part_1

September 14, 2020

1 IBM AI Enterprise Workflow Capstone Project - Part 1

1.1 Data preparation

[1]:
```
#!/usr/bin/env python
"""
collection of functions for the final case study solution
"""

import os
import sys
import re
import shutil
import time
import pickle
from collections import defaultdict
from datetime import datetime
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()

COLORS = ["darkorange","royalblue","slategrey"]

def fetch_data(data_dir):
    """
    laod all json formatted files into a dataframe
    """

    ## input testing
    if not os.path.isdir(data_dir):
        raise Exception("specified data dir does not exist")
    if not len(os.listdir(data_dir)) > 0:
        raise Exception("specified data dir does not contain any files")
    file_list = [os.path.join(data_dir,f) for f in os.listdir(data_dir) if re.
↪search("\.json",f)]
    correct_columns = ['country', 'customer_id', 'day', 'invoice', 'month',
                       'price', 'stream_id', 'times_viewed', 'year']

    ## read data into a temp structure
    all_months = {}
    for file_name in file_list:
        df = pd.read_json(file_name)
        all_months[os.path.split(file_name)[-1]] = df

    ## ensure the data are formatted with correct columns
    for f,df in all_months.items():
        cols = set(df.columns.tolist())
        if 'StreamID' in cols:
             df.rename(columns={'StreamID':'stream_id'},inplace=True)
        if 'TimesViewed' in cols:
            df.rename(columns={'TimesViewed':'times_viewed'},inplace=True)
        if 'total_price' in cols:
            df.rename(columns={'total_price':'price'},inplace=True)

        cols = df.columns.tolist()
        if sorted(cols) != correct_columns:
            raise Exception("columns name could not be matched to correct cols")

    ## concat all of the data
    df = pd.concat(list(all_months.values()),sort=True)
    years,months,days = df['year'].values,df['month'].values,df['day'].values
    dates = ["{}-{}-{}".format(years[i],str(months[i]).zfill(2),str(days[i]).
↪zfill(2)) for i in range(df.shape[0])]
    df['invoice_date'] = np.array(dates,dtype='datetime64[D]')
    df['invoice'] = [re.sub("\D+","",i) for i in df['invoice'].values]

    ## sort by date and reset the index
    df.sort_values(by='invoice_date',inplace=True)
    df.reset_index(drop=True,inplace=True)

    return(df)


def convert_to_ts(df_orig, country=None):
    """
    given the original DataFrame (fetch_data())
    return a numerically indexed time-series DataFrame
    by aggregating over each day
    """
    if country:
        if country not in np.unique(df_orig['country'].values):
            raise Excpetion("country not found")

        mask = df_orig['country'] == country
        df = df_orig[mask]
    else:
        df = df_orig

    ## use a date range to ensure all days are accounted for in the data
    invoice_dates = df['invoice_date'].values
    start_month = '{}-{}'.format(df['year'].values[0],str(df['month'].
↪values[0]).zfill(2))
    stop_month = '{}-{}'.format(df['year'].values[-1],str(df['month'].
↪values[-1]).zfill(2))
    df_dates = df['invoice_date'].values.astype('datetime64[D]')
    days = np.arange(start_month,stop_month,dtype='datetime64[D]')

    purchases = np.array([np.where(df_dates==day)[0].size for day in days])
    invoices = [np.unique(df[df_dates==day]['invoice'].values).size for day in␣
↪days]
    streams = [np.unique(df[df_dates==day]['stream_id'].values).size for day in␣
↪days]
    views =  [df[df_dates==day]['times_viewed'].values.sum() for day in days]
    revenue = [df[df_dates==day]['price'].values.sum() for day in days]
    year_month = ["-".join(re.split("-",str(day))[:2]) for day in days]

    df_time = pd.DataFrame({'date':days,
                            'purchases':purchases,
                            'unique_invoices':invoices,
                            'unique_streams':streams,
                            'total_views':views,
                            'year_month':year_month,
                            'revenue':revenue})
    return(df_time)


def fetch_ts(data_dir, clean=False):
    """
    convenience function to read in new data
    uses csv to load quickly
    use clean=True when you want to re-create the files
    """

    ts_data_dir = os.path.join(data_dir,"ts-data")

    if clean:
        shutil.rmtree(ts_data_dir)
    if not os.path.exists(ts_data_dir):
        os.mkdir(ts_data_dir)

    ## if files have already been processed load them
    if len(os.listdir(ts_data_dir)) > 0:
        print("... loading ts data from files")
        return({re.sub("\.csv","",cf)[3:]:pd.read_csv(os.path.
↪join(ts_data_dir,cf)) for cf in os.listdir(ts_data_dir)})

    ## get original data
    print("... processing data for loading")
    df = fetch_data(data_dir)

    ## find the top ten countries (wrt revenue)
    table = pd.pivot_table(df,index='country',values="price",aggfunc='sum')
    table.columns = ['total_revenue']
    table.sort_values(by='total_revenue',inplace=True,ascending=False)
    top_ten_countries =  np.array(list(table.index))[:10]

    file_list = [os.path.join(data_dir,f) for f in os.listdir(data_dir) if re.
↪search("\.json",f)]
    countries = [os.path.join(data_dir,"ts-"+re.sub("\s+","_",c.lower()) + ".
↪csv") for c in top_ten_countries]

    ## load the data
    dfs = {}
    dfs['all'] = convert_to_ts(df)
    for country in top_ten_countries:
        country_id = re.sub("\s+","_",country.lower())
        file_name = os.path.join(data_dir,"ts-"+ country_id + ".csv")
        dfs[country_id] = convert_to_ts(df,country=country)

    ## save the data as csvs
    for key, item in dfs.items():
        item.to_csv(os.path.join(ts_data_dir,"ts-"+key+".csv"),index=False)

    return(dfs)

def engineer_features(df,training=True):
    """
    for any given day the target becomes the sum of the next days revenue
    for that day we engineer several features that help predict the summed␣
↪revenue

    the 'training' flag will trim data that should not be used for training
    when set to false all data will be returned
    """

    ## extract dates
    dates = df['date'].values.copy()
    dates = dates.astype('datetime64[D]')

    ## engineer some features
    eng_features = defaultdict(list)
    previous =[7, 14, 28, 70]  #[7, 14, 21, 28, 35, 42, 49, 56, 63, 70]
    y = np.zeros(dates.size)
    for d,day in enumerate(dates):

        ## use windows in time back from a specific date
        for num in previous:
            current = np.datetime64(day, 'D')
            prev = current - np.timedelta64(num, 'D')
            mask = np.in1d(dates, np.arange(prev,current,dtype='datetime64[D]'))
            eng_features["previous_{}".format(num)].append(df[mask]['revenue'].
↪sum())

        ## get get the target revenue
        plus_30 = current + np.timedelta64(30,'D')
        mask = np.in1d(dates, np.arange(current,plus_30,dtype='datetime64[D]'))
        y[d] = df[mask]['revenue'].sum()

        ## attempt to capture monthly trend with previous years data (if␣
↪present)
        start_date = current - np.timedelta64(365,'D')
        stop_date = plus_30 - np.timedelta64(365,'D')
        mask = np.in1d(dates, np.
↪arange(start_date,stop_date,dtype='datetime64[D]'))
        eng_features['previous_year'].append(df[mask]['revenue'].sum())

        ## add some non-revenue features
        minus_30 = current - np.timedelta64(30,'D')
        mask = np.in1d(dates, np.arange(minus_30,current,dtype='datetime64[D]'))
        eng_features['recent_invoices'].append(df[mask]['unique_invoices'].
↪mean())
        eng_features['recent_views'].append(df[mask]['total_views'].mean())

    X = pd.DataFrame(eng_features)
    ## combine features in to df and remove rows with all zeros
    X.fillna(0,inplace=True)
    mask = X.sum(axis=1)>0
    X = X[mask]
    y = y[mask]
    dates = dates[mask]
    X.reset_index(drop=True, inplace=True)

    if training == True:
        ## remove the last 30 days (because the target is not reliable)
        mask = np.arange(X.shape[0]) < np.arange(X.shape[0])[-30]
        X = X[mask]
        y = y[mask]
        dates = dates[mask]
        X.reset_index(drop=True, inplace=True)

    return(X,y,dates)
```

[2]:
```
run_start = time.time()
data_dir = os.path.join("..","cs-train")
print("...fetching data")

ts_all = fetch_ts(data_dir,clean=False)

m, s = divmod(time.time()-run_start,60)
h, m = divmod(m, 60)
print("load time:", "%d:%02d:%02d"%(h, m, s))

for key,item in ts_all.items():
    print(key,item.shape)
```

```
…fetching data
… loading ts data from files
load time: 0:00:00
portugal (607, 7)
united_kingdom (607, 7)
hong_kong (426, 7)
eire (607, 7)
spain (607, 7)
france (607, 7)
singapore (456, 7)
all (607, 7)
norway (577, 7)
germany (607, 7)
netherlands (607, 7)
```

