

Cloud and API Deployment

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I. Summary

The created web API application utilizes the dataset used in week 2 assignment (i.e. the *G2M insight for Cab Investment firm*) and predicts the total daily profit of *Yellow Cab* and *Pink Cab* companies using *MLForecast* library. The */predict* endpoint will receive the future *days* to forecast and the *company* name and responses with JSON data needed to render the interactive line charts and pie chart of the results using *Plotly* library.

II. Development Steps

1. Select and pre-process data. To reduce the size of the model, the data for the top three frequent cities were selected. Categorical features were converted into dummies. Lastly, the feature names were modified as per the conventions of the *MLForecast* model. Check Figure 1.
2. Data was split into train and test sets and the model was fitted. *MLForecast* model performs recursive fitting of multiple *Scikit-Learn* models and automatically generates the log features of the target as provided in the *fit()* method. It allows the forecasting of multiple timeseries identified by *unique_id* which was the combination of company name and city name. Therefore, the profit was forecasted by company by city level. Lastly, the fitted model was serialized using *Pickle*. Check Figure 2.

```

27 data_path = 'data/'
28
29 df = pd.read_csv(data_path+'Cab_Data.csv')
30 df['Date of Travel'] = pd.to_datetime(df['Date of Travel'], origin='1899-12-30', unit='d')
31 df['Profit of Trip'] = df['Price Charged'] - df['Cost of Trip']
32 df = df[['Transaction ID', 'Date of Travel', 'Company', 'City', 'Profit of Trip']]
33 df = df.round(2)
34
35 top_3_cities = df['City'].value_counts()[:3].index.tolist()
36 print(top_3_cities)
37
38 df = df[df['City'].isin(top_3_cities)]
39 print(df.head(3), end='\n\n')
40
41 df1 = df.groupby(['Date of Travel', 'Company', 'City'], as_index=False).agg(Total_Profit = ('Profit of Trip', 'sum'))
42 print(df1.head(3), end='\n\n')
43
44 pvt = pd.pivot_table(data=df1, index=['City', 'Company'], columns=['Date of Travel'], values=['Total_Profit'])
45 pvt = pvt.fillna(0)
46 df2 = pvt.stack().reset_index()
47 print(df2.head(3), end='\n\n')
48
49 df2_cat = df2.select_dtypes(include=['object'])
50 print(df2_cat.head(3), end='\n\n')
51
52 df2_cat = df2_cat.replace(r'[\s]+', '_', regex=True)
53 df2_dummies = pd.get_dummies(df2_cat, drop_first=True)
54 print(df2_dummies.head(3), end='\n\n')
55
56 df3 = df2.join(df2_dummies)
57 df3 = df3.rename(columns={'Date of Travel': 'ds'})
58 df3['unique_id'] = df3['Company'] + '_' + df3['City']
59 df3['unique_id'] = df3['unique_id'].replace(r'[\s]+', '_', regex=True)
60 df3 = df3.drop(['Company', 'City'], axis=1)
61 print(df3.head(3), end='\n\n')
62
63 static_features = df2_dummies.columns.tolist()
64 print(static_features, end='\n\n')
65
66 ts_profit = df3.copy()
67 ts_profit = ts_profit.rename(columns={'Total_Profit': 'y'})
68 print(ts_profit.head(3), end='\n\n')

```

Figure 1: development step 1 (model.py)

```

70 ts_profit_train = ts_profit[ts_profit['ds'] < '2018-10-01']
71 ts_profit_test = ts_profit[ts_profit['ds'] >= '2018-10-01']
72
73 models = {
74     'LinearRegression': make_pipeline(StandardScaler(), MinMaxScaler(), LinearRegression()),
75     'Lasso': make_pipeline(StandardScaler(), MinMaxScaler(), Lasso(random_state=0)),
76     'Ridge': make_pipeline(StandardScaler(), MinMaxScaler(), Ridge(random_state=0)),
77     'KNeighborsRegressor': make_pipeline(StandardScaler(), MinMaxScaler(), KNeighborsRegressor()),
78     'SVR': make_pipeline(StandardScaler(), MinMaxScaler(), SVR()),
79     'RandomForestRegressor': RandomForestRegressor(random_state=0),
80     'XGBRegressor': XGBRegressor(random_state=0),
81 }
82
83 fcst = MLForecast(
84     models=models,
85     freq='D',
86     lags=[1, 7, 30, 365],
87     date_features=['day', 'dayofweek', 'week', 'month', 'quarter', 'year'],
88     num_threads=8
89 )
90
91 preprocessed = fcst.preprocess(ts_profit_train)
92 print(preprocessed.head(3), end='\n\n')
93
94 fcst.fit(ts_profit_train, time_col='ds', id_col='unique_id', target_col='y', static_features=static_features)
95 print(fcst, end='\n\n')
96
97 unique_ids = ts_profit_train['unique_id'].unique().tolist()
98 print(unique_ids, end='\n\n')
99
100 with open('profit_model.pkl', 'wb') as file:
101     pickle.dump((fcst, unique_ids), file)
102
103 profit_model = None
104 unique_ids = None
105 with open('profit_model.pkl', 'rb') as file:
106     (profit_model, unique_ids) = pickle.load(file)
107

```

Figure 2: development step 2 (model.py)

3. The backend was developed using *Flask*. Two APIs were defined: the / (root) which serves the fronted *index.html* page, and the */predict* which deserialize the model, accepts two form fields: *days* and *company*, forecasts the daily profit, and returns a JSON data for rendering the interactive *Plotly* charts visualizing the prediction results. Check Figures 3, 4.

```
7 from flask import Flask, request, jsonify, render_template
8 import pickle
9 import re
10 import json
11 import plotly_express as px
12
13
14 app = Flask(__name__)
15
16 @app.route('/')
17 def home():
18     return render_template('index.html')
19
20 @app.route('/predict', methods=['POST'])
21 def predict():
22
23     profit_model = None
24     unique_ids = None
25     with open('model/profit_model.pkl', 'rb') as file:
26         profit_model, unique_ids = pickle.load(file)
27
28     days = int(request.form['days'])
29     company = request.form['company']
30
31     company = re.sub(r'[\s]+', '_', company)
32
33     uids = [uid for uid in unique_ids if company in uid]
34
35     ts_profit_pred = profit_model.predict(days, ids=uids)
36     ts_profit_pred['profit'] = ts_profit_pred[['XGBRegressor', 'RandomForestRegressor']].mean(axis=1)
37     ts_profit_pred = ts_profit_pred.copy()[['unique_id', 'ds', 'profit']]
38     ts_profit_pred['unique_id'] = ts_profit_pred['unique_id'].str.replace(company+'_ ', '')
39     ts_profit_pred = ts_profit_pred.rename(columns={'unique_id': 'city'})
40
```

Figure 3: development step 3 part 1 (app.py)

```
46 ts_profit_pred_summary = ts_profit_pred_summary.melt(id_vars='ds')
47 ts_profit_pred_summary = ts_profit_pred_summary.copy().rename(columns={'value': 'profit'})
48
49 fig1 = px.line(ts_profit_pred_summary,
50               x='ds',
51               y='profit',
52               color='variable',
53               height=600,
54               title=company+'\s Total Profit For Next '+str(days)+' Day(s)')
55
56 fig2 = px.line(ts_profit_pred,
57               x='ds',
58               y='profit',
59               color='city',
60               height=600,
61               title=company+'\s Total Profit For Next '+str(days)+' Day(s) By City')
62
63 fig3 = px.pie(ts_profit_pred,
64              names='city',
65              values='profit',
66              height=600,
67              title=company+'\s Total Profit For Next '+str(days)+' Day(s) By City')
68
69
70
71 return jsonify({'profit_line_plot':json.loads(fig1.to_json()),
72               'profit_per_city_line_plot':json.loads(fig2.to_json()),
73               'profit_per_city_pie_plot':json.loads(fig3.to_json())})
74
75
76 if __name__ == "__main__":
77     app.run(debug=True)
```

Figure 4: development step 3 part 2 (app.py)

- The endpoint `/predict` was tested locally before deployment on the cloud using *Postman*. Check Figure 5.

