':'number_of_children',
                         'number of weekend nights':'number_of_weekend_nights',␣
      ↪'number of week nights':'number_of_week_nights',
                         'type of meal':'type_of_meal','car parking space':
      ↪'car_parking_space', 'room type':'room_type',
                         'lead time':'lead_time', 'market segment type':
      ↪'market_segment_type','number of adults':'number_of_adults', 'average price':
      ↪'average_price','special requests':'special_requests',
                        'date of reservation':'date_of_reservation','booking status':
      ↪'booking_status'}, inplace=True)
```

```
[7]: df1.head(3)
```

```
[7]:       Booking_ID  number_of_adults  number_of_children  \
     36238   INN36239                 1                   0
     83      INN00084                 2                   0
     23449   INN23450                 1                   0

            number_of_weekend_nights  number_of_week_nights  type_of_meal  \
     36238                         0                      1  Not Selected
     83                            1                      4   Meal Plan 1
     23449                         0                      1   Meal Plan 1

            car_parking_space    room_type  lead_time market_segment_type  \
     36238                  0  Room_Type 1        117              Online
     83                     0  Room_Type 4         40              Online
     23449                  1  Room_Type 1          7           Corporate

            repeated  P-C  P-not-C  average_price  special_requests  \
     36238         0    0        0         161.10                 1
     83            0    0        0          98.82                 0
     23449         1    0        7          98.00                 1

           date_of_reservation booking_status
     36238          11/10/2018       Canceled
     83              3/14/2018   Not_Canceled
     23449           6/22/2018   Not_Canceled
```

```
[8]: df1.tail(3)
```

```
[8]:       Booking_ID  number_of_adults  number_of_children  \
     8696    INN08697                 2                   0
     35211   INN35212                 2                   0
     20777   INN20778                 3                   0

            number_of_weekend_nights  number_of_week_nights  type_of_meal  \
8696                         0                      1  Not Selected
35211                        0                      1   Meal Plan 1
20777                        0                      1   Meal Plan 1

       car_parking_space    room_type  lead_time market_segment_type  \
8696                   1  Room_Type 1        153              Online
35211                  0  Room_Type 1         43             Offline
20777                  0  Room_Type 1         72              Online

       repeated  P-C  P-not-C  average_price  special_requests  \
8696          0    0        0          103.5                 1
35211         0    0        0           85.0                 0
20777         0    0        0          159.3                 0

      date_of_reservation booking_status
8696            7/29/2018       Canceled
35211          10/13/2017   Not_Canceled
20777           5/13/2018       Canceled
```

[9]:
```
df1.describe
```

[9]:
```
<bound method NDFrame.describe of        Booking_ID  number_of_adults
number_of_children  \
36238   INN36239                 1                   0
83      INN00084                 2                   0
23449   INN23450                 1                   0
14981   INN14982                 1                   0
18392   INN18393                 2                   0
…          …                …                  …
6755    INN06756                 2                   0
26612   INN26613                 2                   0
8696    INN08697                 2                   0
35211   INN35212                 2                   0
20777   INN20778                 3                   0

       number_of_weekend_nights  number_of_week_nights  type_of_meal  \
36238                         0                      1  Not Selected
83                            1                      4   Meal Plan 1
23449                         0                      1   Meal Plan 1
14981                         2                      1   Meal Plan 1
18392                         1                      0   Meal Plan 1
…                          …                      …            …
6755                          0                      2   Meal Plan 1
26612                         0                      2   Meal Plan 1
8696                          0                      1  Not Selected
35211                         0                      1   Meal Plan 1
20777                         0                      1   Meal Plan 1
```

```
       car_parking_space    room_type  lead_time market_segment_type  \
36238                  0  Room_Type 1        117              Online
83                     0  Room_Type 4         40              Online
23449                  1  Room_Type 1          7           Corporate
14981                  0  Room_Type 1        116              Online
18392                  0  Room_Type 1        141             Offline
…                    …          …        …                 …
6755                   0  Room_Type 1          8              Online
26612                  0  Room_Type 1        211             Offline
8696                   1  Room_Type 1        153              Online
35211                  0  Room_Type 1         43             Offline
20777                  0  Room_Type 1         72              Online

       repeated  P-C  P-not-C  average_price  special_requests  \
36238         0    0        0         161.10                 1
83            0    0        0          98.82                 0
23449         1    0        7          98.00                 1
14981         0    0        0           1.00                 0
18392         0    0        0          90.00                 0
…           …  …      …            …                …
6755          0    0        0         111.35                 1
26612         0    0        0         100.00                 0
8696          0    0        0         103.50                 1
35211         0    0        0          85.00                 0
20777         0    0        0         159.30                 0

      date_of_reservation booking_status
36238          11/10/2018       Canceled
83              3/14/2018   Not_Canceled
23449           6/22/2018   Not_Canceled
14981           2/28/2018   Not_Canceled
18392           9/20/2017   Not_Canceled
…                     …            …
6755            5/31/2018   Not_Canceled
26612           5/20/2018       Canceled
8696            7/29/2018       Canceled
35211          10/13/2017   Not_Canceled
20777           5/13/2018       Canceled

[10000 rows x 17 columns]>
```

[11]:
```
df1.shape
```

[11]:
```
(10000, 17)
```

[12]:
```
df1.columns
```

```
[12]: Index(['Booking_ID', 'number_of_adults', 'number_of_children',
              'number_of_weekend_nights', 'number_of_week_nights', 'type_of_meal',
              'car_parking_space', 'room_type', 'lead_time', 'market_segment_type',
              'repeated', 'P-C', 'P-not-C', 'average_price', 'special_requests',
              'date_of_reservation', 'booking_status'],
             dtype='object')
```

```
[13]: df1.isna().sum()
```

```
[13]: Booking_ID                  0
      number_of_adults            0
      number_of_children          0
      number_of_weekend_nights    0
      number_of_week_nights       0
      type_of_meal                0
      car_parking_space           0
      room_type                   0
      lead_time                   0
      market_segment_type         0
      repeated                    0
      P-C                         0
      P-not-C                     0
      average_price               0
      special_requests            0
      date_of_reservation         0
      booking_status              0
      dtype: int64
```

```
[14]: df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10000 entries, 36238 to 20777
Data columns (total 17 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   Booking_ID                10000 non-null  object
 1   number_of_adults          10000 non-null  int64
 2   number_of_children        10000 non-null  int64
 3   number_of_weekend_nights  10000 non-null  int64
 4   number_of_week_nights     10000 non-null  int64
 5   type_of_meal              10000 non-null  object
 6   car_parking_space         10000 non-null  int64
 7   room_type                 10000 non-null  object
 8   lead_time                 10000 non-null  int64
 9   market_segment_type       10000 non-null  object
 10  repeated                  10000 non-null  int64
 11  P-C                       10000 non-null  int64
 12  P-not-C                   10000 non-null  int64
 13  average_price             10000 non-null  float64
 14  special_requests          10000 non-null  int64
 15  date_of_reservation       10000 non-null  object
 16  booking_status            10000 non-null  object
dtypes: float64(1), int64(10), object(6)
memory usage: 1.4+ MB
```

[15]:
```
df1['booking_status'].value_counts()
print(df1['booking_status'].value_counts())
```

```
booking_status
Not_Canceled    6700
Canceled        3300
Name: count, dtype: int64
```

[16]:
```
df1 = df1.drop(['Booking_ID', 'date_of_reservation'], axis=1)
```

[17]:
```
df1
```

[17]:
```
       number_of_adults  number_of_children  number_of_weekend_nights  \
36238                 1                   0                         0
83                    2                   0                         1
23449                 1                   0                         0
14981                 1                   0                         2
18392                 2                   0                         1
…                   …                   …                         …
6755                  2                   0                         0
26612                 2                   0                         0
8696                  2                   0                         0
35211                 2                   0                         0
20777                 3                   0                         0

       number_of_week_nights  type_of_meal  car_parking_space    room_type  \
36238                      1  Not Selected                  0  Room_Type 1
83                         4   Meal Plan 1                  0  Room_Type 4
23449                      1   Meal Plan 1                  1  Room_Type 1
14981                      1   Meal Plan 1                  0  Room_Type 1
18392                      0   Meal Plan 1                  0  Room_Type 1
…                        …           …                  …          …
6755                       2   Meal Plan 1                  0  Room_Type 1
26612                      2   Meal Plan 1                  0  Room_Type 1
8696                       1  Not Selected                  1  Room_Type 1
35211                      1   Meal Plan 1                  0  Room_Type 1
20777                      1   Meal Plan 1                  0  Room_Type 1

       lead_time market_segment_type  repeated  P-C  P-not-C  average_price  \
36238        117           Online        0    0        0         161.10
83            40           Online        0    0        0          98.82
23449          7        Corporate        1    0        7          98.00
14981        116           Online        0    0        0           1.00
18392        141          Offline        0    0        0          90.00
…          …                  …       …  …      …        …
6755           8           Online        0    0        0         111.35
26612        211          Offline        0    0        0         100.00
8696         153           Online        0    0        0         103.50
35211         43          Offline        0    0        0          85.00
20777         72           Online        0    0        0         159.30

       special_requests booking_status
36238                 1       Canceled
83                    0   Not_Canceled
23449                 1   Not_Canceled
14981                 0   Not_Canceled
18392                 0   Not_Canceled
…                  …            …
6755                  1   Not_Canceled
26612                 0       Canceled
8696                  1       Canceled
35211                 0   Not_Canceled
20777                 0       Canceled