[3]:
```
ts_all["all"].head()
```

[3]:
```
         date  purchases  unique_invoices  unique_streams  total_views  \
0  2017-11-01          0                0               0            0
1  2017-11-02          0                0               0            0
2  2017-11-03          0                0               0            0
```

```
3  2017-11-04          0                0                0               0
4  2017-11-05          0                0                0               0

  year_month  revenue
0    2017-11      0.0
1    2017-11      0.0
2    2017-11      0.0
3    2017-11      0.0
4    2017-11      0.0
```

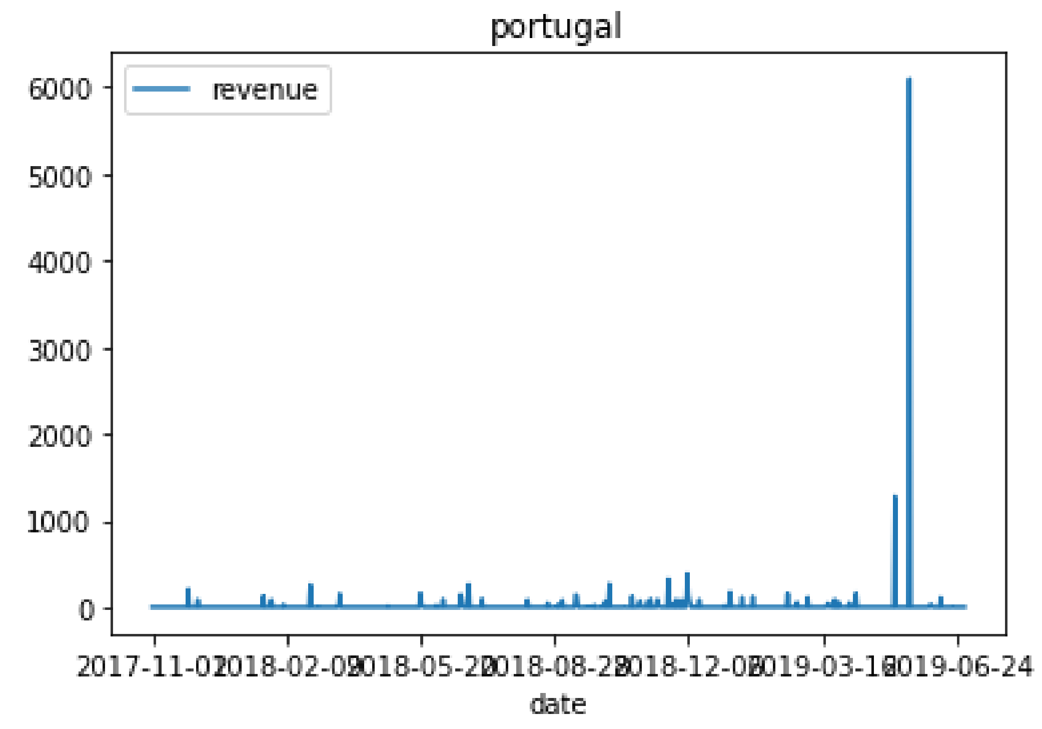
[4]:
```
countries = []
for k in ts_all.keys():
    countries.append(k)
countries
```

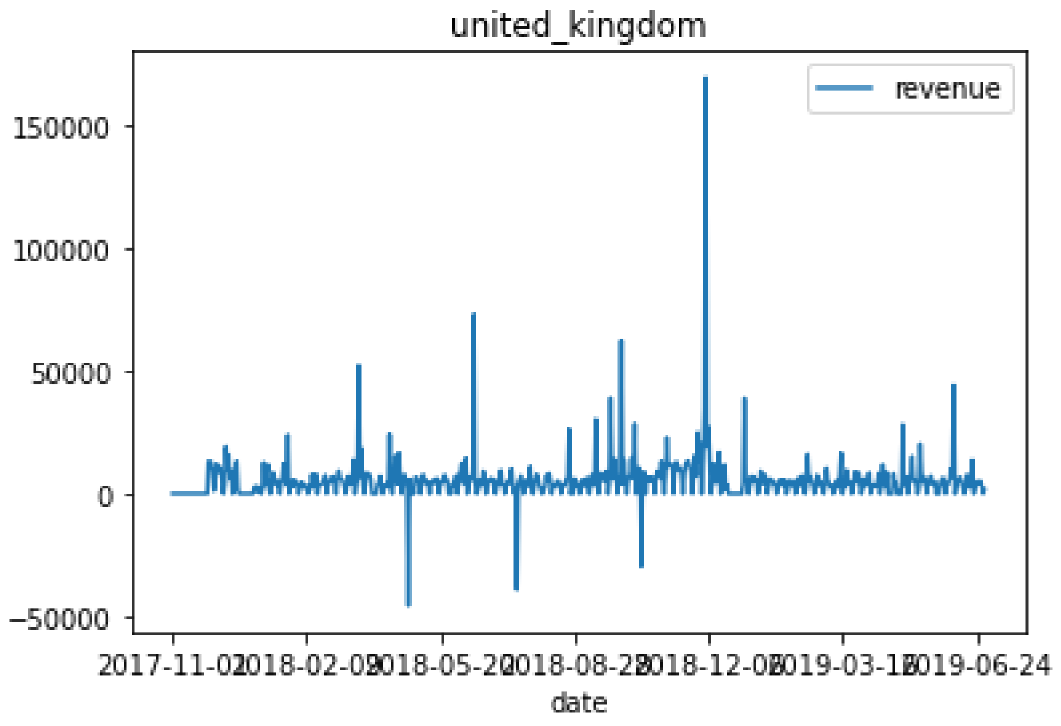
[4]:
```
['portugal',
 'united_kingdom',
 'hong_kong',
 'eire',
 'spain',
 'france',
 'singapore',
 'all',
 'norway',
 'germany',
 'netherlands']
```