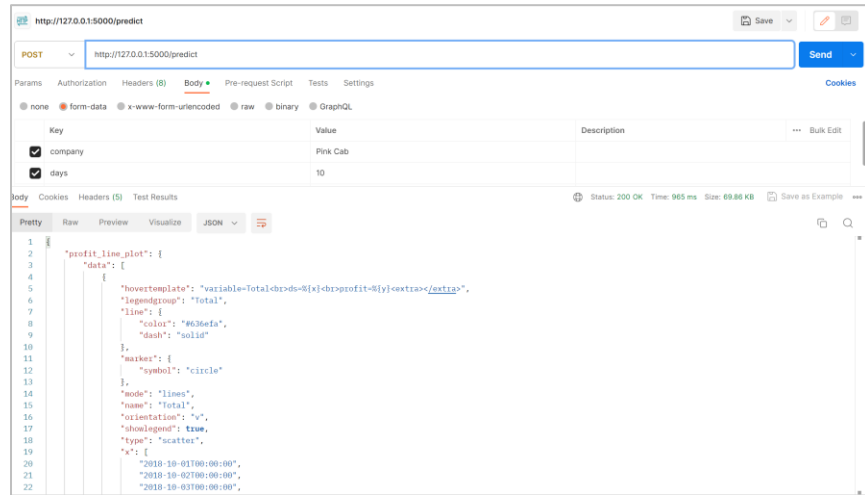


Figure 5: development step 4 Postman

- The frontend was created using *HTML5*, *CSS3*, *Bootstrap v5*, and *JQuery*. The request to the backend's API was developed using *Ajax*. Check Figures 6, 7, 8.
- Finally, the backend code (`app.py`), model code (`model.py`) and frontend files (in `static` and `templates` folders) were pushed onto *GitHub* repository. Check Figure 9.

```

23     <div class="row" id="form">
24       <div class="col">
25         <form action="/predict" method="POST" id="forecastform">
26           <div class="mb-3">
27             <label class="form-label"><h4>Select Company:</h4></label>
28             <br/>
29             <div class="form-check form-check-inline">
30               <input class="form-check-input" type="radio" name="company" id="yellow" value="Yellow
31                 Cab" checked>
32               <label class="form-check-label" for="yellow">Yellow Cab</label>
33             </div>
34             <div class="form-check form-check-inline">
35               <input class="form-check-input" type="radio" name="company" id="pink" value="Pink Cab">
36               <label class="form-check-label" for="pink">Pink Cab</label>
37             </div>
38           </div>
39           <div class="mb-3">
40             <label for="days" class="form-label"><h4>Select Forecast Days:</h4></label>
41             <div class="slider-container">
42               <input type="text" id="days" class="slider" name="days" value="{{ days }}" />
43             </div>
44           </div>
45           <br/>
46           <button type="submit" class="btn btn-primary" id="submit">Forecast</button>
47         </form>
48       </div>
49     </div>
50   </div>
51

```

Figure 6: development step 5 part 1 (index.html)

```

53     <div class="row" id="result">
54         <div class="col">
55
56             <div class="row">
57                 <div class="col" id="profit_line"></div>
58             </div>
59
60             <div class="row">
61                 <div class="col" id="profit_per_city_line"></div>
62             </div>
63
64             <div class="row">
65                 <div class="col" id="profit_per_city_pie"></div>
66             </div>
67         </div>
68     </div>

```

Figure 7: development step 5 part 2 (index.html)

```

101     $("#submit").click(function(e) {
102         e.preventDefault();
103         $("#submit").html("Loading...");
104         var form = $("#forecastform");
105         var url = form.attr("action");
106         $.ajax({
107             type: "POST",
108             url: url,
109             data: form.serialize(),
110             success: function(data) {
111
112                 $("#submit").html("Forecast");
113
114                 // Ajax call completed successfully
115                 console.log("Form Submitted Successfully");
116                 console.log(data);
117
118                 Plotly.newPlot( document.getElementById("profit_line"),
119                               data.profit_line_plot.data,
120                               data.profit_line_plot.layout);
121
122                 Plotly.newPlot( document.getElementById("profit_per_city_line"),
123                               data.profit_per_city_line_plot.data,
124                               data.profit_per_city_line_plot.layout);
125
126                 Plotly.newPlot( document.getElementById("profit_per_city_pie"),
127                               data.profit_per_city_pie_plot.data,
128                               data.profit_per_city_pie_plot.layout);
129
130             },
131             error: function(err) {
132
133                 // Some error in ajax call
134                 console.log("Some Error");
135                 console.log(err);
136             }
137         });
138     });

```

Figure 8: development step 5 part 3 (index.html)















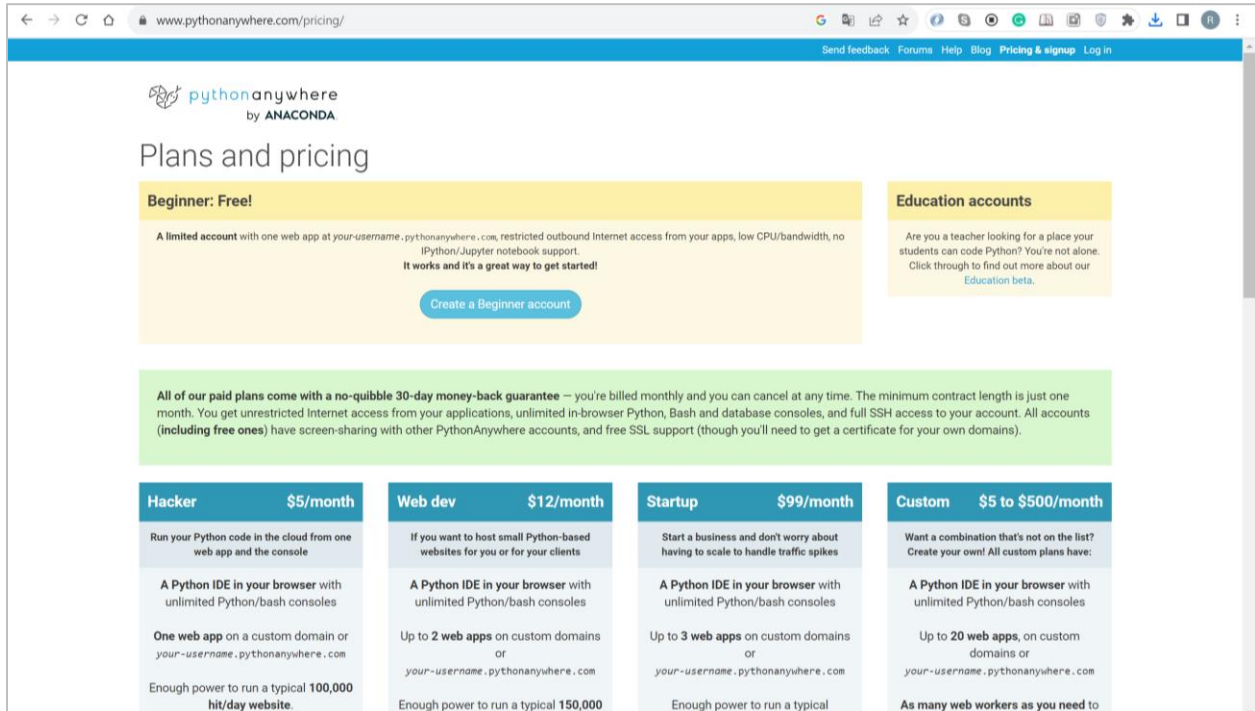
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 rfakeeh Flask app version 3		16d8675 now  4 commits	
 model	Flask app version 3	now	
 static	Flask app version 1	13 hours ago	
 templates	Flask app version 1	13 hours ago	
 README.md	Initial commit	13 hours ago	
 app.py	Flask app version 3	now	

Figure 9: development step 6 GitHub

III. Deployment Steps

1. Go to <https://www.pythonanywhere.com/> and click on *Create Beginner account*.
This kind of account is free for three months. Follow the steps for creating the account and sign in. Check Figure 10.