[10000 rows x 15 columns]
```

[18]:
```
df1 = pd.get_dummies(df1, columns=['type_of_meal', 'room_type',␣
↪'market_segment_type'])
```

[19]:
```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10000 entries, 36238 to 20777
Data columns (total 28 columns):
 #   Column                              Non-Null Count  Dtype
---  ------                              --------------  -----
 0   number_of_adults                    10000 non-null  int64
 1   number_of_children                  10000 non-null  int64
 2   number_of_weekend_nights            10000 non-null  int64
 3   number_of_week_nights               10000 non-null  int64
 4   car_parking_space                   10000 non-null  int64
 5   lead_time                           10000 non-null  int64
 6   repeated                            10000 non-null  int64
 7   P-C                                 10000 non-null  int64
 8   P-not-C                             10000 non-null  int64
 9   average_price                       10000 non-null  float64
 10  special_requests                  10000 non-null  int64
 11  booking_status                    10000 non-null  object
 12  type_of_meal_Meal Plan 1          10000 non-null  bool
 13  type_of_meal_Meal Plan 2          10000 non-null  bool
 14  type_of_meal_Meal Plan 3          10000 non-null  bool
 15  type_of_meal_Not Selected         10000 non-null  bool
 16  room_type_Room_Type 1             10000 non-null  bool
 17  room_type_Room_Type 2             10000 non-null  bool
 18  room_type_Room_Type 3             10000 non-null  bool
 19  room_type_Room_Type 4             10000 non-null  bool
 20  room_type_Room_Type 5             10000 non-null  bool
 21  room_type_Room_Type 6             10000 non-null  bool
 22  room_type_Room_Type 7             10000 non-null  bool
 23  market_segment_type_Aviation      10000 non-null  bool
 24  market_segment_type_Complementary  10000 non-null  bool
 25  market_segment_type_Corporate     10000 non-null  bool
 26  market_segment_type_Offline       10000 non-null  bool
 27  market_segment_type_Online        10000 non-null  bool
dtypes: bool(16), float64(1), int64(10), object(1)
memory usage: 1.1+ MB
```

[20]:
```
feature_columns = ['lead_time', 'number_of_adults', 'number_of_children',␣
↪'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',␣
↪'average_price']
target_column = 'booking_status'
```

[21]:
```
X = df1[feature_columns]
y = df1[target_column]
```

[22]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)
```

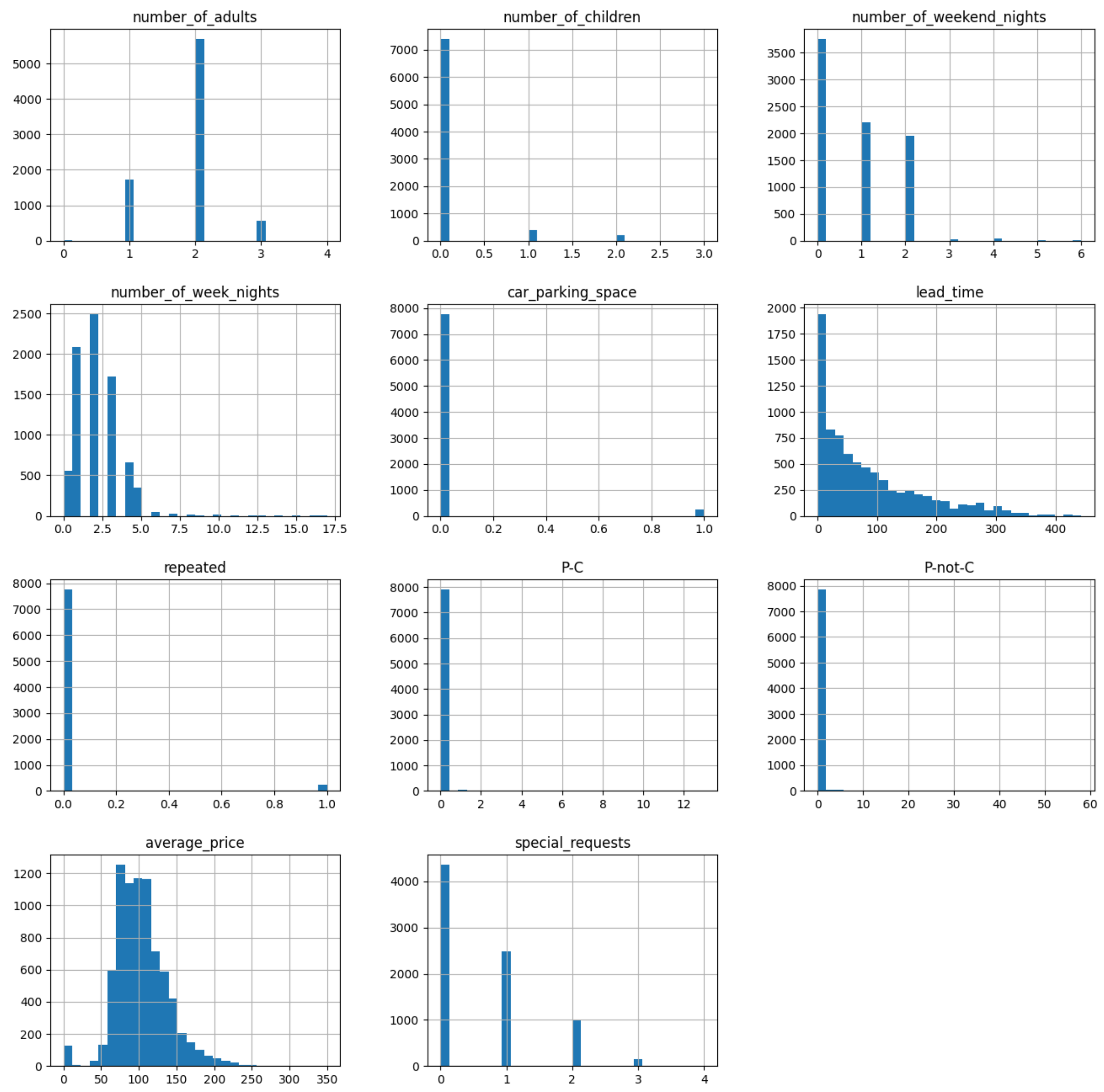
[23]:
```
#X = df1.drop('booking_status', axis=1)  ######need later maybe
#y = df1['booking_status']
```

[24]:
```
# X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42) ######need later maybe
```

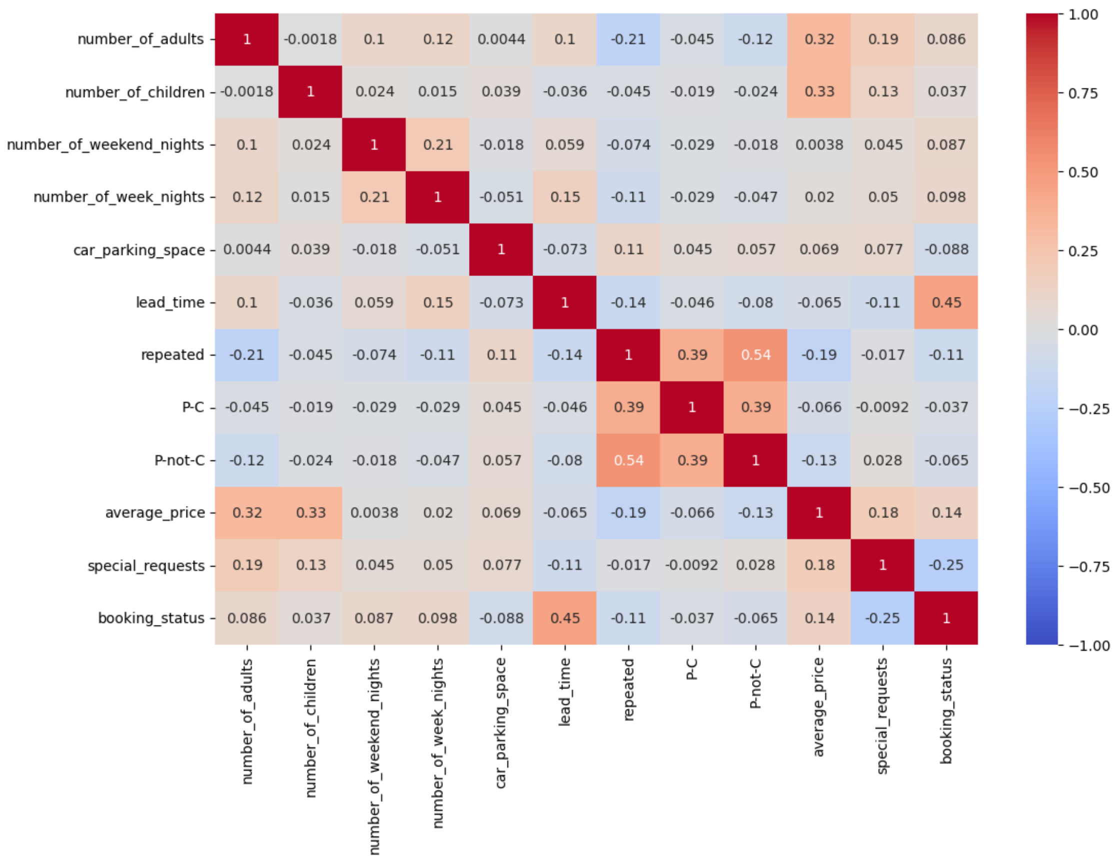
[25]:
```
train_data, test_data = train_test_split(df1, test_size=0.2, random_state=42)
```