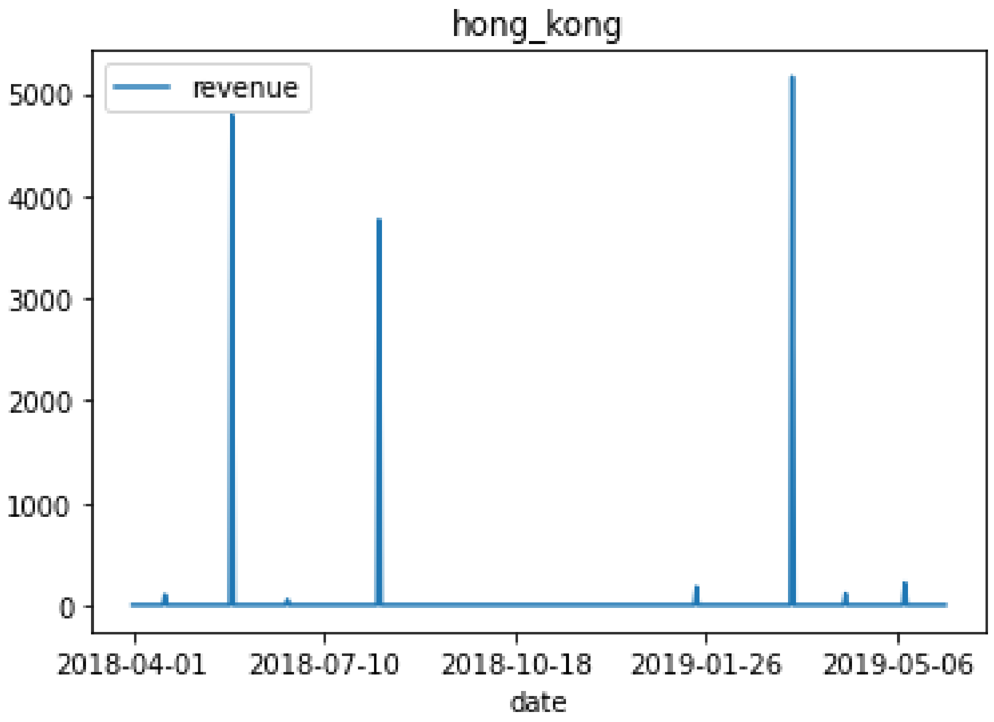
1.2 Revenue Analysis

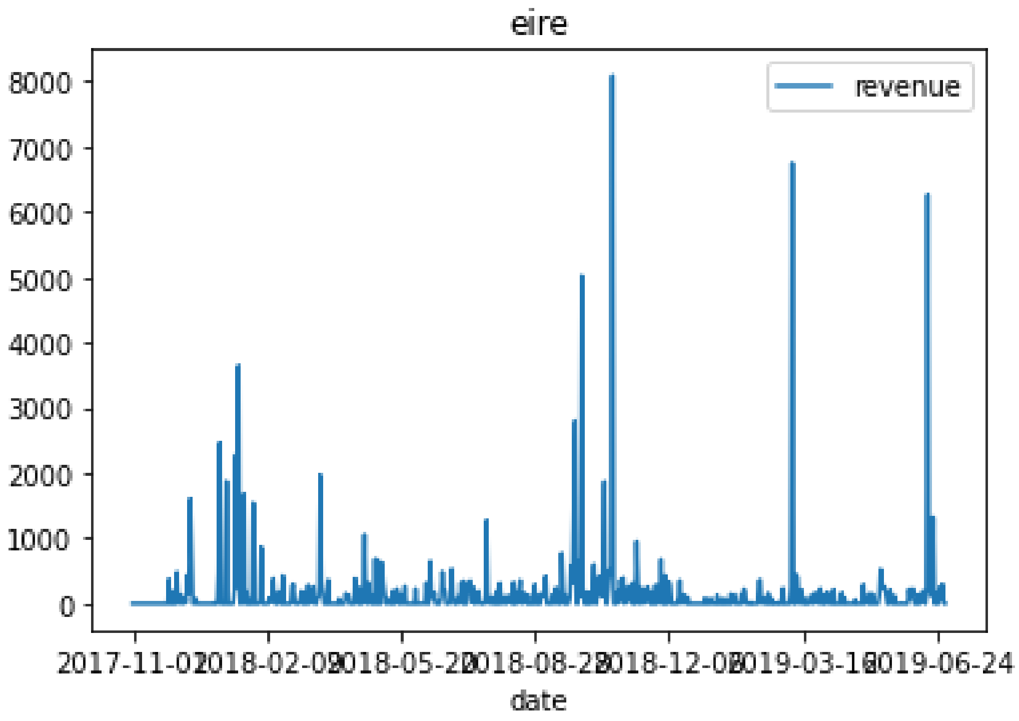
1.2.1 Revenue per day

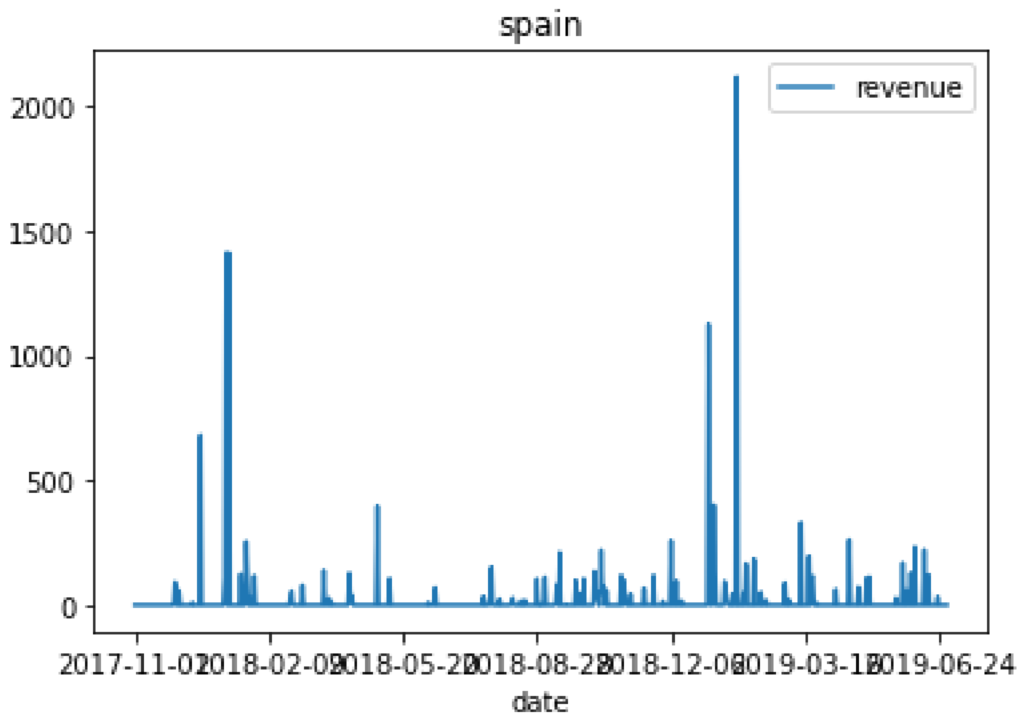
[5]:
```
for country in countries:
    ts_all[country].plot(x="date", y="revenue", title=country)
```

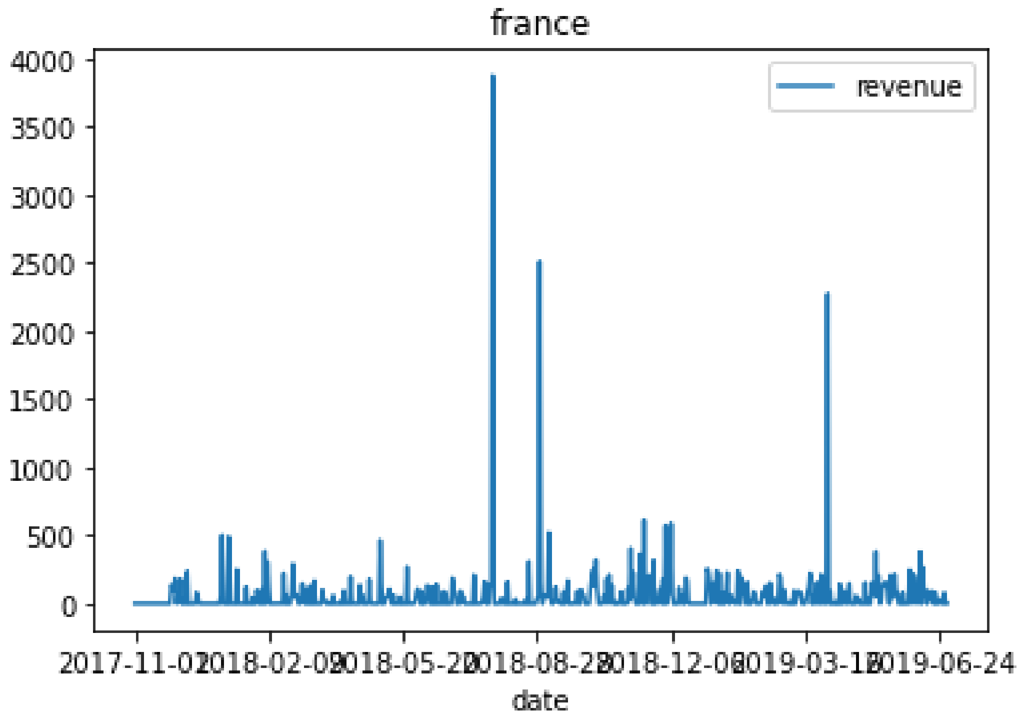

portugal
revenue
6000
5000
4000
3000
2000
1000
0
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

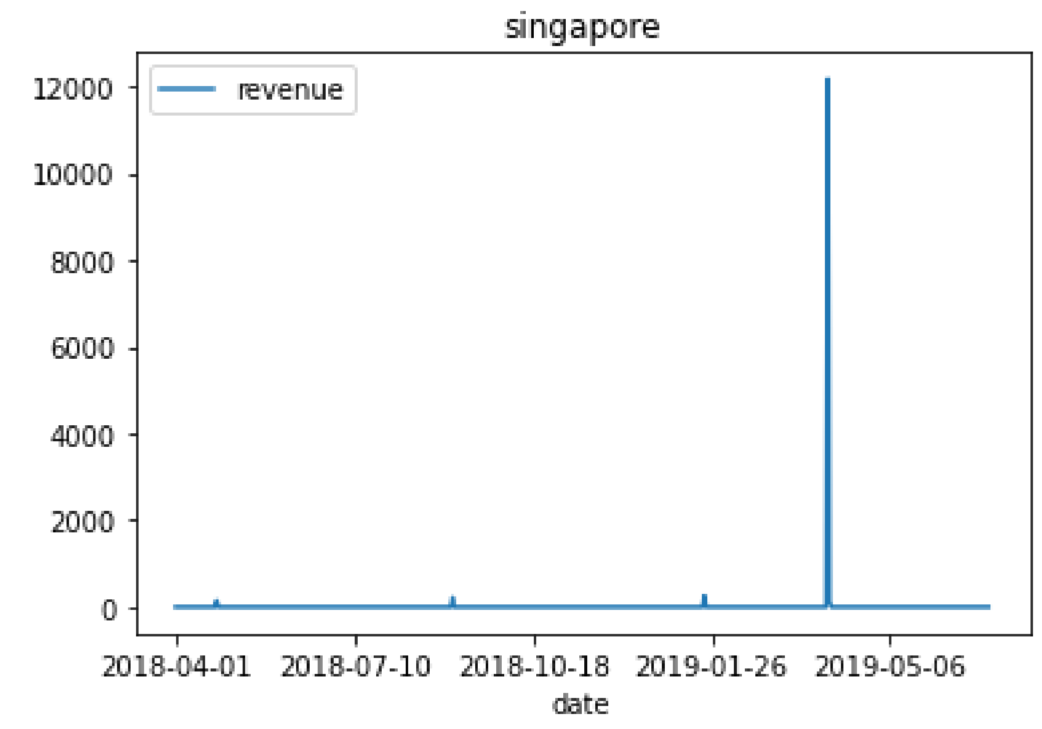

united_kingdom
revenue
150000
100000
50000
0
−50000
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