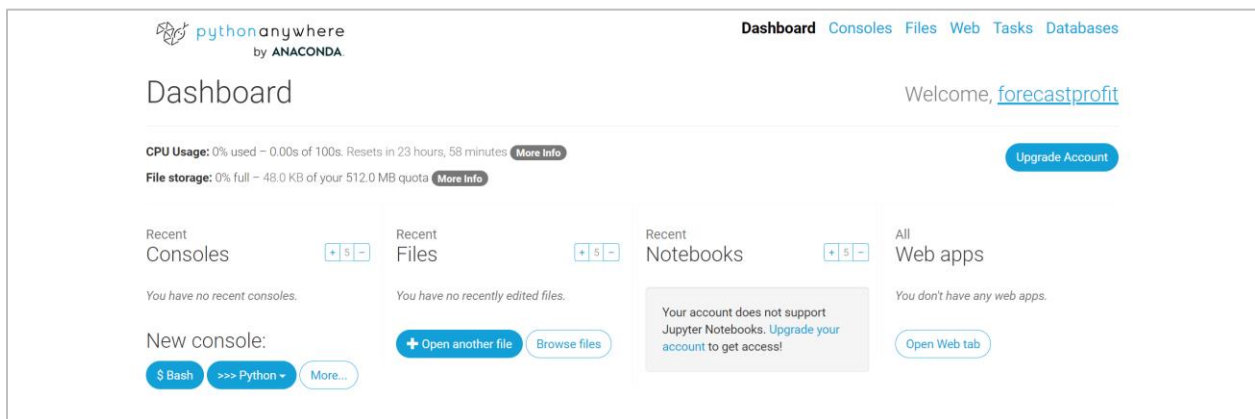


The screenshot shows the PythonAnywhere pricing page. At the top, there's a navigation bar with links like 'Send feedback', 'Forums', 'Help', 'Blog', 'Pricing & signup', and 'Log in'. The main heading is 'Plans and pricing'. Below this, there's a 'Beginner: Free!' section with a description of the free plan and a 'Create a Beginner account' button. To the right, there's an 'Education accounts' section. Below these, a green box states a 'no-quibble 30-day money-back guarantee'. At the bottom, there are four plan cards: 'Hacker' (\$5/month), 'Web dev' (\$12/month), 'Startup' (\$99/month), and 'Custom' (\$5 to \$500/month). Each card lists features like 'Run your Python code in the cloud', 'A Python IDE in your browser', and 'One web app on a custom domain'.

Plan	Price
Hacker	\$5/month
Web dev	\$12/month
Startup	\$99/month
Custom	\$5 to \$500/month

Figure 10: deployment step 1

2. On *Dashboard* page, navigate to *Web* page from top right menu. Check Figure 11.



The screenshot shows the PythonAnywhere dashboard. At the top, there's a navigation bar with links like 'Dashboard', 'Consoles', 'Files', 'Web', 'Tasks', and 'Databases'. The main heading is 'Dashboard'. Below this, there's a 'Welcome, forecastprofit' message. The dashboard displays various metrics: 'CPU Usage: 0% used - 0.00s of 100s', 'File storage: 0% full - 48.0 KB of your 512.0 MB quota', 'Recent Consoles', 'Recent Files', 'Recent Notebooks', and 'All Web apps'. There are buttons for 'Upgrade Account', 'New console', 'Open another file', 'Browse files', and 'Open Web tab'.

Figure 11: deployment step 2

3. On *Web* page, click on *Add a new web app* and follow the steps to launch the initial Flask web app. Check Figures 12, 13, 14, 15, 16.
4. On *Web* page, navigate to *Files* page from top right menu and click on *mysite/* directory below *Directories* panel. Notice *flask_app.py* file. Check Figures 17, 18.