[26]:
```
X_num = train_data.select_dtypes(include = ['int64', 'float64', 'datetime'])
```

[27]:
```
X_num.hist(bins = 30, figsize = (16, 16));
plt.savefig('histogram_plot.png')
plt.show()
```



```
[28]: corr = pd.concat([X_num, (y_train == 'Canceled')], axis = 1).corr()
      plt.figure(figsize = (12, 8))
      sns.heatmap(corr, vmin = -1, vmax = 1, cmap = 'coolwarm', annot = True);
      plt.savefig('correlation.png')
```



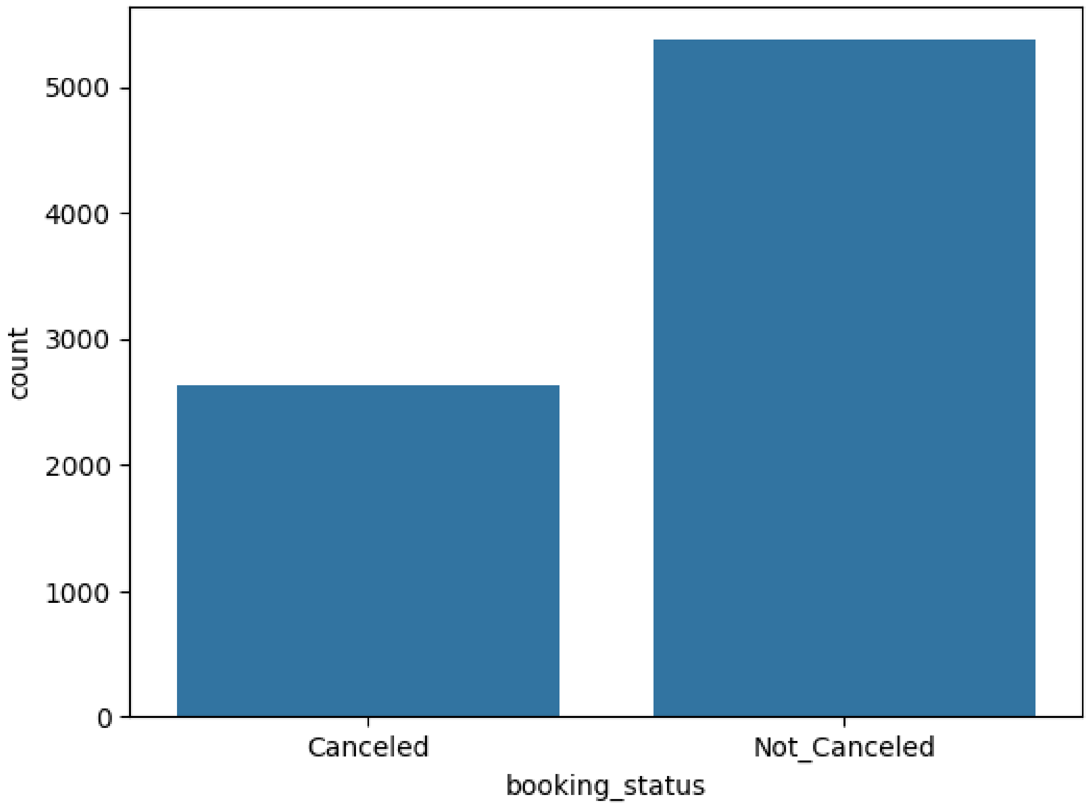
[29]:
```
train_data.shape
```

[29]:
```
(8000, 28)
```

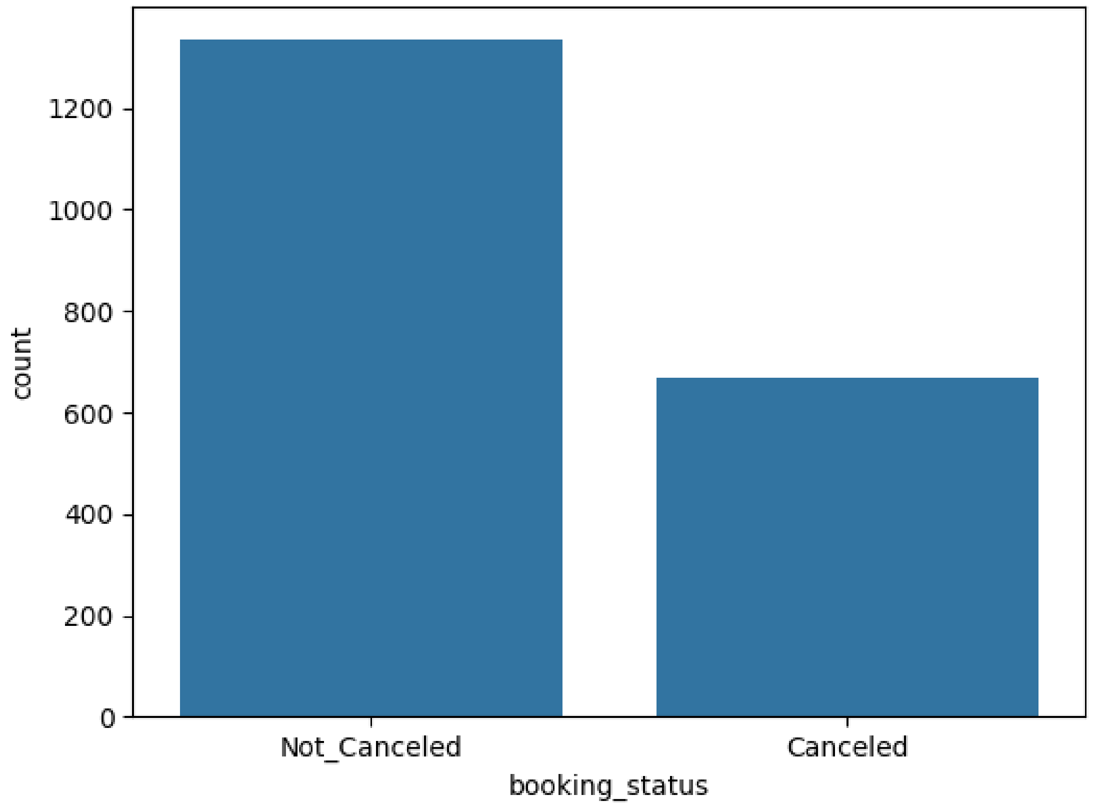
[30]:
```
test_data.shape
```

[30]:
```
(2000, 28)
```

[31]:
```
sns.countplot(x = y_train)
plt.savefig('train_data.png')
plt.show()
```



[32]:
```
sns.countplot(x = y_test)
plt.savefig('test_data.png')
plt.show()
```



[33]:
```
model = RandomForestClassifier()
model.fit(X_train, y_train)
```

[33]:
```
RandomForestClassifier()
```

[34]:
```
feature_importances = pd.Series(model.feature_importances_, index=X.columns)
feature_importances.sort_values(ascending=False, inplace=True)
print(feature_importances)
```

```
lead_time                   0.440510
average_price               0.301694
special_requests            0.086859
number_of_week_nights       0.074783
number_of_weekend_nights    0.047972
number_of_adults            0.033834
number_of_children          0.014349
dtype: float64
```