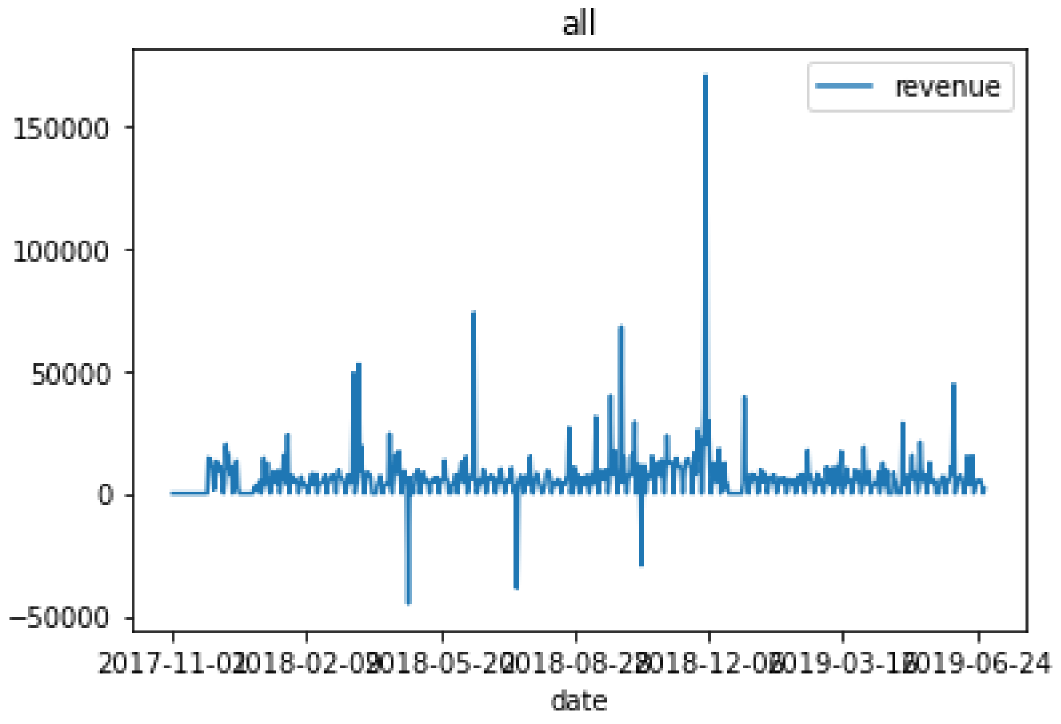

hong_kong
revenue
5000
4000
3000
2000
1000
0
2018-04-01
2018-07-10
2018-10-18
2019-01-26
2019-05-06
date

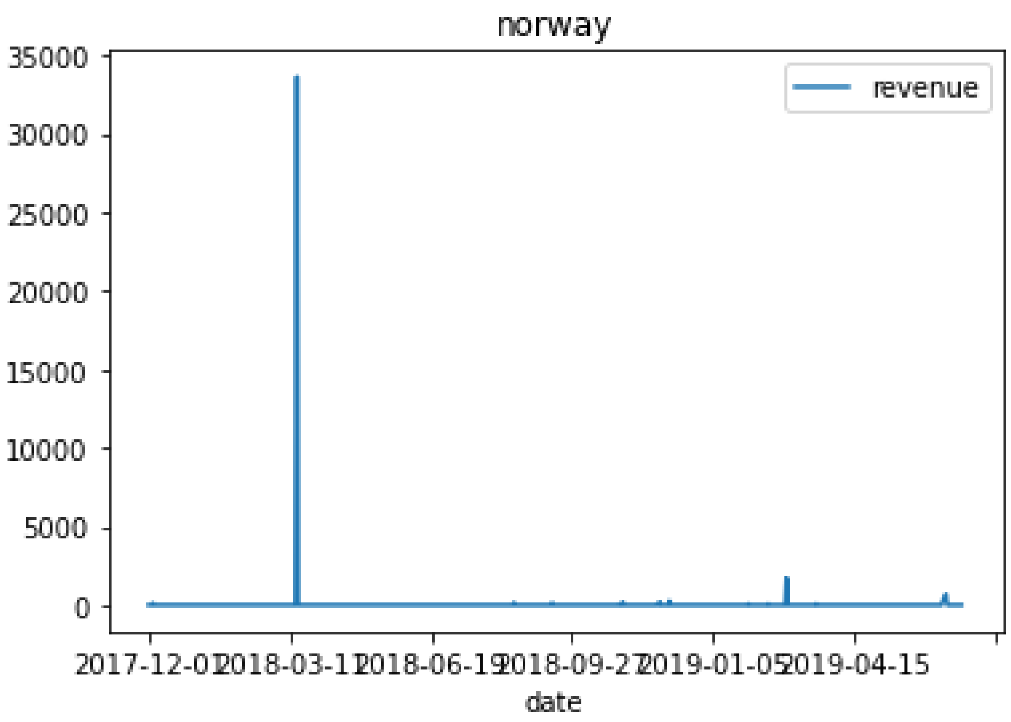

eire
revenue
8000
7000
6000
5000
4000
3000
2000
1000
0
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

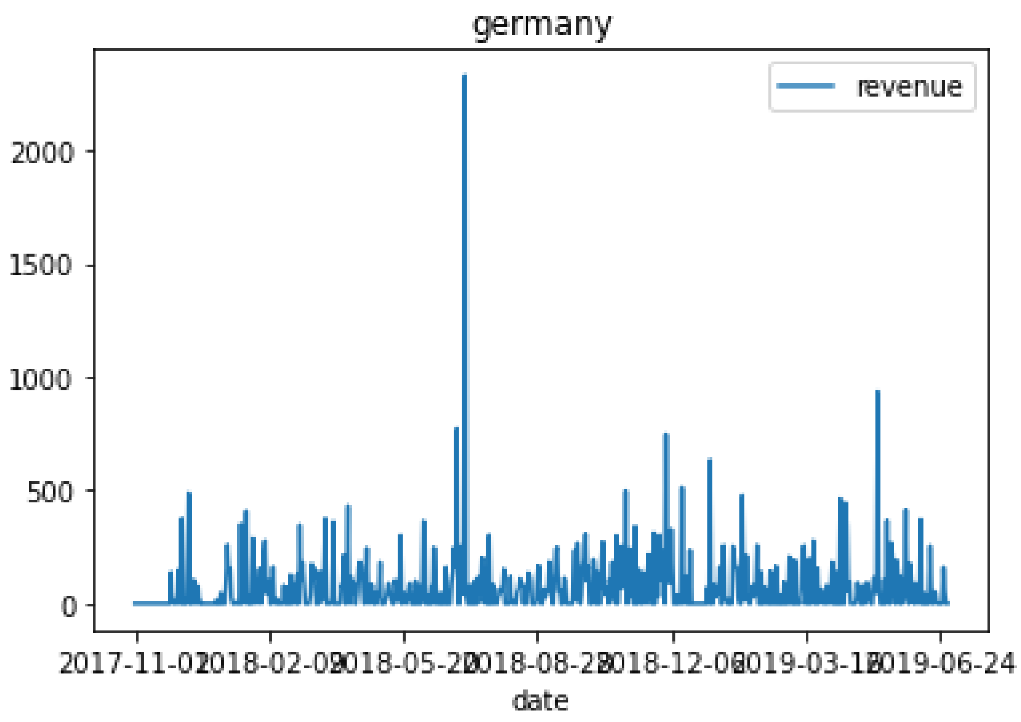

spain
revenue
2000
1500
1000
500
0
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