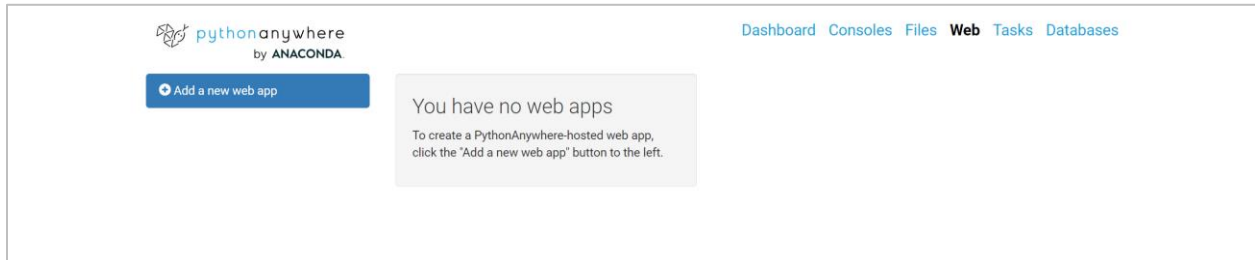


Figure 12: deployment step 3 part 1

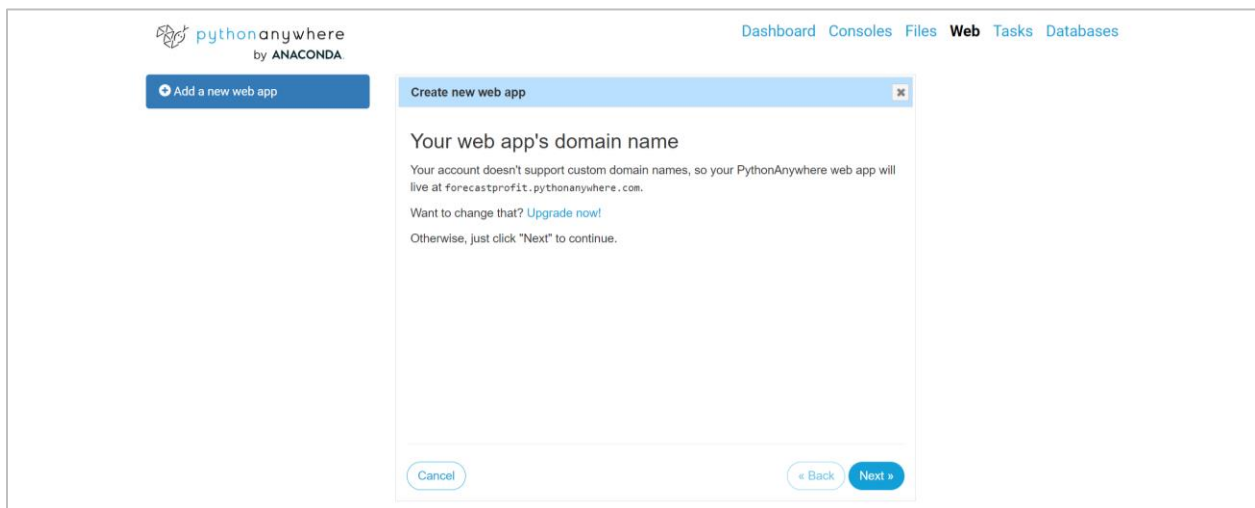


Figure 13: deployment step 3 part 2

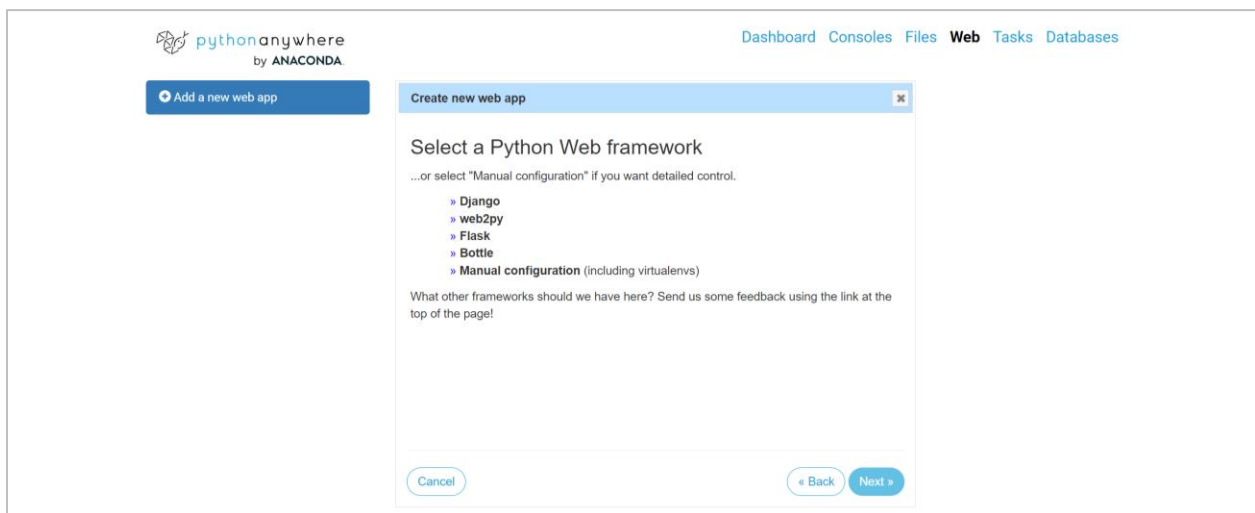


Figure 14: deployment step 3 part 3

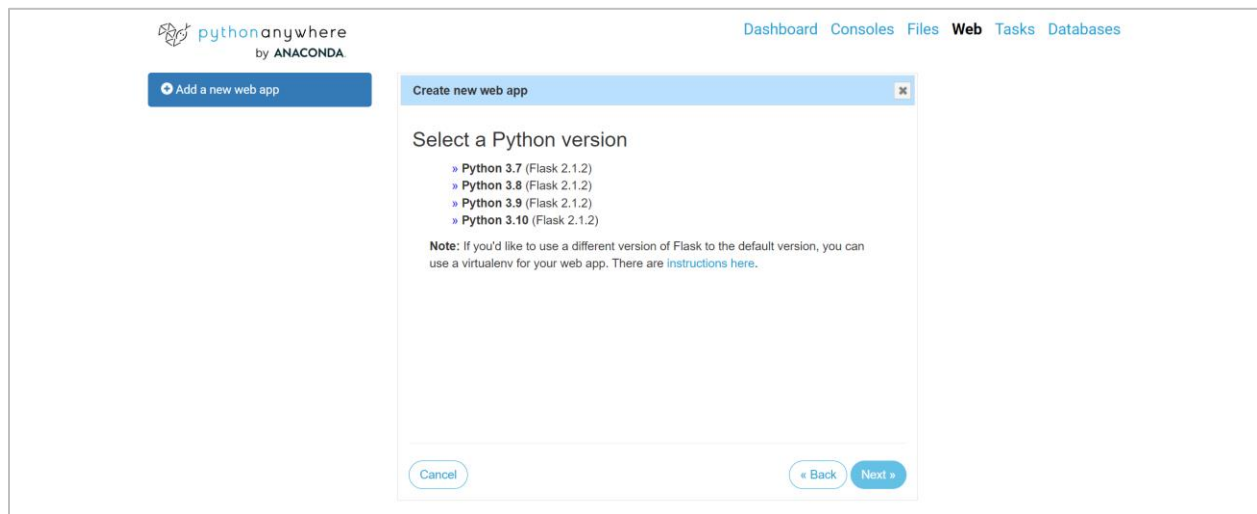


Figure 15: deployment step 3 part 4

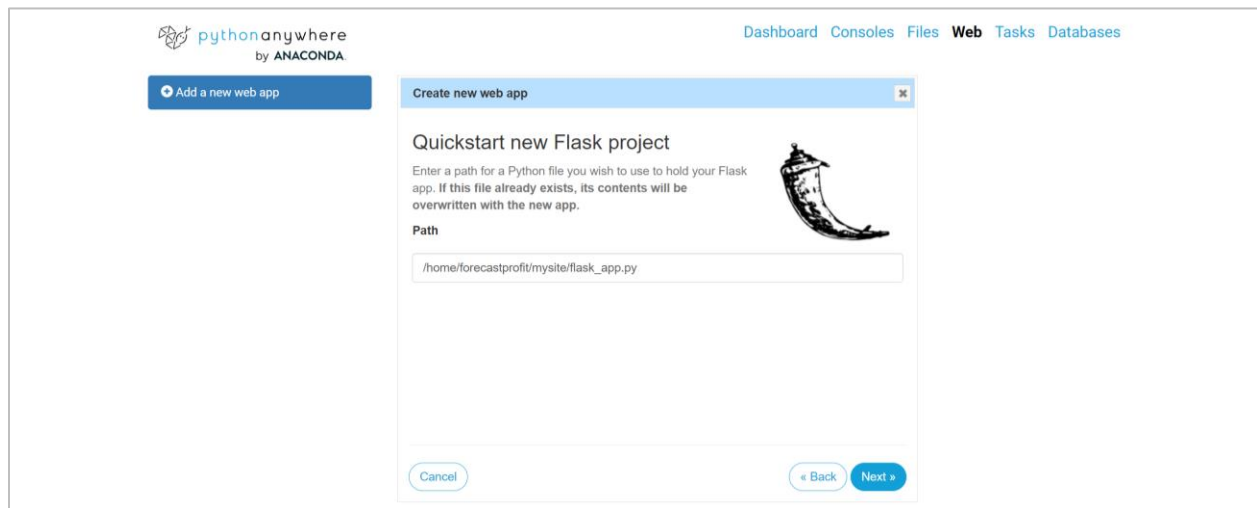


Figure 16: deployment step 3 part 5

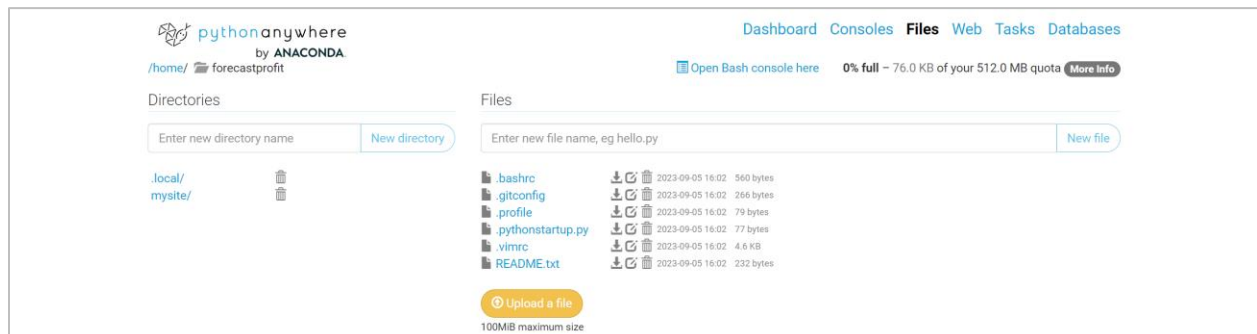
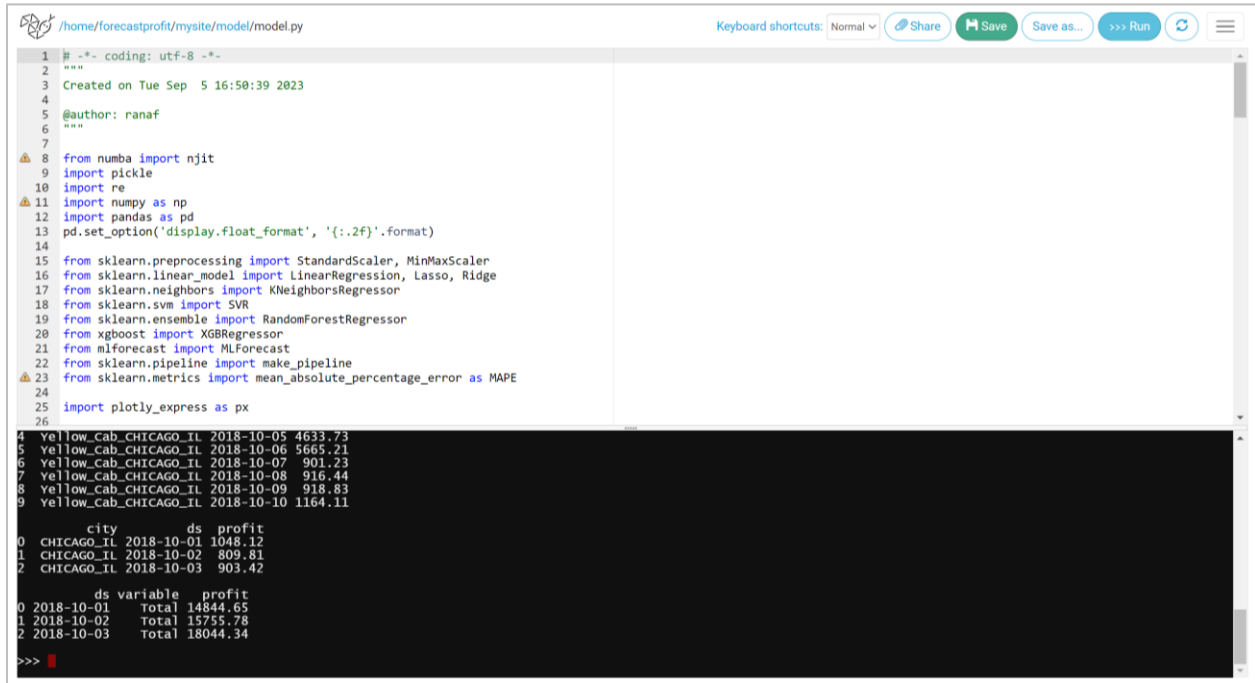