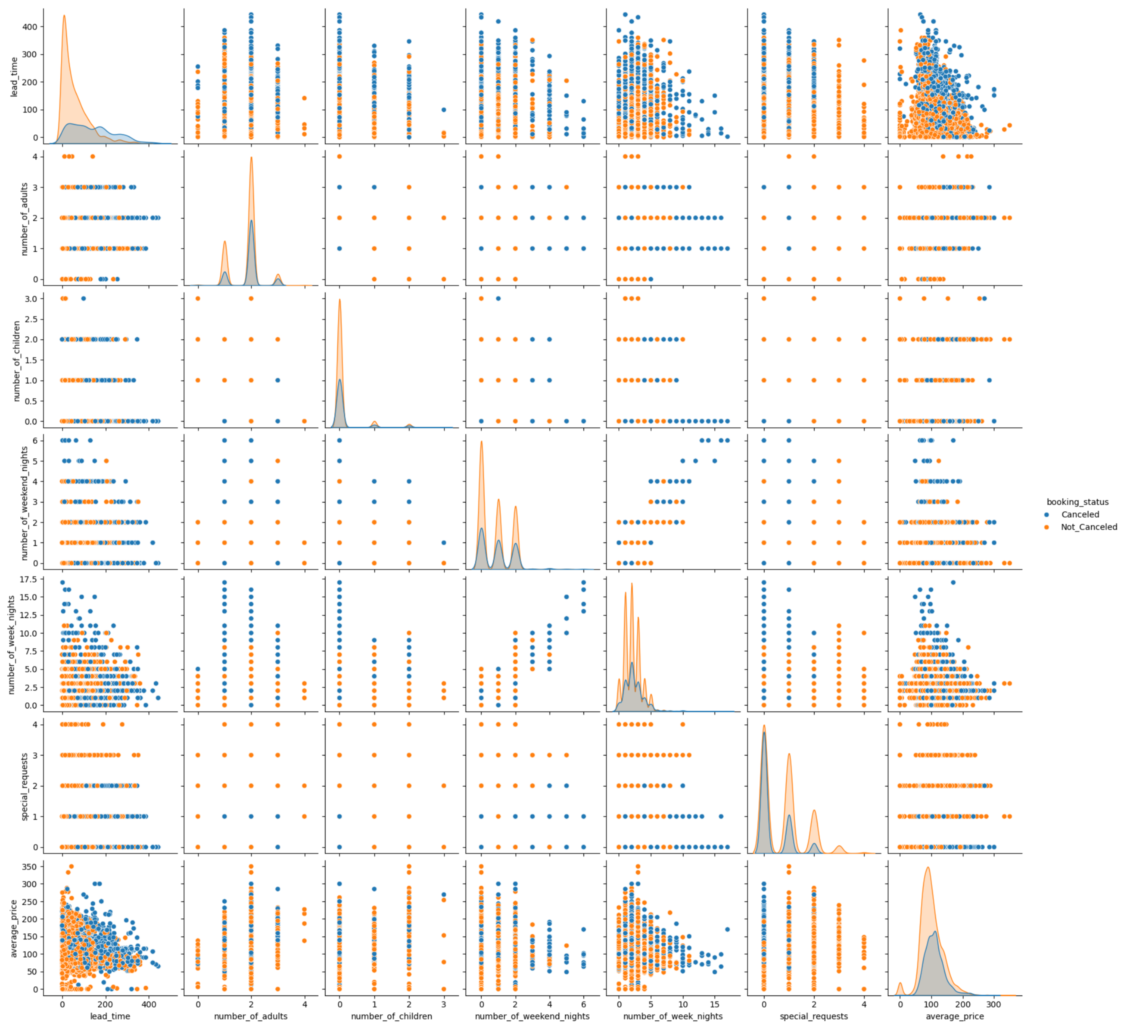
[35]:
```
print(df1.columns)
```

```
Index(['number_of_adults', 'number_of_children', 'number_of_weekend_nights',
       'number_of_week_nights', 'car_parking_space', 'lead_time', 'repeated',
       'P-C', 'P-not-C', 'average_price', 'special_requests', 'booking_status',
       'type_of_meal_Meal Plan 1', 'type_of_meal_Meal Plan 2',
       'type_of_meal_Meal Plan 3', 'type_of_meal_Not Selected',
       'room_type_Room_Type 1', 'room_type_Room_Type 2',
       'room_type_Room_Type 3', 'room_type_Room_Type 4',
       'room_type_Room_Type 5', 'room_type_Room_Type 6',
       'room_type_Room_Type 7', 'market_segment_type_Aviation',
       'market_segment_type_Complementary', 'market_segment_type_Corporate',
       'market_segment_type_Offline', 'market_segment_type_Online'],
      dtype='object')
```

[36]:
```python
selected_columns_1 = ['lead_time', 'number_of_adults',
                      'number_of_children', 'number_of_weekend_nights',
                      'number_of_week_nights', 'special_requests',
                      'average_price', 'booking_status']
selected_df = df1[selected_columns_1]
```

[37]:
```python
#Pairplot for selected variables
sns.pairplot(selected_df, hue='booking_status', diag_kind='kde')
plt.savefig('Pairplot_for_selected_variables.png')
plt.show()
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\seaborn\axisgrid.py:123: UserWarning: The figure layout has changed to
tight
  self._figure.tight_layout(*args, **kwargs)
```



Focused on: Predictive Booking Model: Implement a Bayesian model that predicts the likelihood of a successful booking based on variables such as lead time, number of adults and children, weekend and week nights, room type, and special requests. Use historical data to train the model and continuously update it to enhance accuracy.

GLM Implement -- Done

[38]:
```
with pm.Model() as bayesian_model:
    pm.glm.GLM.from_formula('booking_status ~ lead_time + number_of_adults +␣
 ↪number_of_children + number_of_weekend_nights + number_of_week_nights +␣
 ↪special_requests + average_price', train_data)
    trace = pm.sample(100, tune=10)

# Check the summary of the Bayesian model  #average_price is also important. so␣
 ↪need to add next training.
print(pm.summary(trace))
```

```python
pm.plot_posterior(trace)
plt.savefig('summary_GLM.png')
plt.show()
```

```
The glm module is deprecated and will be removed in version 4.0
We recommend to instead use Bambi https://bambinos.github.io/bambi/
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\deprecat\classic.py:215: FutureWarning: In v4.0, pm.sample will return
an `arviz.InferenceData` object instead of a `MultiTrace` by default. You can
pass return_inferencedata=True or return_inferencedata=False to be safe and
silence this warning.
  return wrapped_(*args_, **kwargs_)
Only 100 samples in chain.
Auto-assigning NUTS sampler…
Initializing NUTS using jitter+adapt_diag…
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: divide by zero
encountered in log
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: invalid value
encountered in multiply
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
Multiprocess sampling (4 chains in 4 jobs)
NUTS: [sd, average_price, special_requests, number_of_week_nights,
number_of_weekend_nights, number_of_children, number_of_adults, lead_time,
Intercept]
```

```
<IPython.core.display.HTML object>
```

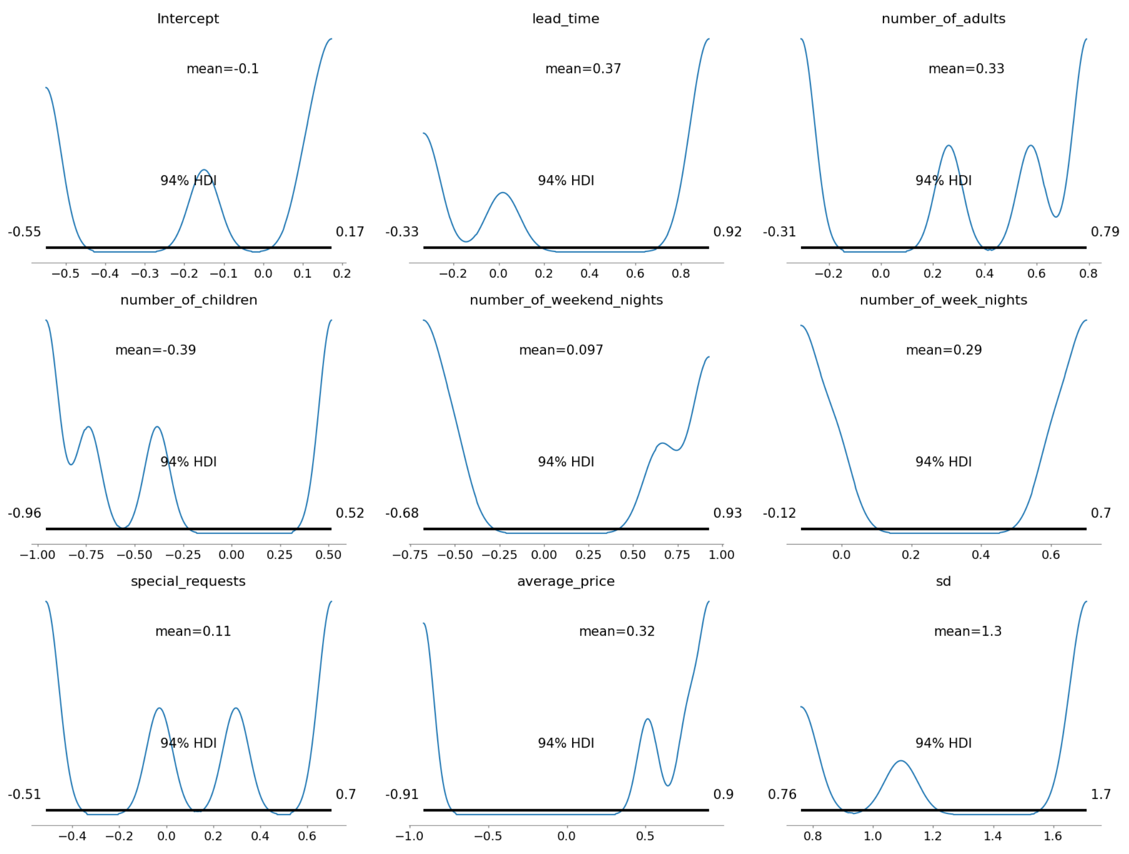
```
<IPython.core.display.HTML object>
```

```
Sampling 4 chains for 10 tune and 100 draw iterations (40 + 400 draws total)
took 152 seconds.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The rhat statistic is larger than 1.4 for some parameters. The sampler did not
converge.
The number of effective samples is smaller than 10% for some parameters.
```

```
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
Got error No model on context stack. trying to find log_likelihood in
translation.
```

```
                         mean     sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  \
Intercept              -0.103  0.286  -0.551    0.173      0.137    0.104
lead_time               0.371  0.544  -0.332    0.925      0.261    0.198
number_of_adults        0.330  0.415  -0.309    0.792      0.199    0.151
number_of_children     -0.391  0.563  -0.958    0.516      0.270    0.206
number_of_weekend_nights 0.097  0.703  -0.678    0.928      0.337    0.257
number_of_week_nights   0.294  0.365  -0.117    0.702      0.175    0.133
special_requests        0.115  0.446  -0.513    0.704      0.214    0.163
average_price           0.318  0.726  -0.914    0.905      0.348    0.265
sd                      1.316  0.408   0.759    1.711      0.196    0.149

                         ess_bulk  ess_tail         r_hat
Intercept                     4.0       4.0  3.215194e+16
lead_time                     4.0       4.0  3.215194e+16
number_of_adults              4.0       4.0  3.215194e+16
number_of_children            4.0       4.0  3.215194e+16
number_of_weekend_nights      4.0       4.0  3.215194e+16
number_of_week_nights         4.0       4.0  3.215194e+16
special_requests              4.0       4.0  3.215194e+16
average_price                 4.0       4.0  3.215194e+16
sd                            4.0     400.0  3.215194e+16
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
```