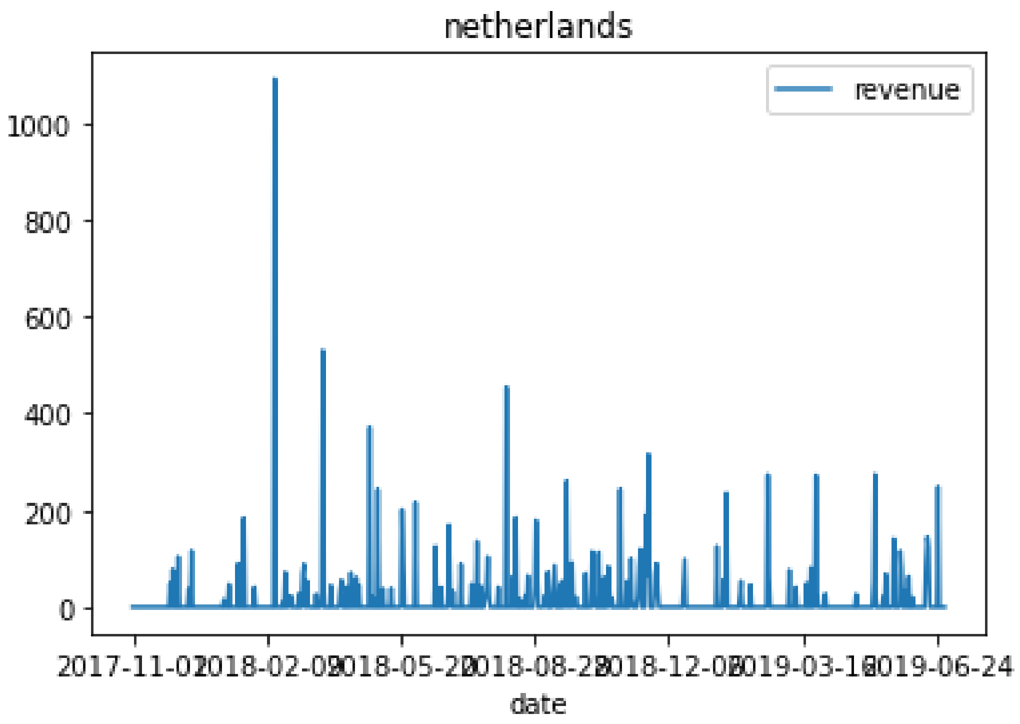

france
revenue
4000
3500
3000
2500
2000
1500
1000
500
0
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date


singapore
revenue
12000
10000
8000
6000
4000
2000
0
2018-04-01
2018-07-10
2018-10-18
2019-01-26
2019-05-06
date


all
revenue
150000
100000
50000
0
−50000
2017-11-02
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

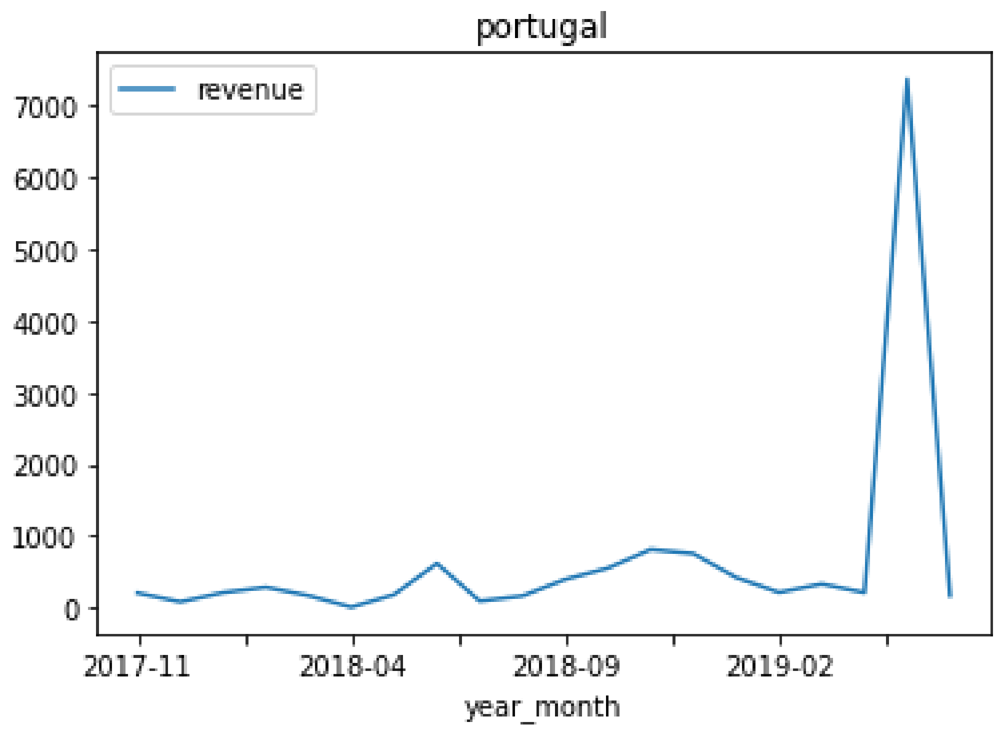

norway
revenue
35000
30000
25000
20000
15000
10000
5000
0
2017-12-01
2018-03-11
2018-06-19
2018-09-27
2019-01-05
2019-04-15
date

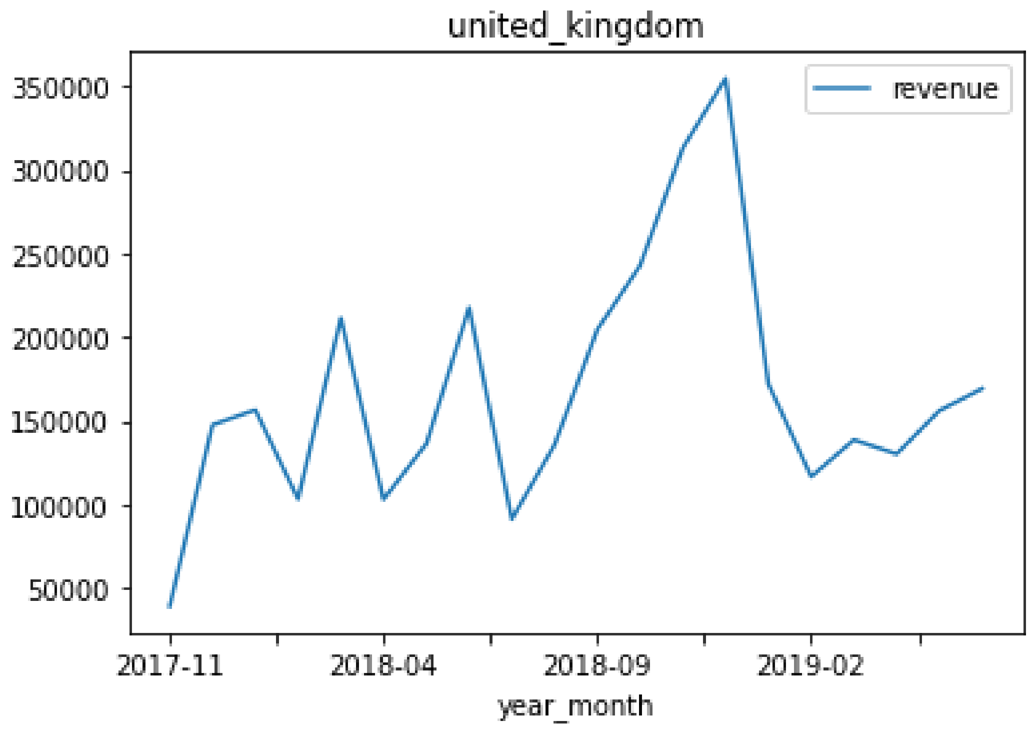

germany
revenue
2000
1500
1000
500
0
2017-11-01
2018-02-09
2018-05-20
2018-08-28
2018-12-06
2019-03-16
2019-06-24
date