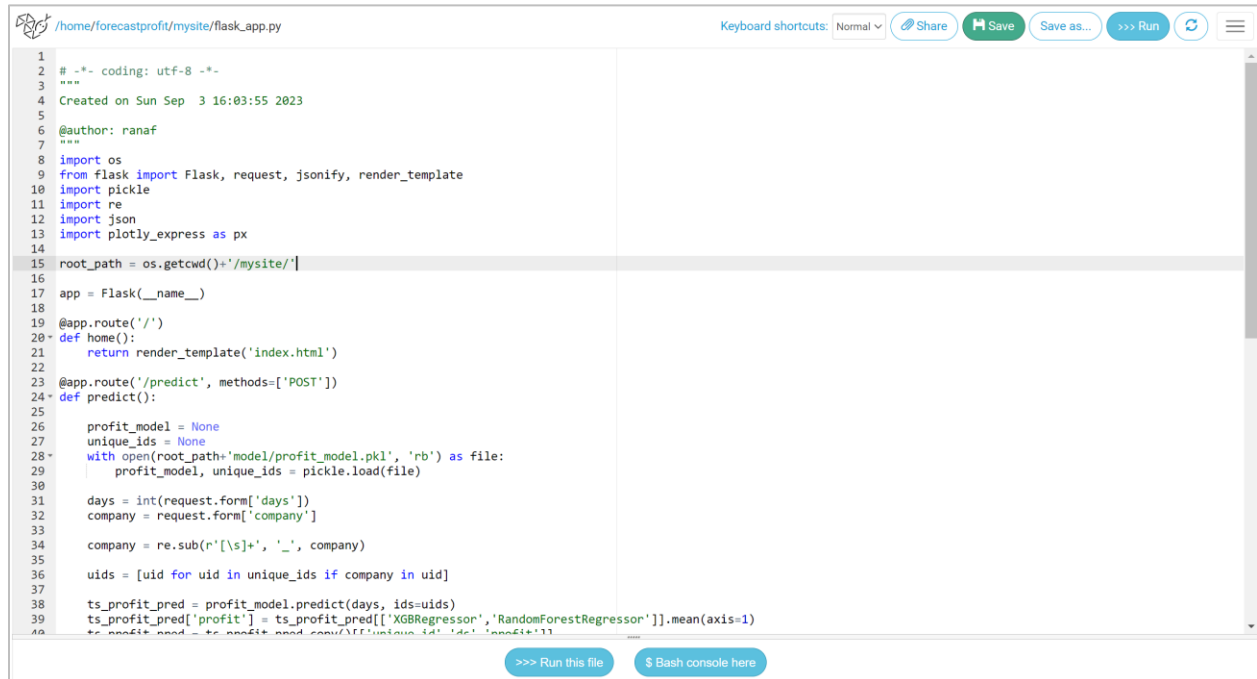
Figure 17: deployment step 4 part 1

6. On *mysite/* directory, navigate to *model/* directory, open and run *model.py* to generate the serialized model file. Check Figures 21, 22.



```
1 # -*- coding: utf-8 -*-
2 """
3 Created on Tue Sep 5 16:50:39 2023
4
5 @author: ranaf
6 """
7
8 from numba import njit
9 import pickle
10 import re
11 import numpy as np
12 import pandas as pd
13 pd.set_option('display.float_format', '{:.2f}'.format)
14
15 from sklearn.preprocessing import StandardScaler, MinMaxScaler
16 from sklearn.linear_model import LinearRegression, Lasso, Ridge
17 from sklearn.neighbors import KNeighborsRegressor
18 from sklearn.svm import SVR
19 from sklearn.ensemble import RandomForestRegressor
20 from xgboost import XGBRegressor
21 from mlforecast import MLForecast
22 from sklearn.pipeline import make_pipeline
23 from sklearn.metrics import mean_absolute_percentage_error as MAPE
24
25 import plotly_express as px
26
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```

7. Navigate to *mysite/* directory, open *app.py* file and copy the code, open *flask_app.py* and paste the code there. Save the absolute path to locate the serialized model. Finally, delete *app.py* file. Check Figure 23.