[39]:
```
train_X = train_data[['lead_time', 'number_of_adults', 'number_of_children',␣
↪'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',␣
↪'average_price']]
train_y = train_data['booking_status']
```

[40]:
```
test_X = test_data[['lead_time', 'number_of_adults', 'number_of_children',␣
↪'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',␣
↪'average_price']]
test_y = test_data['booking_status']
```

[41]:
```
with bayesian_model:
    post_pred_train = pm.sample_posterior_predictive(trace, samples=10)
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:1708: UserWarning: samples parameter is smaller than
nchains times ndraws, some draws and/or chains may not be represented in the
returned posterior predictive sample
  warnings.warn(
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

[42]:
```python
# Assuming you have the trained model from the previous step
with bayesian_model:
    post_pred = pm.sample_posterior_predictive(trace, samples=10)
```

```
<IPython.core.display.HTML object>

<IPython.core.display.HTML object>
```

[43]:
```python
train_y_int_labels = train_y.map({'Canceled': 1, 'Not_Canceled': 0})
from sklearn.metrics import accuracy_score, classification_report

predicted_labels_train = (post_pred_train['y'].mean(axis=0) > 0.5).astype(int)
predicted_labels_train = predicted_labels_train[:len(train_y)]

# Calculate accuracy with integer labels for the training set
accuracy_train = accuracy_score(train_y_int_labels, predicted_labels_train)
print(f'Accuracy on training set: {accuracy_train}')

# Print classification report with integer labels for the training set
print(classification_report(train_y_int_labels, predicted_labels_train))
```

```
Accuracy on training set: 0.28975
              precision    recall  f1-score   support

           0       0.39      0.11      0.17      5367
           1       0.27      0.66      0.38      2633

    accuracy                           0.29      8000
   macro avg       0.33      0.38      0.27      8000
weighted avg       0.35      0.29      0.24      8000
```

[44]:
```python
test_y_int_labels = test_y.map({'Canceled': 1, 'Not_Canceled': 0})
from sklearn.metrics import accuracy_score, classification_report

predicted_labels = (post_pred['y'].mean(axis=0) > 0.5).astype(int)
predicted_labels = predicted_labels[:len(test_y)]

# Calculate accuracy with integer labels
accuracy = accuracy_score(test_y_int_labels, predicted_labels)
print(f'Accuracy on test set: {accuracy}')

# Print classification report with integer labels
print(classification_report(test_y_int_labels, predicted_labels))
```

```
Accuracy on test set: 0.396
              precision    recall  f1-score   support
```

```
           0       0.68      0.18      0.29      1333
           1       0.34      0.83      0.48       667

    accuracy                           0.40      2000
   macro avg       0.51      0.50      0.38      2000
weighted avg       0.56      0.40      0.35      2000
```

[45]:
```python
# List all variable names in the trace
print(trace.varnames)
```

```
['Intercept', 'lead_time', 'number_of_adults', 'number_of_children',
'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',
'average_price', 'sd_log__', 'sd']
```

[46]:
```python
with pm.Model() as bayesian_model:
    pm.glm.GLM.from_formula('booking_status ~ lead_time + number_of_adults +␣
 ↪number_of_children + number_of_weekend_nights + number_of_week_nights +␣
 ↪special_requests + average_price', train_data)
    trace = pm.sample(100, tune=10)

# Check the summary of the Bayesian model  #average_price is also important. so␣
 ↪need to add next training.
print(pm.summary(trace))
pm.plot_posterior(trace)
plt.savefig('summary_GLM.png')
plt.show()
```

```
The glm module is deprecated and will be removed in version 4.0
We recommend to instead use Bambi https://bambinos.github.io/bambi/
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\deprecat\classic.py:215: FutureWarning: In v4.0, pm.sample will return
an `arviz.InferenceData` object instead of a `MultiTrace` by default. You can
pass return_inferencedata=True or return_inferencedata=False to be safe and
silence this warning.
  return wrapped_(*args_, **kwargs_)
Only 100 samples in chain.
Auto-assigning NUTS sampler…
Initializing NUTS using jitter+adapt_diag…
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: divide by zero
encountered in log
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: invalid value
encountered in multiply
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
Multiprocess sampling (4 chains in 4 jobs)
```

```
NUTS: [sd, average_price, special_requests, number_of_week_nights,
number_of_weekend_nights, number_of_children, number_of_adults, lead_time,
Intercept]
```

```
<IPython.core.display.HTML object>
```

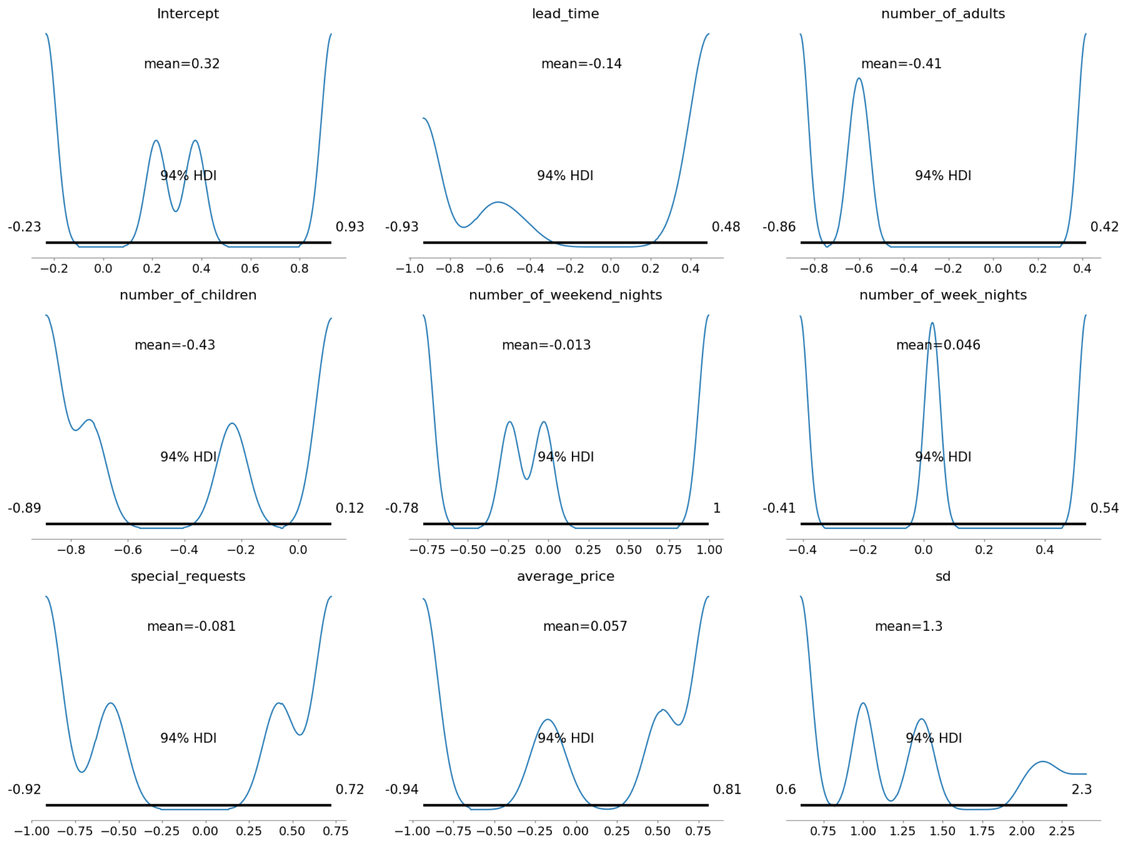
```
<IPython.core.display.HTML object>
```

```
Sampling 4 chains for 10 tune and 100 draw iterations (40 + 400 draws total)
took 217 seconds.
There were 35 divergences after tuning. Increase `target_accept` or
reparameterize.
The acceptance probability does not match the target. It is 1.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
There were 42 divergences after tuning. Increase `target_accept` or
reparameterize.
The acceptance probability does not match the target. It is 1.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The rhat statistic is larger than 1.4 for some parameters. The sampler did not
converge.
The number of effective samples is smaller than 10% for some parameters.
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
Got error No model on context stack. trying to find log_likelihood in
translation.
```

```
                          mean     sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  \
Intercept                0.321  0.417  -0.235    0.930      0.200    0.152
lead_time               -0.144  0.613  -0.934    0.483      0.294    0.224
number_of_adults        -0.412  0.491  -0.863    0.416      0.235    0.179
number_of_children      -0.434  0.400  -0.889    0.117      0.192    0.146
number_of_weekend_nights -0.013  0.644  -0.778    0.996      0.309    0.235
number_of_week_nights    0.046  0.335  -0.409    0.537      0.161    0.122
special_requests        -0.081  0.675  -0.920    0.724      0.324    0.246
average_price            0.057  0.677  -0.937    0.813      0.325    0.247
sd                       1.286  0.585   0.604    2.286      0.280    0.213