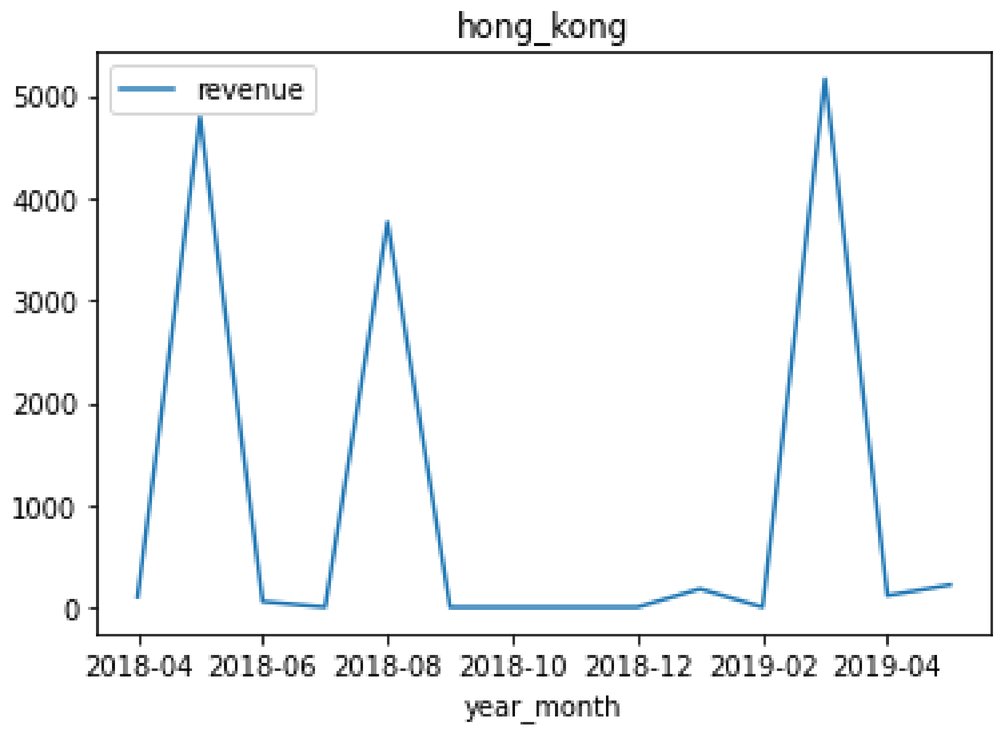


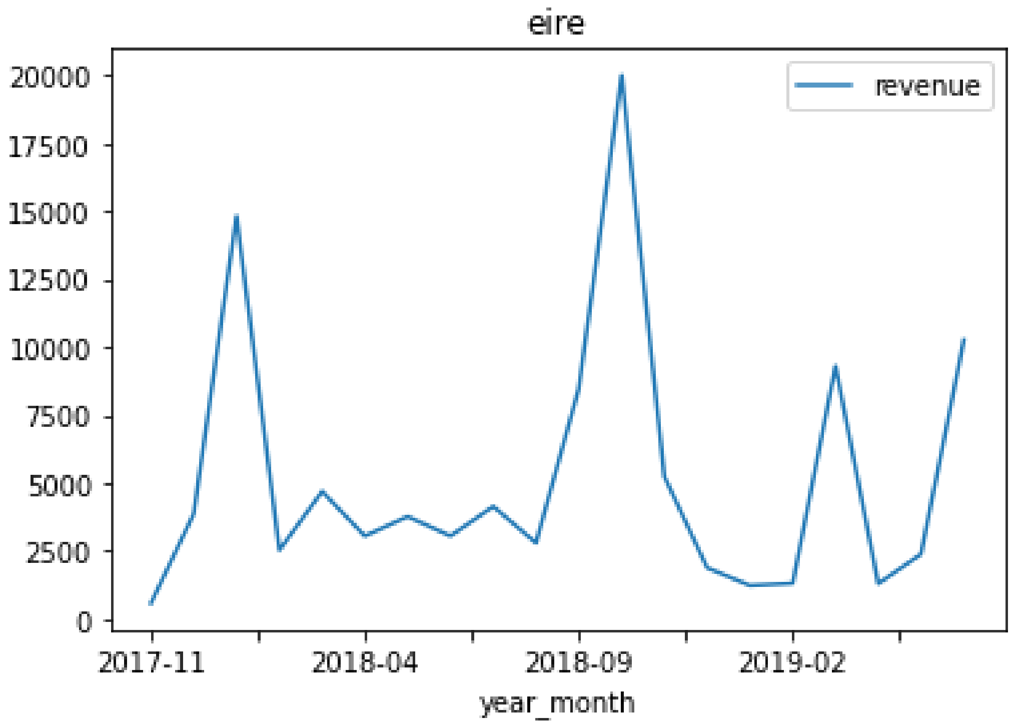
1.2.2 Revenue per month

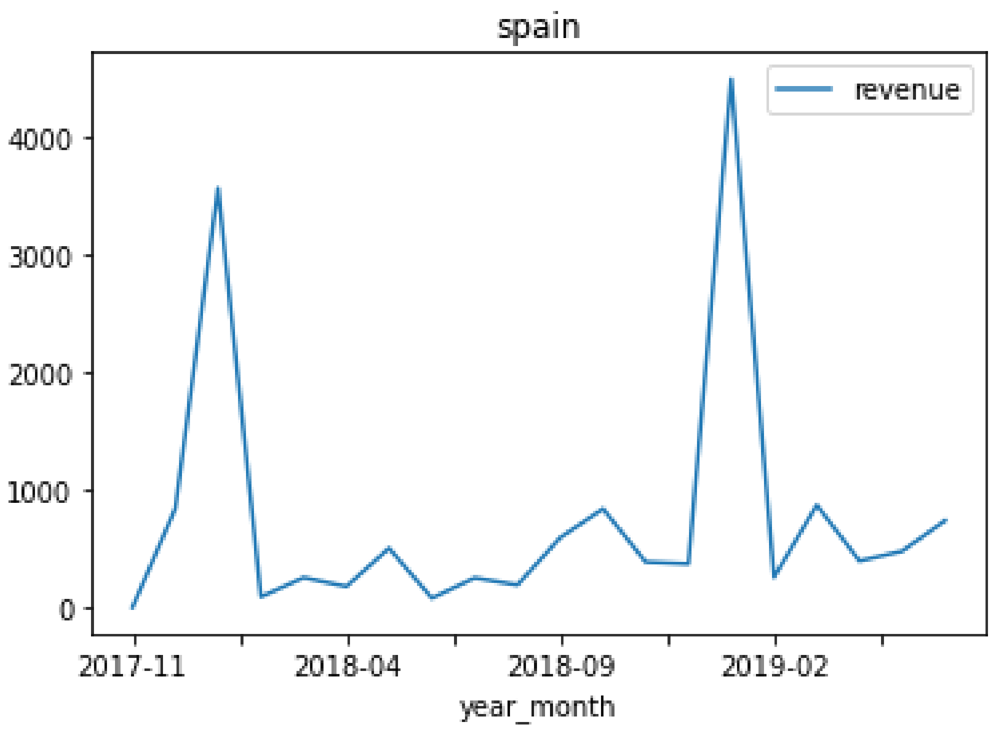
[6]:
```
for country in countries:
    ts_all[country].groupby("year_month").agg({"revenue": "sum"}).
 ↪plot(title=country)
```

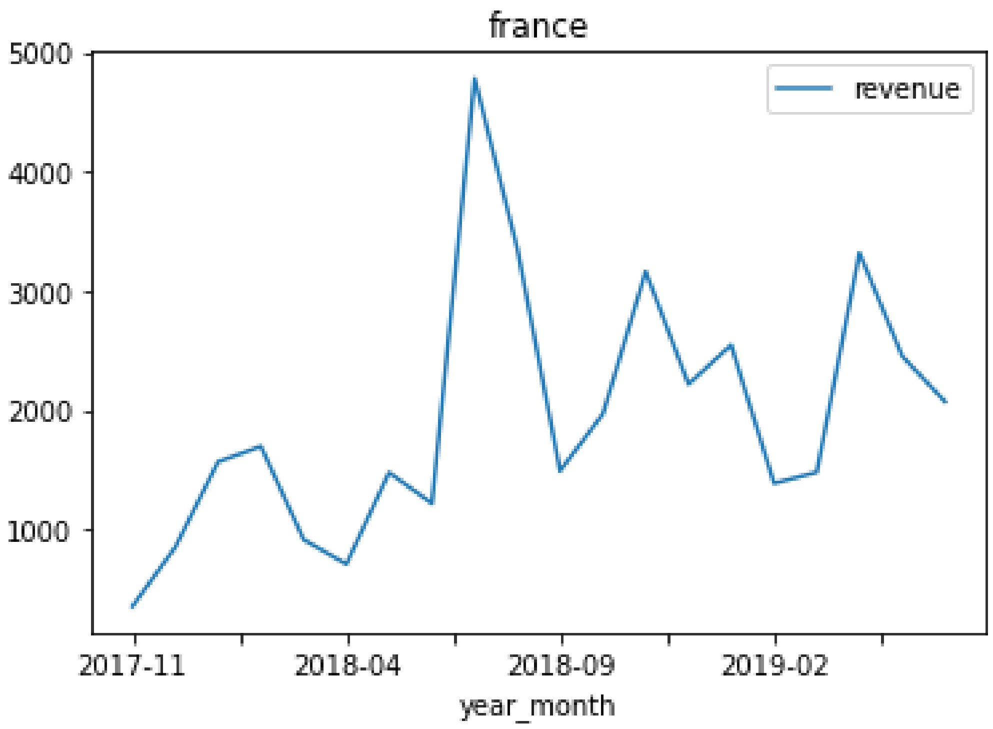

portugal
revenue
7000
6000
5000
4000
3000
2000
1000
0
2017-11
2018-04
2018-09
2019-02
year_month