```
1 # -*- coding: utf-8 -*-
2 """
3 Created on Sun Sep  3 16:03:55 2023
4
5 @author: ranaf
6 """
7
8 import os
9 from flask import Flask, request, jsonify, render_template
10 import pickle
11 import re
12 import json
13 import plotly_express as px
14
15 root_path = os.getcwd()+ '/mysite/'
16
17 app = Flask(__name__)
18
19 @app.route('/')
20 def home():
21     return render_template('index.html')
22
23 @app.route('/predict', methods=['POST'])
24 def predict():
25
26     profit_model = None
27     unique_ids = None
28     with open(root_path+'model/profit_model.pkl', 'rb') as file:
29         profit_model, unique_ids = pickle.load(file)
30
31     days = int(request.form['days'])
32     company = request.form['company']
33
34     company = re.sub(r'[\s]+', '_', company)
35
36     uids = [uid for uid in unique_ids if company in uid]
37
38     ts_profit_pred = profit_model.predict(days, ids=uids)
39     ts_profit_pred[['profit']] = ts_profit_pred[['XGBRegressor', 'RandomForestRegressor']].mean(axis=1)
40     ts_profit_pred = ts_profit_pred[['profit']]
```

Figure 23: deployment step 7

8. Navigate back to Web page and click on Reload forecastcabprofit.pythonanywhere.com then click on the URL above it to run and view the app on the browser. Check Figures 24, 25.

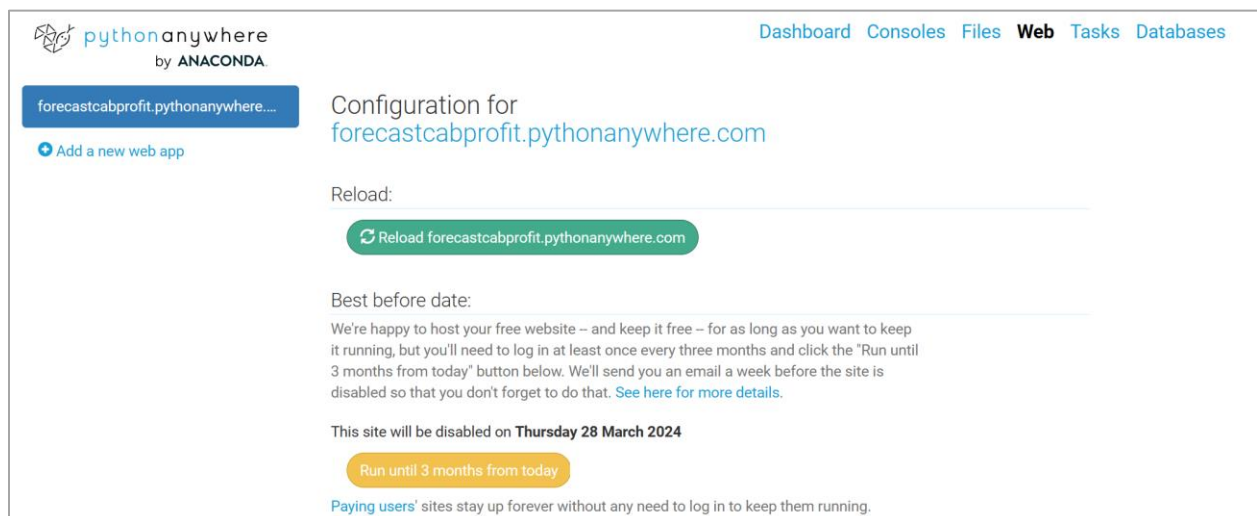


Figure 24: deployment step 8 part 1

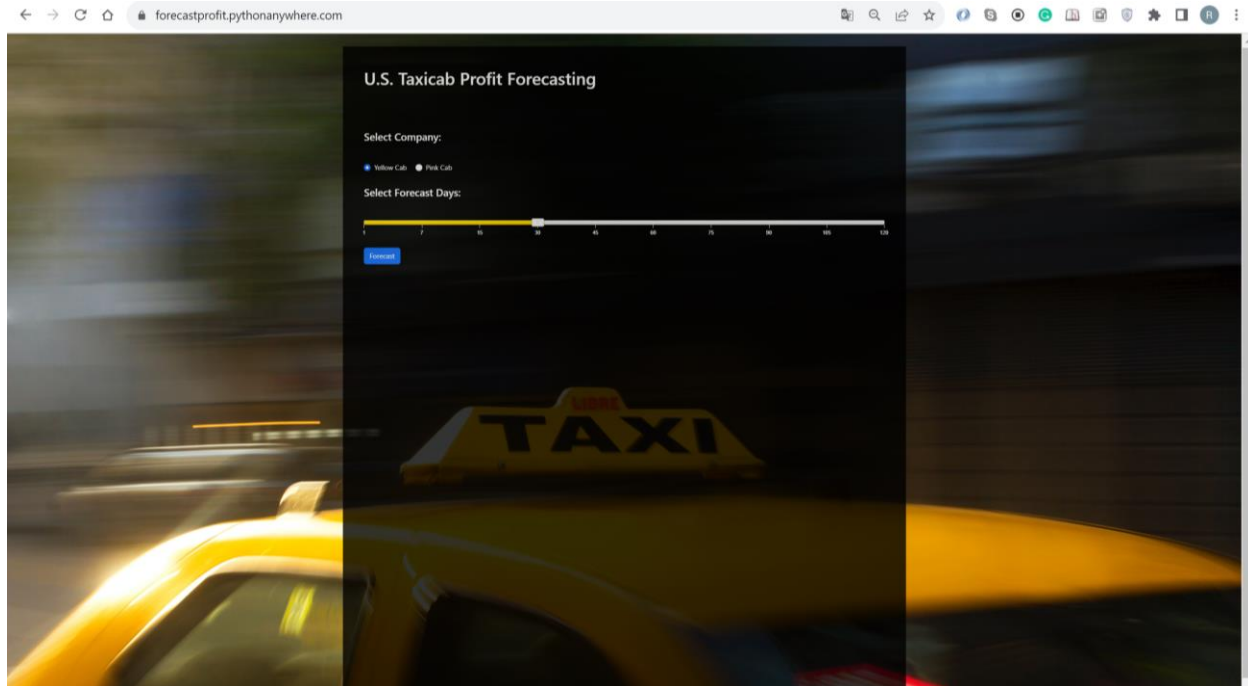


Figure 25: deployment step 8 part 2

9. Test the `/predict` endpoint using *Postman*. Provide form data of *company* and *days*. The response is a JSON file with data for rendering interactive *Plotly* charts. Check Figure 26.

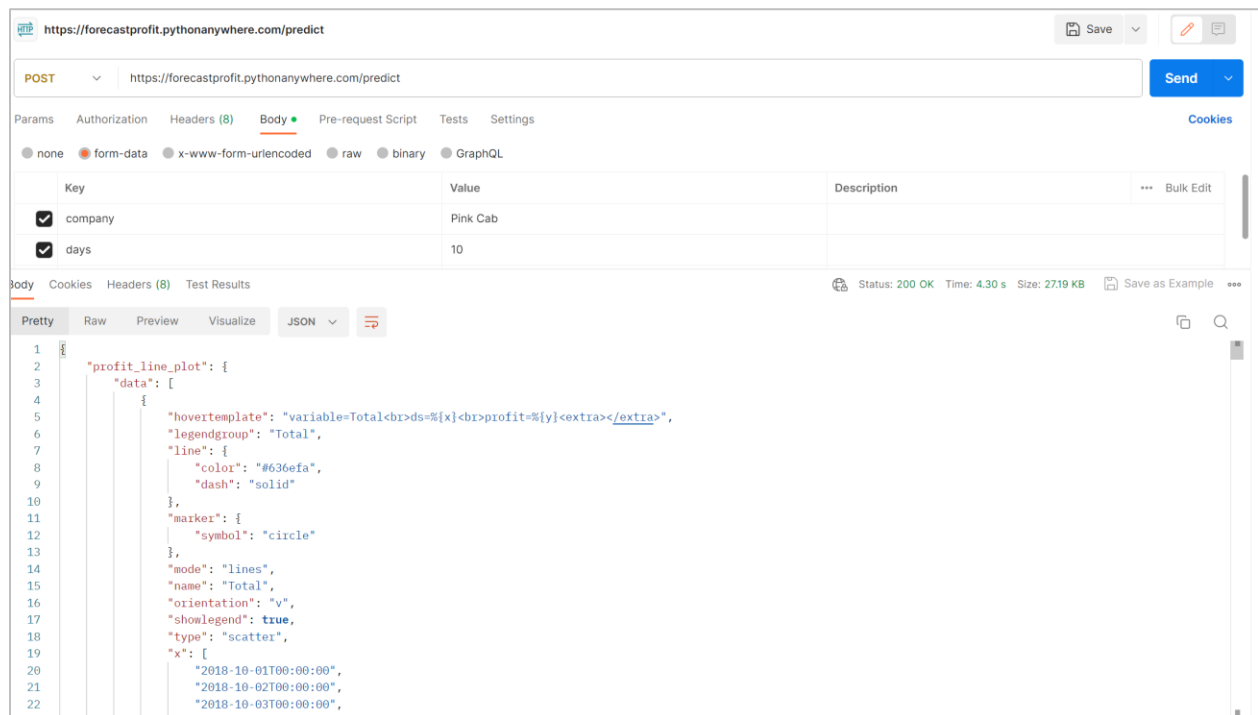


Figure 26: deployment step 9

