Vladimir_Shteyn_EmployeeRetention

February 20, 2019

In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
import os
import pandas as pd
from sksurv.nonparametric import kaplan_meier_estimator
from sksurv.linear_model import CoxPHSurvivalAnalysis
from sksurv.preprocessing import OneHotEncoder
```

In [2]:
```
folder = r"/home/vladimir/projects/insight/datachallenges/insight/week1/data"
filename = r"employee_retention_data.csv"
path = os.path.join(folder, filename)
```

In [3]:
```
# read data from the CSV file
df = pd.read_csv(path)
```

In [4]:
```
# convert to datetime format
df['join_date'] = pd.to_datetime(df['join_date'], format="%Y-%m-%d")
df['quit_date'] = pd.to_datetime(df['quit_date'], format="%Y-%m-%d")
```

In [5]:
```
# number of days at the company
df['days'] = (df['quit_date'] - df['join_date']).apply(lambda x: getattr(x, 'days'))
```

In [6]:
```
# create column indicating whether employee has quit by the last day of the study
df['censored'] = ~df['days'].isna()
```

In [7]:
```
df.head()
```

Out[7]:

	employee_id	company_id	dept	seniority	salary	join_date	quit_date	days	censored
0	13021.0	7	customer_service	28	89000.0	2014-03-24	2015-10-30	585.0	True
1	825355.0	7	marketing	20	183000.0	2013-04-29	2014-04-04	340.0	True
2	927315.0	4	marketing	14	101000.0	2014-10-13	NaT	NaN	False
3	662910.0	7	customer_service	20	115000.0	2012-05-14	2013-06-07	389.0	True
4	256971.0	2	data_science	23	276000.0	2011-10-17	2014-08-22	1040.0	True

In [8]:
```
# for employees who haven't quit by the end of the study,
# calculate the total number of days they've been at the company
lastday = pd.datetime.strptime('2015-12-13', "%Y-%m-%d")
index = np.arange(len(df.index))[~df['censored'].values]
df.loc[index, 'days'] = (lastday - df['join_date']).apply(lambda x: getattr(x, 'days'))
```

In [9]:
```
df.head()
```

Out[9]:

	employee_id	company_id	dept	seniority	salary	join_date	quit_date	days	censored
0	13021.0	7	customer_service	28	89000.0	2014-03-24	2015-10-30	585.0	True
1	825355.0	7	marketing	20	183000.0	2013-04-29	2014-04-04	340.0	True
2	927315.0	4	marketing	14	101000.0	2014-10-13	NaT	426.0	False
3	662910.0	7	customer_service	20	115000.0	2012-05-14	2013-06-07	389.0	True
4	256971.0	2	data_science	23	276000.0	2011-10-17	2014-08-22	1040.0	True

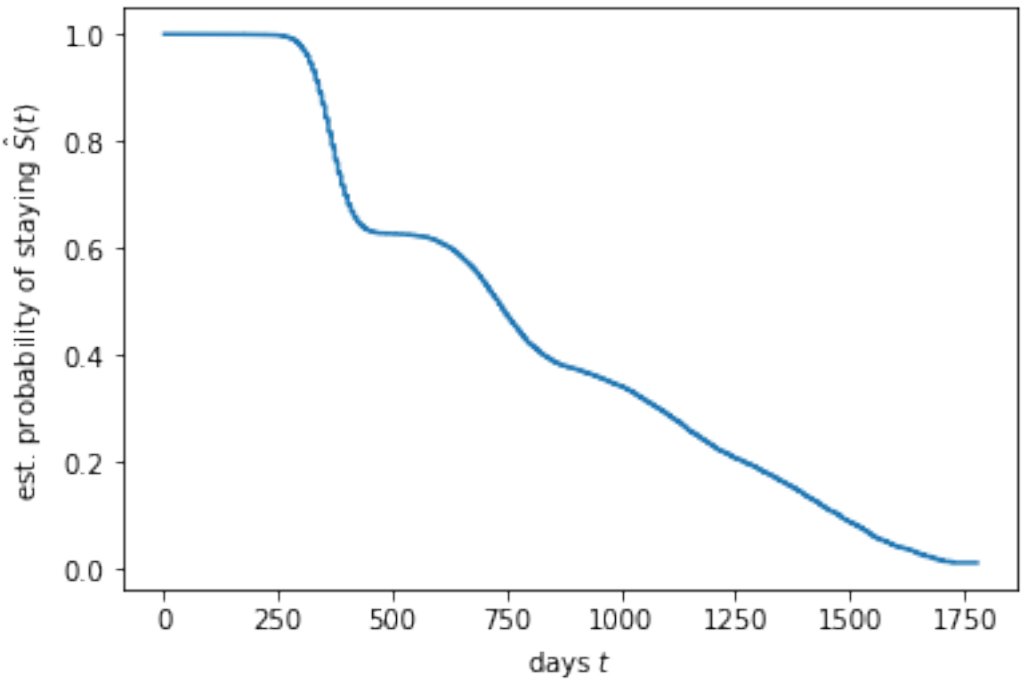
In [10]:
```
# calculate Kaplan-Meier statistic in order to estimate probability of quitting
time, survival_prob = kaplan_meier_estimator(df["censored"], df["days"])
```

In [11]:
```
%matplotlib inline
```

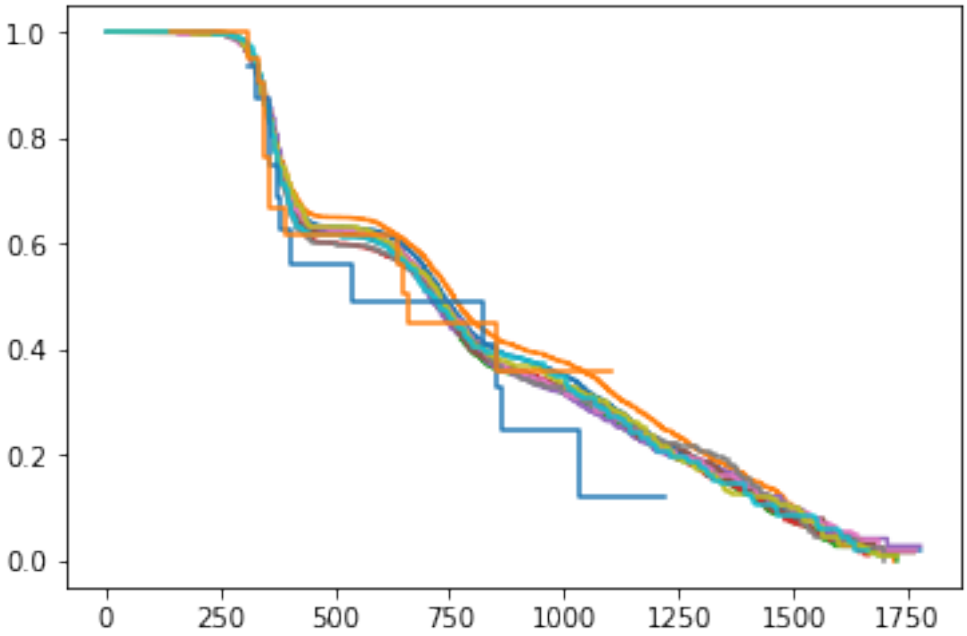
In [12]:
```
# plotting the survival curve accross all employees
fig_all_together, ax_all_together = plt.subplots(1, 1)