                         ess_bulk  ess_tail  r_hat
```

```
Intercept                      4.0       4.0  13.17
lead_time                      5.0       4.0   4.02
number_of_adults               4.0      12.0   6.52
number_of_children             5.0      12.0   4.99
number_of_weekend_nights       4.0       4.0   6.06
number_of_week_nights          4.0      12.0  11.98
special_requests               4.0       4.0  11.97
average_price                  4.0       4.0  13.17
sd                             4.0       4.0   6.06
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
```



Binomial-Beta Model - Testing error

```
[ ]:
```

```
[47]: import pymc3 as pm
import pandas as pd
import arviz as az
from scipy.stats import percentileofscore

# Assuming df is your DataFrame

# Encode 'booking_status' into binary format
df1['booking_status'] = (df1['booking_status'] == 'Canceled').astype(int)

with pm.Model() as binomial_beta_model:
    # Prior for the probability parameter (Beta distribution)
    p = pm.Beta('p', alpha=2, beta=2)

    # Likelihood (Binomial distribution)
    likelihood = pm.Binomial('likelihood', n=len(df1['booking_status']), p=p,␣
 ↪observed=df1['booking_status'])


    trace = pm.sample(50, tune=7, cores=1)  # Adjust the number of samples and␣
 ↪tuning steps as needed


print(pm.summary(trace))


az.plot_posterior(trace, var_names=['p'])
plt.savefig('posterior_plot.png')

# Hypothesis testing

threshold = 0.5
posterior_prob_greater_than_threshold = percentileofscore(trace['p'], threshold)
print(f"Probability that 'p' is greater than {threshold}: {100 -␣
 ↪posterior_prob_greater_than_threshold:.2f}%")
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\deprecat\classic.py:215: FutureWarning: In v4.0, pm.sample will return
an `arviz.InferenceData` object instead of a `MultiTrace` by default. You can
pass return_inferencedata=True or return_inferencedata=False to be safe and
silence this warning.
  return wrapped_(*args_, **kwargs_)
Only 50 samples in chain.
Auto-assigning NUTS sampler…
Initializing NUTS using jitter+adapt_diag…
Sequential sampling (2 chains in 1 job)
NUTS: [p]
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

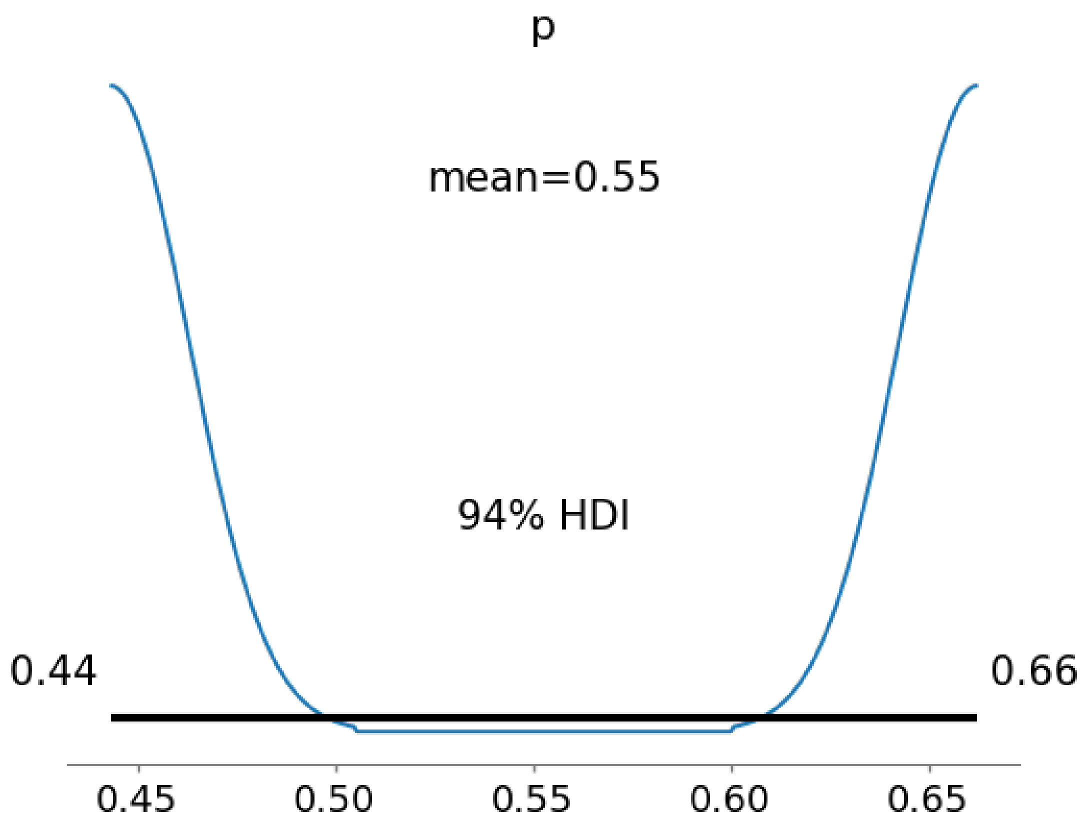
```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\scalar\basic.py:2851: RuntimeWarning: divide by zero encountered
in true_divide
  return np.float32(1.0) / x
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\numpy\core\fromnumeric.py:86: RuntimeWarning: invalid value encountered
in reduce
  return ufunc.reduce(obj, axis, dtype, out, **passkwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: invalid value
encountered in impl (vectorized)
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\scalar\basic.py:3133: RuntimeWarning: overflow encountered in
expm1
  return np.expm1(x)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\scalar\basic.py:2893: RuntimeWarning: divide by zero encountered
in log
  return np.log(x)
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
Sampling 2 chains for 7 tune and 50 draw iterations (14 + 100 draws total) took
63 seconds.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:659: UserWarning: The number of samples is too small
to check convergence reliably.
  warnings.warn("The number of samples is too small to check convergence
reliably.")
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
The chain contains only diverging samples. The model is probably misspecified.
The acceptance probability does not match the target. It is 0.0, but should be
close to 0.8. Try to increase the number of tuning steps.
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\stats\diagnostics.py:586: RuntimeWarning: divide by zero
encountered in double_scalars
  (between_chain_variance / within_chain_variance + num_samples - 1) /
(num_samples)
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
```

```
    mean    sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  ess_bulk  ess_tail  r_hat
p  0.553  0.11   0.443    0.662      0.073     0.06       2.0       2.0    inf
Probability that 'p' is greater than 0.5: 50.00%
```



[48]:
```
train_X = train_data[['lead_time', 'number_of_adults', 'number_of_children',␣
↪'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',␣
↪'average_price']]
```

```
train_y = train_data['booking_status']
```

[49]:
```
test_X = test_data[['lead_time', 'number_of_adults', 'number_of_children',␣
 ↪'number_of_weekend_nights', 'number_of_week_nights', 'special_requests',␣
 ↪'average_price']]
test_y = test_data['booking_status']
```

[50]:
```
with binomial_beta_model:
    # Sample from the posterior predictive distribution
    post_pred_train = pm.sample_posterior_predictive(trace, samples=10)
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:1708: UserWarning: samples parameter is smaller than
nchains times ndraws, some draws and/or chains may not be represented in the
returned posterior predictive sample
  warnings.warn(

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>
```

[51]:
```
# Assuming you have the trained model from the previous step
with binomial_beta_model:
    post_pred = pm.sample_posterior_predictive(trace, samples=10)
```

```
<IPython.core.display.HTML object>

<IPython.core.display.HTML object>
```

[75]:
```
import numpy as np
from scipy.stats import beta
from sklearn.metrics import accuracy_score, classification_report

# Define some_scaling_factor appropriately
some_scaling_factor = 1.0  # Adjust this based on your model's requirements

# Using 'likelihood' instead of 'y'
predicted_probs = post_pred_train['likelihood'].mean(axis=0)

# Ensure predicted_probs are within (0, 1)
epsilon = 1e-6  # Small value to prevent 0 or 1
predicted_probs = np.clip(predicted_probs, epsilon, 1 - epsilon)

alpha_train = predicted_probs * some_scaling_factor
beta_train = (1 - predicted_probs) * some_scaling_factor

# Ensure all values in alpha_train and beta_train are positive
if np.any(alpha_train <= 0) or np.any(beta_train <= 0):
    raise ValueError("Non-positive values found in alpha_train or beta_train.")
```

```python
# Sample from the Beta distribution for the training set
sampled_labels_train = np.random.beta(alpha_train[:len(train_y_int_labels)],␣
 ↪beta_train[:len(train_y_int_labels)])

# Convert probabilities to binary labels for the training set
predicted_labels_beta_train = (sampled_labels_train > 0.5).astype(int)

# Calculate accuracy with binary labels for the training set
accuracy_train_beta = accuracy_score(train_y_int_labels,␣
 ↪predicted_labels_beta_train)
print(f'Accuracy on training set (Binomial-Beta Model): {accuracy_train_beta}')
print(classification_report(train_y_int_labels, predicted_labels_beta_train))
```

```
Accuracy on training set (Binomial-Beta Model): 0.329125
              precision    recall  f1-score   support

           0       0.00      0.00      0.00      5367
           1       0.33      1.00      0.50      2633

    accuracy                           0.33      8000
   macro avg       0.16      0.50      0.25      8000
weighted avg       0.11      0.33      0.16      8000


c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[76]:
```python
print(f"Length of train_y_int_labels: {len(train_y_int_labels)}")
print(f"Length of predicted_labels_beta_train:␣
 ↪{len(predicted_labels_beta_train)}")
```

```
Length of train_y_int_labels: 8000
Length of predicted_labels_beta_train: 8000
```

```
[81]: import numpy as np
      from sklearn.metrics import accuracy_score, classification_report

      # Define some_scaling_factor appropriately
      some_scaling_factor = 1.0  # Adjust this based on your model's requirements

      # Using the correct key for the posterior predictive distribution
      predicted_probabilities = post_pred['likelihood'].mean(axis=0)

      # Ensure the size of predicted_probabilities matches the size of the test set
      predicted_probabilities = predicted_probabilities[:len(test_y)]

      # Ensure predicted_probabilities are within (0, 1)
      epsilon = 1e-6  # Small value to prevent 0 or 1
      predicted_probabilities = np.clip(predicted_probabilities, epsilon, 1 - epsilon)

      alpha = predicted_probabilities * some_scaling_factor
      beta_value = (1 - predicted_probabilities) * some_scaling_factor

      # Check if alpha and beta_value are valid (all values should be > 0)
      if np.any(alpha <= 0) or np.any(beta_value <= 0):
          raise ValueError("Invalid values in alpha or beta_value. Adjust␣
        ↪some_scaling_factor or predicted_probabilities.")