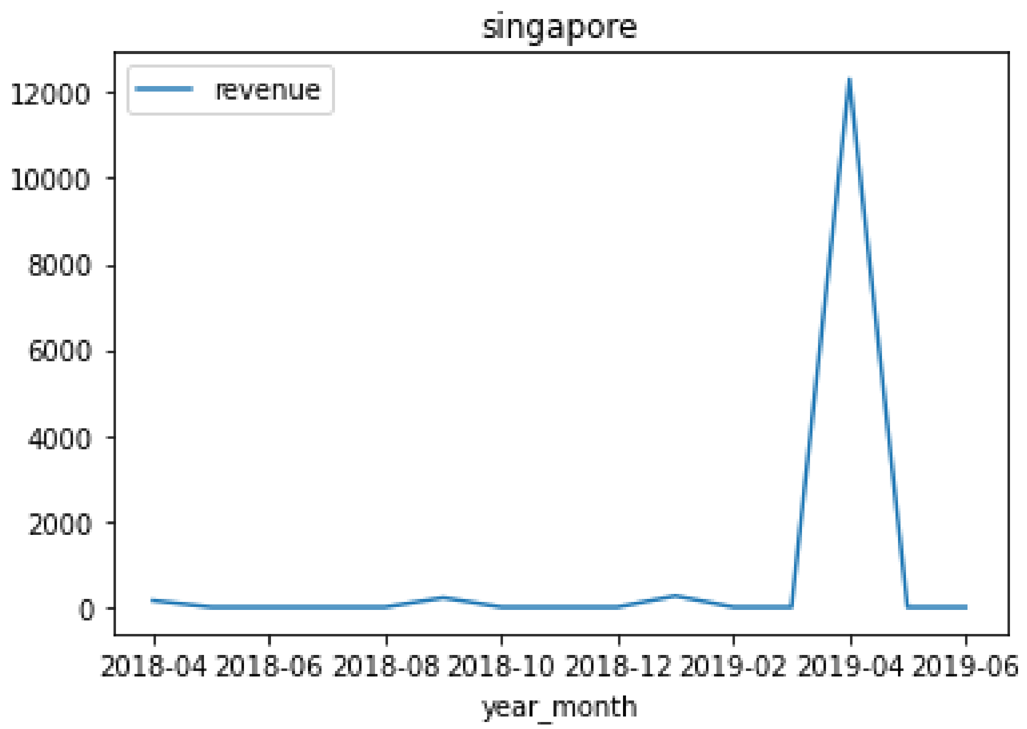

united_kingdom
revenue
350000
300000
250000
200000
150000
100000
50000
2017-11
2018-04
2018-09
2019-02
year_month

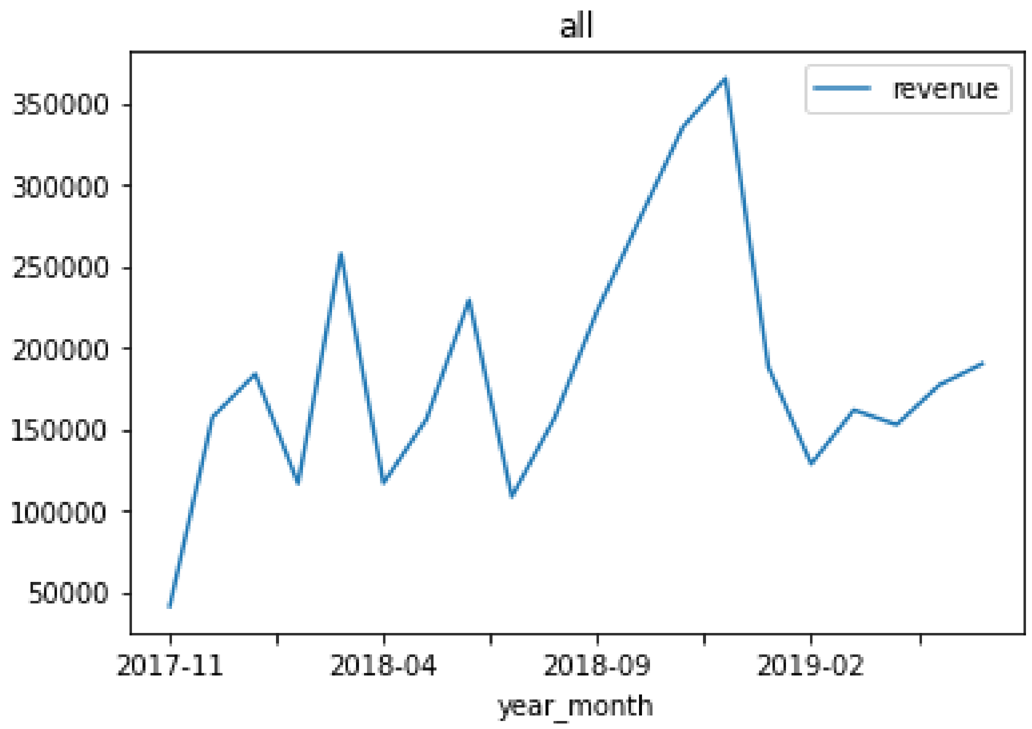

hong_kong
revenue
5000
4000
3000
2000
1000
0
2018-04
2018-06
2018-08
2018-10
2018-12
2019-02
2019-04
year_month

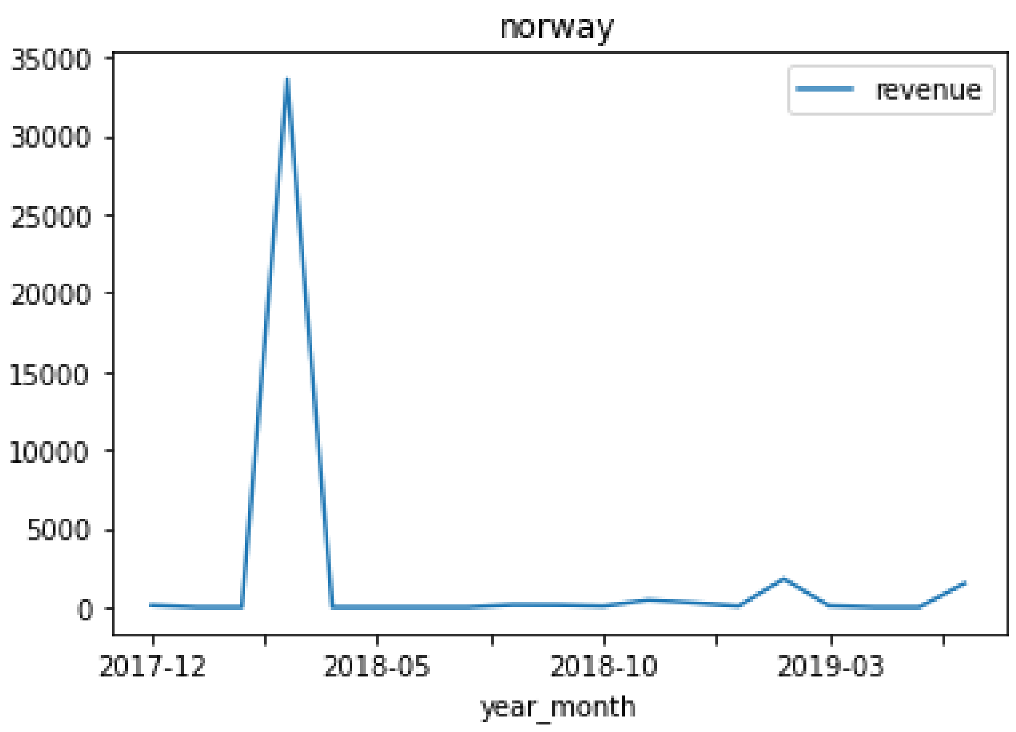

eire
revenue
20000
17500
15000
12500
10000
7500
5000
2500
0
2017-11
2018-04
2018-09
2019-02
year_month