10. Test the `/predict` endpoint using the live app by selecting different company name and forecasting days. Hover on points and click on legend values to interact with the plots. Check all Figures below.

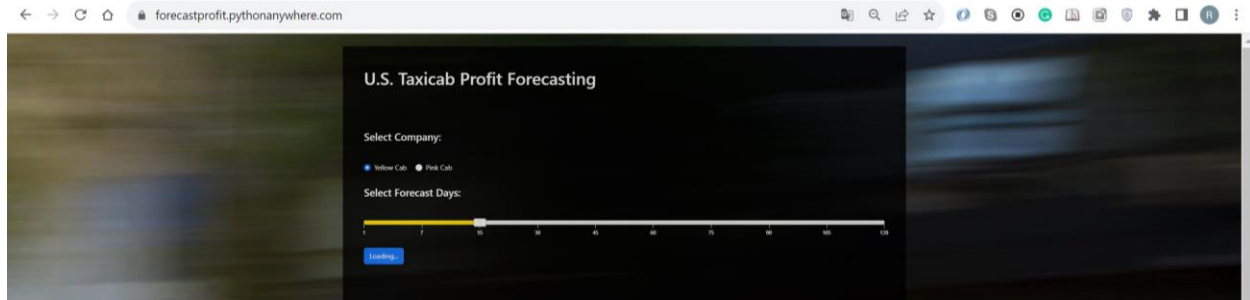


Figure 27: deployment step 10 part 1

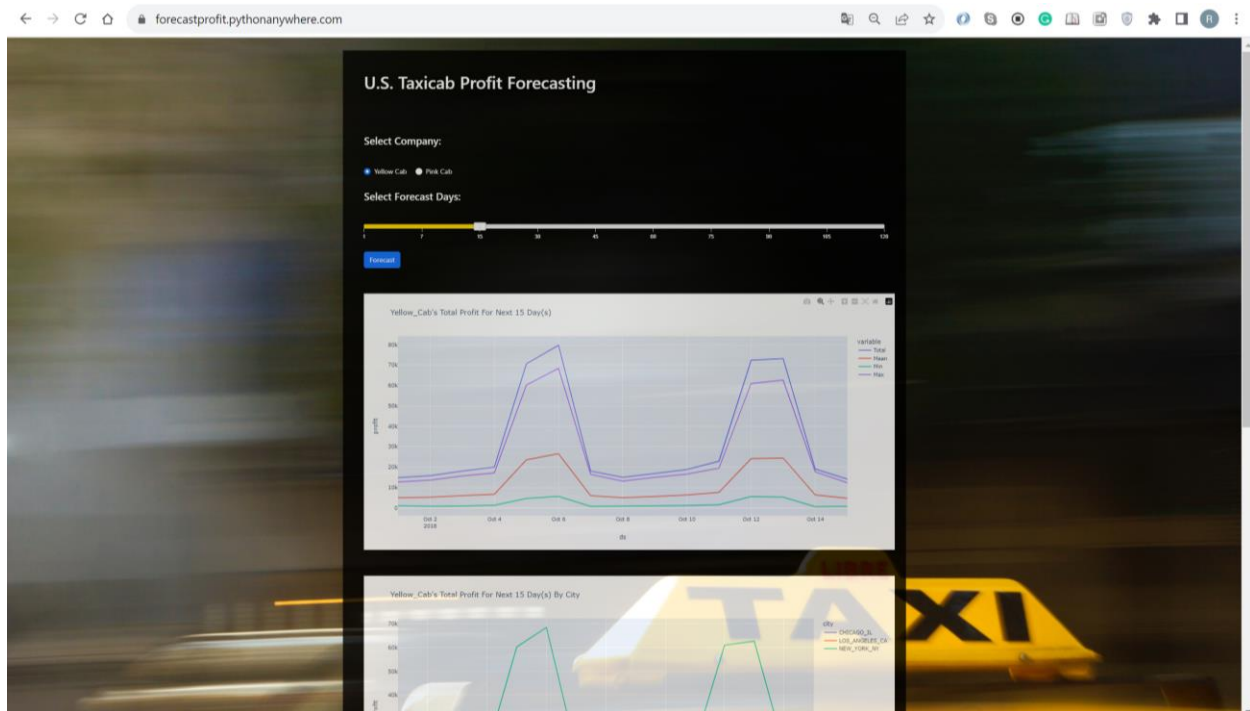


Figure 28: deployment step 10 part 2

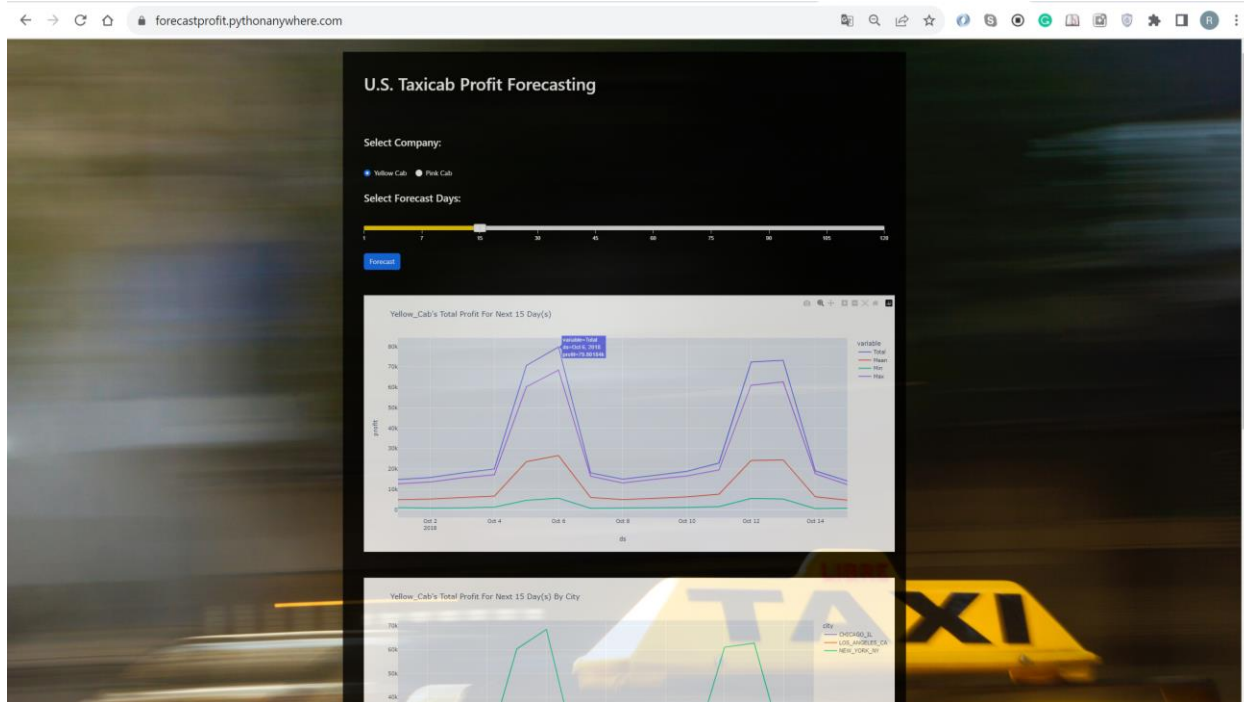


Figure 29: deployment step 10 part 3

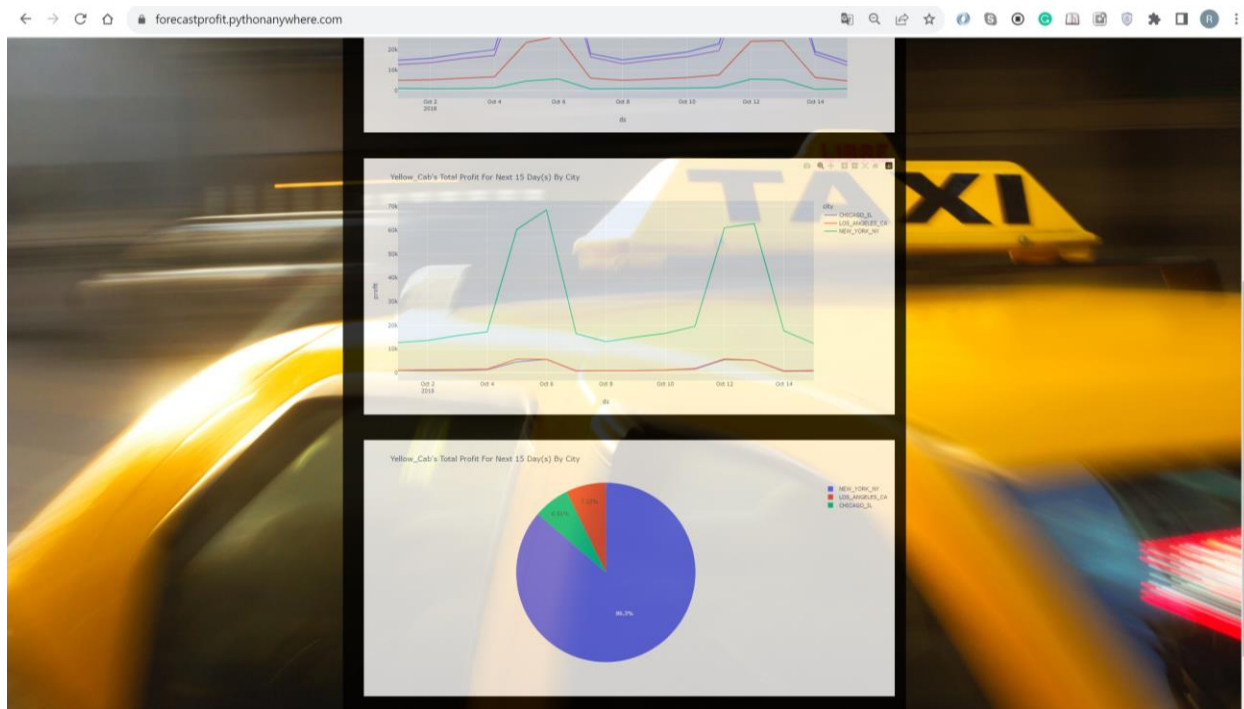


Figure 30: deployment step 10 part 4

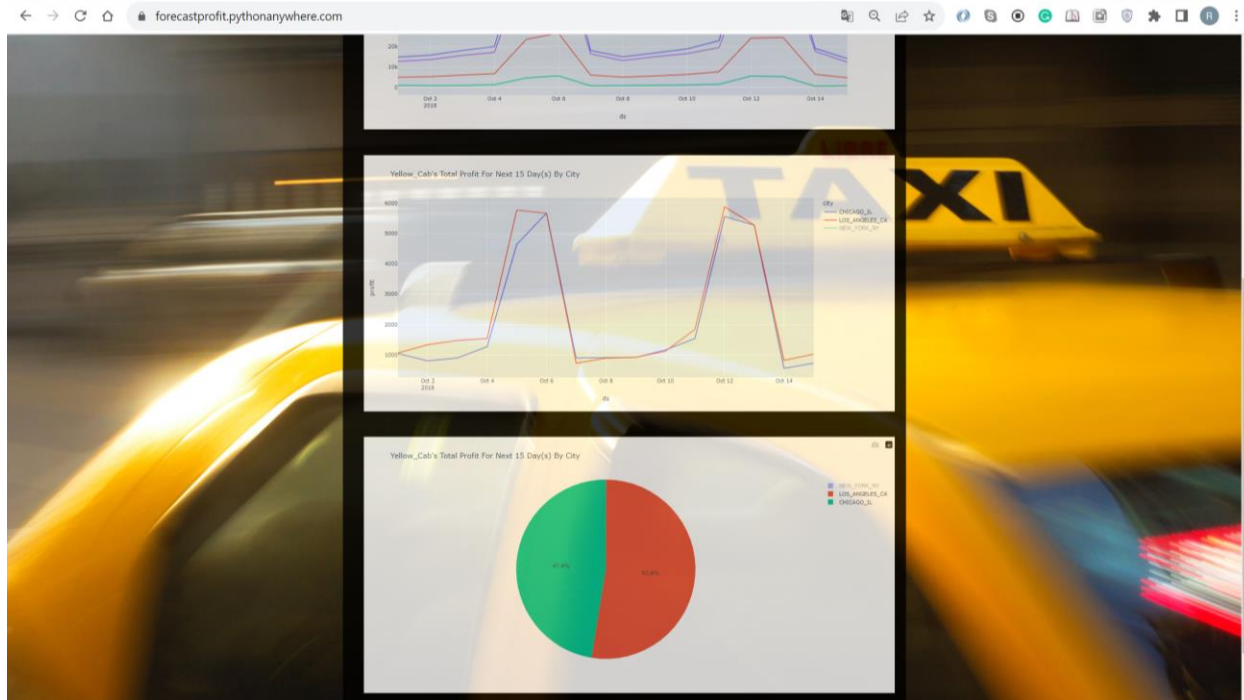


Figure 31: deployment step 10 part 5

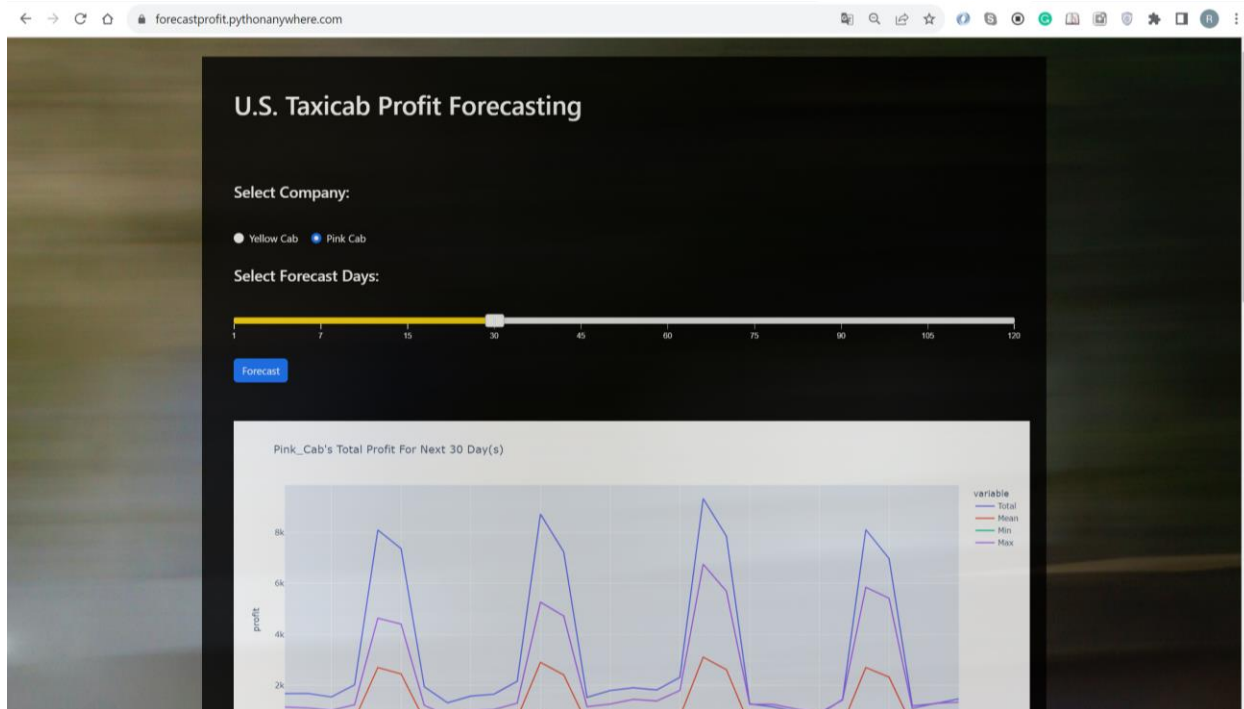


Figure 32: deployment step 10 part 6

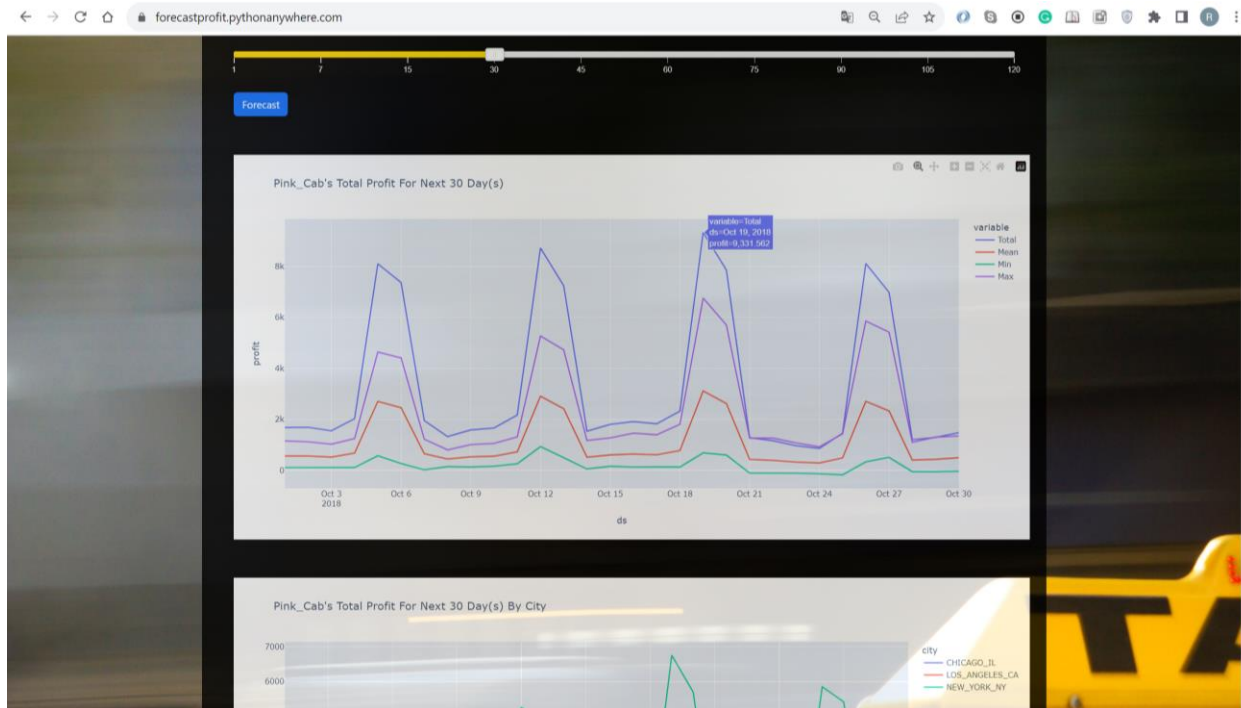


Figure 33: deployment step 10 part 7

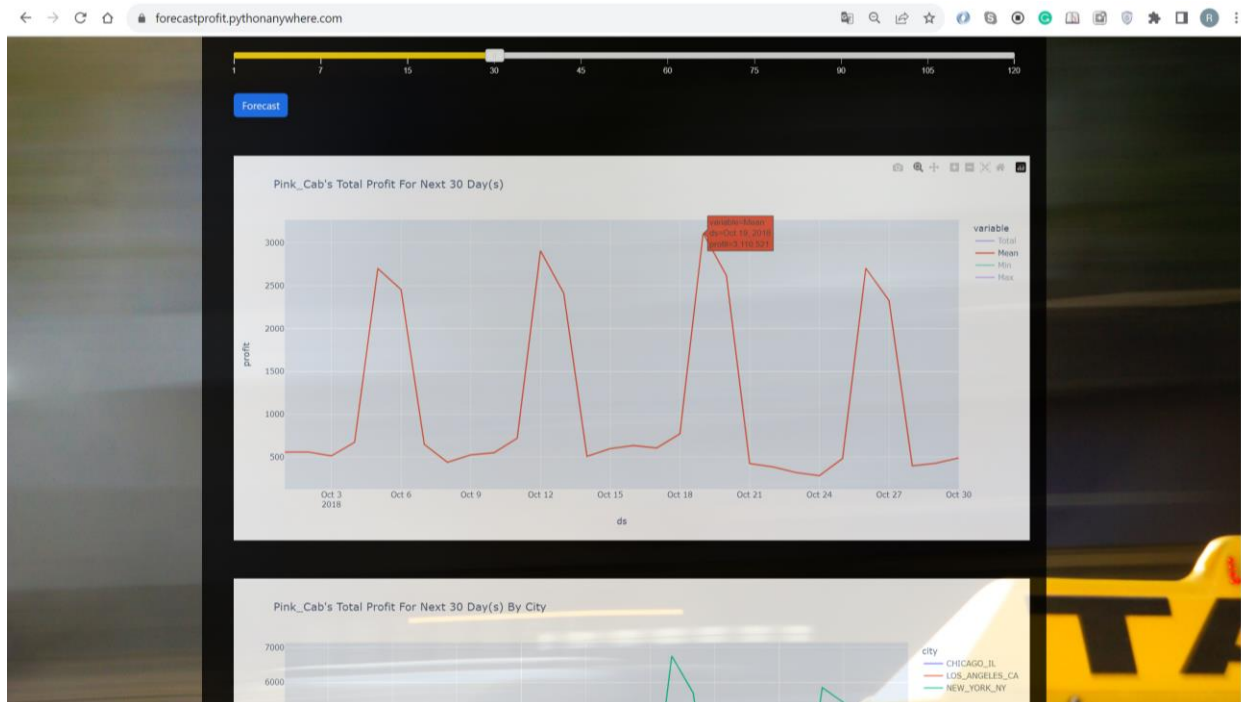


Figure 34: deployment step 10 part 8