      # Sample from the Beta distribution for the test set
      sampled_labels = np.random.beta(alpha, beta_value, size=len(test_y))

      # Convert probabilities to binary labels for the test set
      predicted_labels_beta = (sampled_labels > 0.5).astype(int)

      # Calculate accuracy with binary labels for the test set
      accuracy_beta = accuracy_score(test_y_int_labels, predicted_labels_beta)
      print(f'Accuracy on test set (Binomial-Beta Model): {accuracy_beta}')

      # Print classification report with binary labels for the test set
      print(classification_report(test_y_int_labels, predicted_labels_beta))
```

```
Accuracy on test set (Binomial-Beta Model): 0.3335
              precision    recall  f1-score   support

           0       0.00      0.00      0.00      1333
           1       0.33      1.00      0.50       667

    accuracy                           0.33      2000
   macro avg       0.17      0.50      0.25      2000
weighted avg       0.11      0.33      0.17      2000
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\sklearn\metrics\_classification.py:1471: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[ ]:

```

```

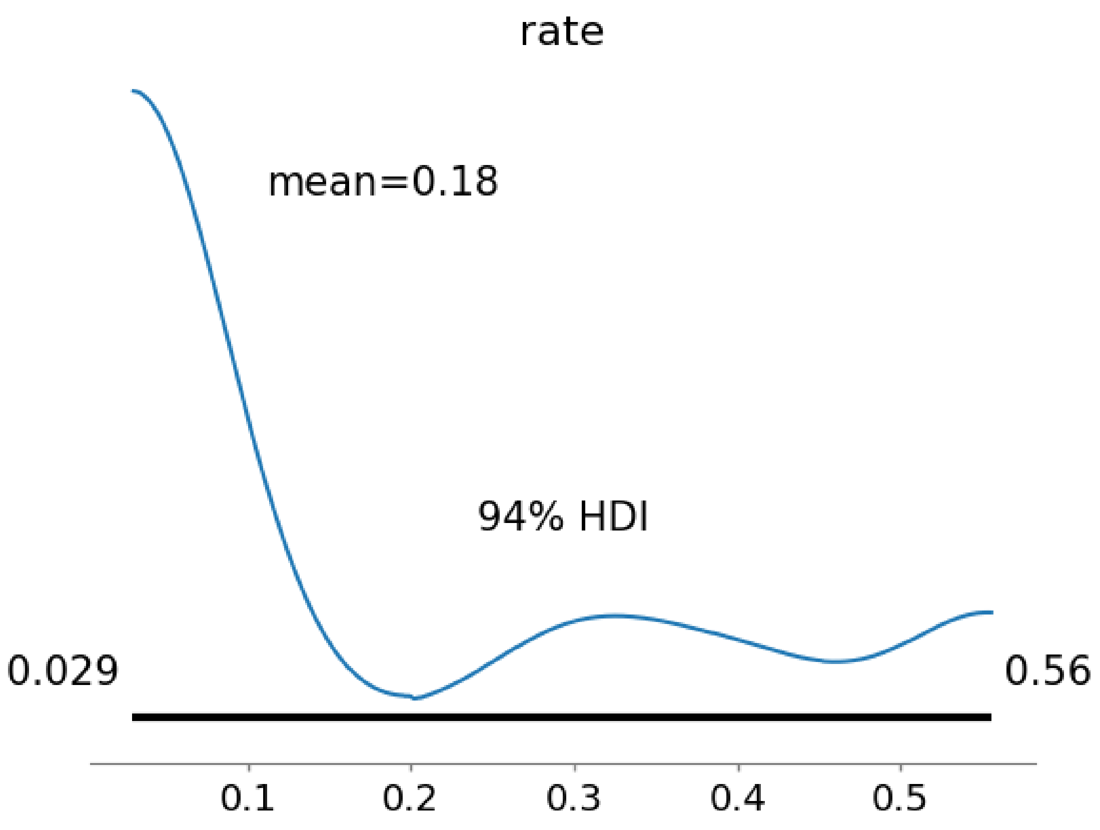
Poisson-Gamma Model - - Testing error

[82]:

```python
import pymc3 as pm
import pandas as pd
import arviz as az

# Assuming df is your DataFrame

# Encode 'booking_status' into binary format
df1['booking_status'] = (df1['booking_status'] == 'Canceled').astype(int)

with pm.Model() as bayesian_model:
    # Prior for the rate parameter (Gamma distribution)
    rate = pm.Gamma('rate', alpha=2, beta=2)

    # Poisson likelihood
    likelihood = pm.Poisson('likelihood', mu=rate,␣
 ↪observed=df1['booking_status'])

    # Sample from the posterior distribution
    trace = pm.sample(5, tune=5, cores=1)  # Adjust the number of samples and␣
 ↪tuning steps as needed

# Check the summary of the Bayesian model
print(pm.summary(trace))

# Plot posterior distribution
az.plot_posterior(trace, var_names=['rate'])
plt.savefig('Poisson-Gamma_Model.png')
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\deprecat\classic.py:215: FutureWarning: In v4.0, pm.sample will return
an `arviz.InferenceData` object instead of a `MultiTrace` by default. You can
pass return_inferencedata=True or return_inferencedata=False to be safe and
silence this warning.
  return wrapped_(*args_, **kwargs_)
Only 5 samples in chain.
Auto-assigning NUTS sampler…
Initializing NUTS using jitter+adapt_diag…
Sequential sampling (2 chains in 1 job)
NUTS: [rate]

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>

c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\scalar\basic.py:2893: RuntimeWarning: divide by zero encountered
in log
  return np.log(x)

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>

Sampling 2 chains for 5 tune and 5 draw iterations (10 + 10 draws total) took 7
seconds.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:659: UserWarning: The number of samples is too small
to check convergence reliably.
  warnings.warn("The number of samples is too small to check convergence
reliably.")
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
Got error No model on context stack. trying to find log_likelihood in
translation.

       mean     sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  ess_bulk  ess_tail  \
rate  0.183  0.197   0.029    0.556      0.073    0.054       7.0       7.0


      r_hat
rate    3.0

c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
```

```
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
```



[84]:
```python
with bayesian_model:
    post_pred_test = pm.sample_posterior_predictive(trace, samples=5)

# Convert Poisson counts to binary labels for the test set
predicted_labels_test = (post_pred_test['likelihood'].mean(axis=0) > 0.5).
 ↪astype(int)

# Ensure the size of predicted_labels_test matches the size of the test set
predicted_labels_test = predicted_labels_test[:len(test_data)]

actual_labels_test = (test_data['booking_status'] == 'Canceled').astype(int)

# Check the lengths
print(f"Length of actual_labels_test: {len(actual_labels_test)}")
print(f"Length of predicted_labels_test: {len(predicted_labels_test)}")

# Ensure both arrays have the same length
```

```
if len(actual_labels_test) != len(predicted_labels_test):
    raise ValueError("The number of actual and predicted labels do not match.")

# Calculate accuracy with binary labels for the test set
accuracy_test = accuracy_score(actual_labels_test, predicted_labels_test)
print(f'Accuracy on test set: {accuracy_test}')

# Print classification report with binary labels for the test set
print(classification_report(actual_labels_test, predicted_labels_test))
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:1708: UserWarning: samples parameter is smaller than
nchains times ndraws, some draws and/or chains may not be represented in the
returned posterior predictive sample
  warnings.warn(
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
Length of actual_labels_test: 2000
Length of predicted_labels_test: 2000
Accuracy on test set: 0.6655
              precision    recall  f1-score   support

           0       0.67      1.00      0.80      1333
           1       0.25      0.00      0.00       667

    accuracy                           0.67      2000
   macro avg       0.46      0.50      0.40      2000
weighted avg       0.53      0.67      0.53      2000
```