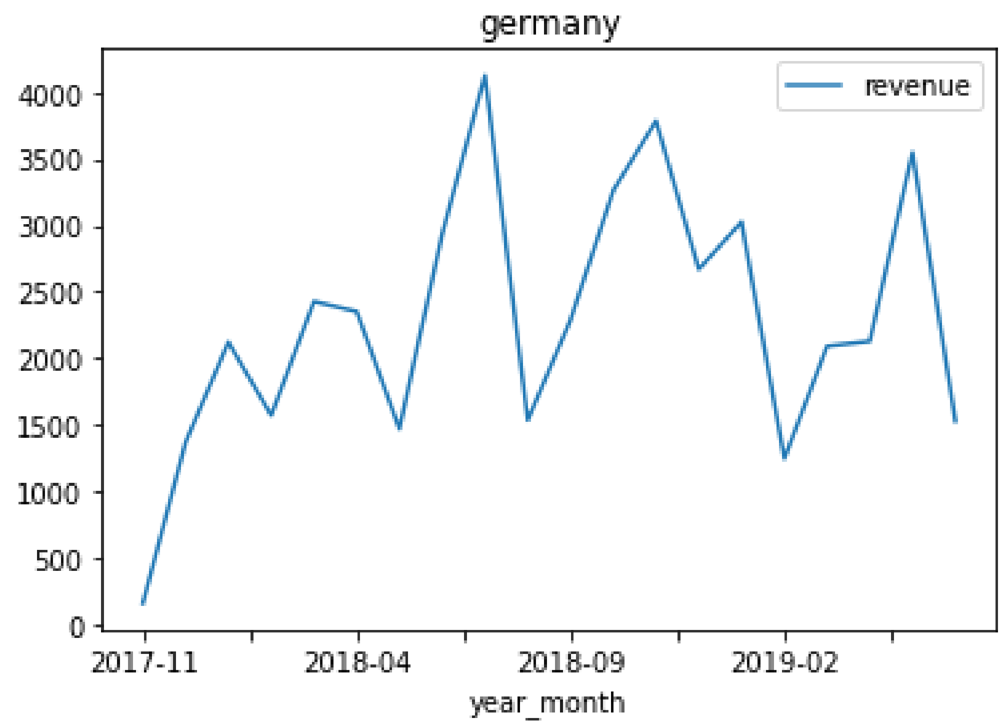

spain
revenue
4000
3000
2000
1000
0
2017-11
2018-04
2018-09
2019-02
year_month

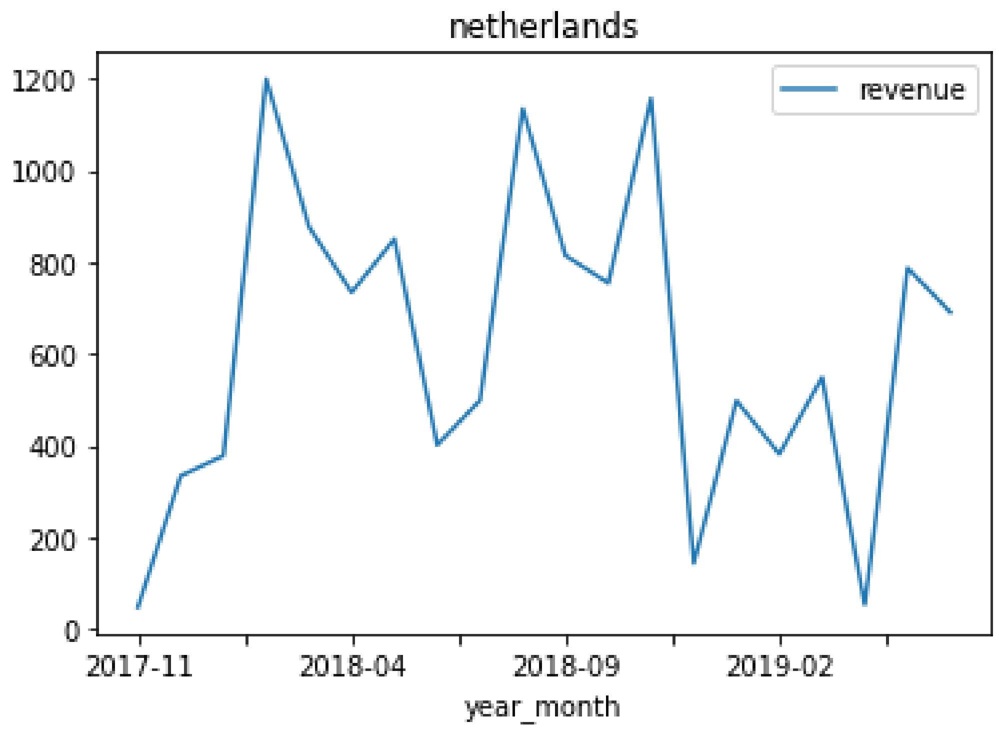

france
revenue
5000
4000
3000
2000
1000
2017-11
2018-04
2018-09
2019-02
year_month


singapore
revenue
12000
10000
8000
6000
4000
2000
0
2018-04
2018-06
2018-08
2018-10
2018-12
2019-02
2019-04
2019-06
year_month


all
revenue
350000
300000
250000
200000
150000
100000
50000
2017-11
2018-04
2018-09
2019-02
year_month


norway
revenue
35000
30000
25000
20000
15000
10000
5000
0
2017-12
2018-05
2018-10
2019-03
year_month


germany
revenue
4000
3500
3000
2500
2000
1500
1000
500
0
2017-11
2018-04
2018-09
2019-02
year_month



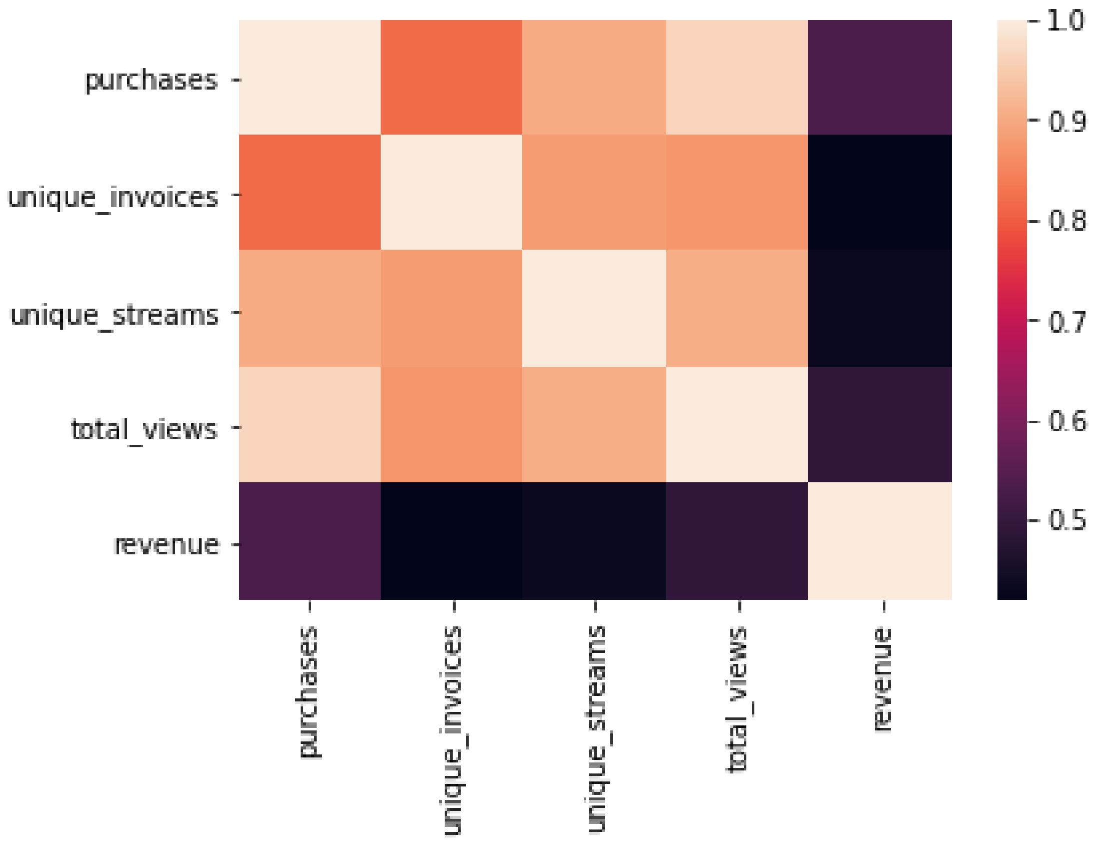
1.3 Relationship between the relevant data and target

[17]:
```
import seaborn as sns
```

[14]:
```
df = ts_all["all"][["purchases", "unique_invoices", "unique_streams",␣
 ↪"total_views", "revenue"]]
c = df.corr()
```

[18]:
```
sns.heatmap(c)
```

[18]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x11b33d0d0>
```


purchases
unique_invoices
unique_streams
total_views
revenue
1.0
0.9
0.8
0.7
0.6
0.5