Exponential-Gamma Model - Testing error

```
[85]: import pymc3 as pm
import pandas as pd
import arviz as az

# Assuming df is your DataFrame

# Encode 'booking_status' into binary format
df1['booking_status'] = (df1['booking_status'] == 'Canceled').astype(int)

with pm.Model() as bayesian_model:
    # Prior for the rate parameter (Gamma distribution)
    rate = pm.Gamma('rate', alpha=2, beta=2)

    # Exponential likelihood
    likelihood = pm.Exponential('likelihood', lam=rate,␣
 ↪observed=df1['booking_status'])

    # Sample from the posterior distribution
    trace = pm.sample(5, tune=5, cores=1)  # Adjust the number of samples and␣
 ↪tuning steps as needed

# Check the summary of the Bayesian model
print(pm.summary(trace))

# Plot posterior distribution
az.plot_posterior(trace, var_names=['rate'])
plt.savefig('Exponential-Gamma_Model.png')
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: invalid value
encountered in log
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\deprecat\classic.py:215: FutureWarning: In v4.0, pm.sample will return
an `arviz.InferenceData` object instead of a `MultiTrace` by default. You can
pass return_inferencedata=True or return_inferencedata=False to be safe and
silence this warning.
  return wrapped_(*args_, **kwargs_)
Only 5 samples in chain.
Auto-assigning NUTS sampler…
Initializing NUTS using jitter+adapt_diag…
Sequential sampling (2 chains in 1 job)
NUTS: [rate]
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\tensor\elemwise.py:826: RuntimeWarning: overflow encountered in
exp
  variables = ufunc(*ufunc_args, **ufunc_kwargs)
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\theano\scalar\basic.py:1813: RuntimeWarning: invalid value encountered
in double_scalars
  return sum(inputs)
```

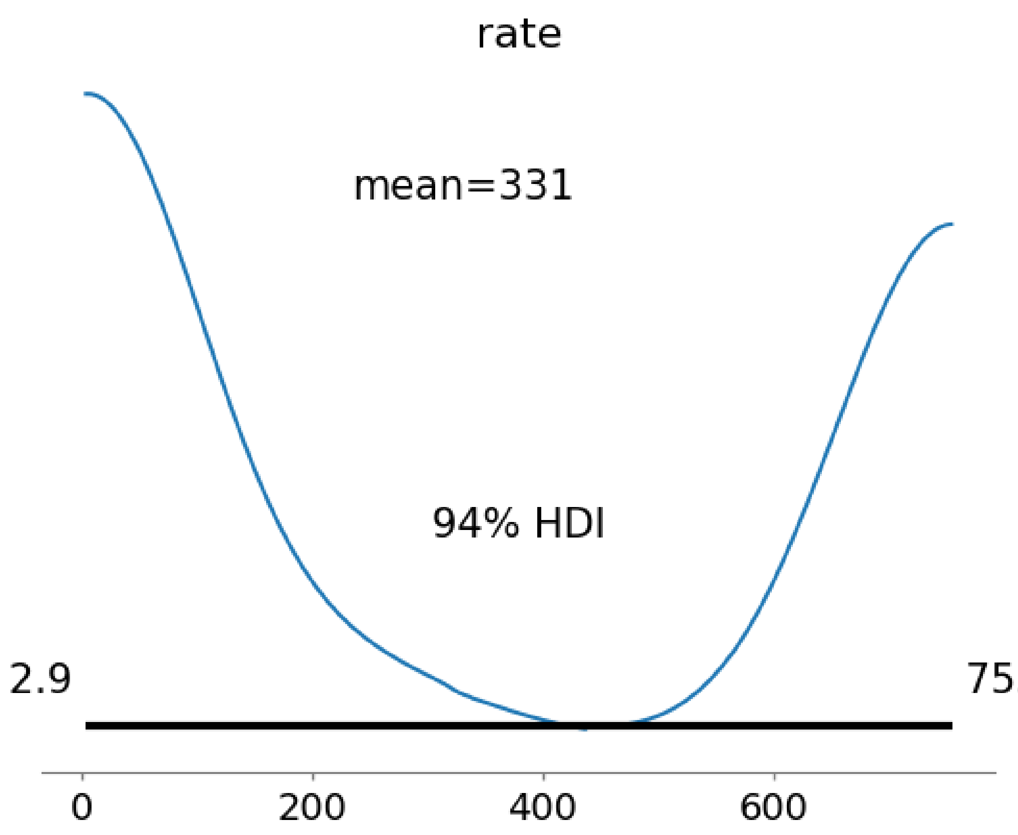
```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
Sampling 2 chains for 5 tune and 5 draw iterations (10 + 10 draws total) took 0
seconds.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
```

```
packages\pymc3\sampling.py:659: UserWarning: The number of samples is too small
to check convergence reliably.
  warnings.warn("The number of samples is too small to check convergence
reliably.")
There were 4 divergences after tuning. Increase `target_accept` or
reparameterize.
The acceptance probability does not match the target. It is 0.4, but should be
close to 0.8. Try to increase the number of tuning steps.
There were 4 divergences after tuning. Increase `target_accept` or
reparameterize.
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
```

```
         mean      sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  ess_bulk  \
rate  331.243  371.91   2.895  755.393    138.365  102.085       7.0

      ess_tail  r_hat
rate       7.0   2.71
```



[89]:
```
import pymc3 as pm
import arviz as az
import numpy as np
import theano.tensor as tt

test_data['booking_status'] = (test_data['booking_status'] == 'Canceled').
↪astype(int)

# Calculate the mean outside the model context
rate_posterior_mean = trace['rate'].mean(axis=0)

# Make predictions on the test data using the trained model
with bayesian_model:
    # Create a deterministic variable using the computed mean
    rate_posterior = pm.Deterministic('rate_posterior', tt.
↪as_tensor_variable(rate_posterior_mean))

    # Exponential likelihood for the test data
    test_likelihood = pm.Exponential('test_likelihood', lam=rate_posterior,␣
↪observed=test_data['booking_status'])
```

```
    # Sample from the posterior distribution for the test likelihood
    test_trace = pm.sample_posterior_predictive(trace, samples=5)

az.plot_ppc(az.from_pymc3(trace, posterior_predictive=test_trace), figsize=(12,␣
 ↪6), mean=False)
```

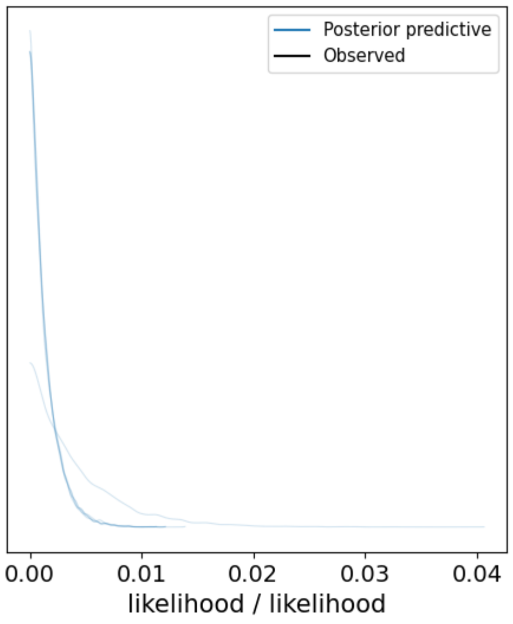
```
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\pymc3\sampling.py:1708: UserWarning: samples parameter is smaller than
nchains times ndraws, some draws and/or chains may not be represented in the
returned posterior predictive sample
  warnings.warn(
```

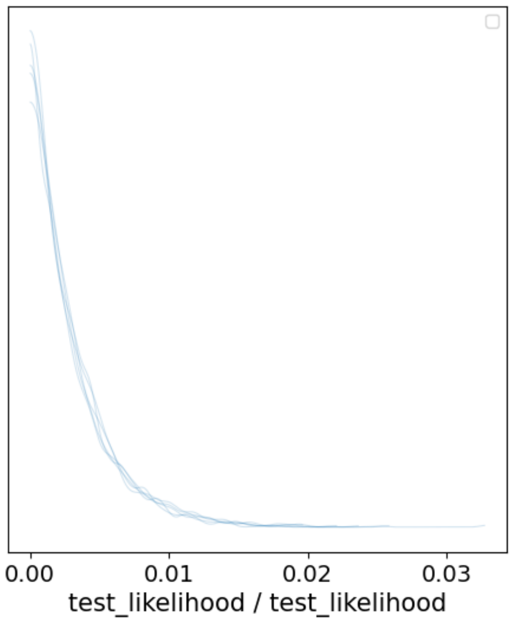
```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
Got error No model on context stack. trying to find log_likelihood in
translation.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\data\io_pymc3_3x.py:98: FutureWarning: Using `from_pymc3` without
the model will be deprecated in a future release. Not using the model will
return less accurate and less useful results. Make sure you use the model
argument or call from_pymc3 within a model context.
  warnings.warn(
posterior predictive variable likelihood's shape not compatible with number of
chains and draws. This can mean that some draws or even whole chains are not
represented.
posterior predictive variable test_likelihood's shape not compatible with number
of chains and draws. This can mean that some draws or even whole chains are not
represented.
c:\users\sriva\appdata\local\programs\python\python38\lib\site-
packages\arviz\stats\density_utils.py:491: UserWarning: Your data appears to
have a single value or no finite values
  warnings.warn("Your data appears to have a single value or no finite values")
```

```
[89]: array([<Axes: xlabel='likelihood / likelihood'>,
              <Axes: xlabel='test_likelihood / test_likelihood'>], dtype=object)
```


Posterior predictive
Observed
0.00
0.01
0.02
0.03
0.04
likelihood / likelihood


0.00
0.01
0.02
0.03
test_likelihood / test_likelihood