ax_all_together.step(time, survival_prob, where="post")
ax_all_together.set_ylabel("est. probability of staying $\hat{S}(t)$")
ax_all_together.set_xlabel("days $t$")
```

Out[12]:
```
Text(0.5, 0, 'days $t$')
```




```
In [13]: # brief data exploration:
         # plot the survival curve by company
         company_id_group = df.groupby('company_id')
         fig_by_company, ax_by_company = plt.subplots(1, 1)
         time_by_company, survival_prob_by_company = [], []
         for name in company_id_group.groups:
             group = company_id_group.get_group(name)
             _time_by_company, _survival_prob_by_company = kaplan_meier_estimator(group["censo
                                                                                  group["days"]
             time_by_company.append(_time_by_company)
             survival_prob_by_company.append(_survival_prob_by_company)
             ax_by_company.step(_time_by_company, _survival_prob_by_company, where='post')
```




```
In [14]: # change the pd.DataFrame index to employee ID
         df_by_employee_ID = df.set_index("employee_id", drop=True)

In [15]: df_by_employee_ID.head()
```

Out[15]:

employee_id	company_id	dept	seniority	salary	join_date	quit_date	days	censored
13021.0	7	customer_service	28	89000.0	2014-03-24	2015-10-30	585.0	True
825355.0	7	marketing	20	183000.0	2013-04-29	2014-04-04	340.0	True
927315.0	4	marketing	14	101000.0	2014-10-13	NaT	426.0	False
662910.0	7	customer_service	20	115000.0	2012-05-14	2013-06-07	389.0	True
256971.0	2	data_science	23	276000.0	2011-10-17	2014-08-22	1040.0	True

```
In [16]: # one-hot encoding of the company ID and the department
         df_by_employee_ID['company_id'] = df_by_employee_ID['company_id'].astype(str)

In [17]: dummies = pd.get_dummies(df_by_employee_ID[['company_id', 'dept']])

In [18]: df_dummied = pd.concat([dummies, df_by_employee_ID.loc[:, ['seniority', 'salary', 'day
```

In [19]:
```
# each column represents probability that employee_id is from company_id_(X)
df_dummied.head()
```

Out[19]:

employee_id	company_id_1	company_id_10	company_id_11	company_id_12	\
13021.0	0	0	0	0	
825355.0	0	0	0	0	
927315.0	0	0	0	0	
662910.0	0	0	0	0	
256971.0	0	0	0	0	

employee_id	company_id_2	company_id_3	company_id_4	company_id_5	\
13021.0	0	0	0	0	
825355.0	0	0	0	0	
927315.0	0	0	1	0	
662910.0	0	0	0	0	
256971.0	1	0	0	0	

employee_id	company_id_6	company_id_7	...	dept_customer_service	\
			...		
13021.0	0	1	...	1	
825355.0	0	1	...	0	
927315.0	0	0	...	0	
662910.0	0	1	...	1	
256971.0	0	0	...	0	

employee_id	dept_data_science	dept_design	dept_engineer	dept_marketing	\
13021.0	0	0	0	0	
825355.0	0	0	0	1	
927315.0	0	0	0	1	
662910.0	0	0	0	0	
256971.0	1	0	0	0	

employee_id	dept_sales	seniority	salary	days	censored
13021.0	0	28	89000.0	585.0	True
825355.0	0	20	183000.0	340.0	True
927315.0	0	14	101000.0	426.0	False
662910.0	0	20	115000.0	389.0	True
256971.0	0	23	276000.0	1040.0	True

[5 rows x 22 columns]

In [20]:
```
# use Cox survival analysis to fit a logistic regression
data_x = df_dummied.iloc[:, slice(None, -2)]
data_y = df_dummied.loc[:, ['censored', 'days']]
```

```
        estimator = CoxPHSurvivalAnalysis(alpha=0, n_iter=1000, tol=1e-06, verbose=0)
        estimator.fit(data_x, data_y.to_records(index=False))
```

```
/home/vladimir/anaconda3/envs/datachallenges/lib/python3.6/site-packages/sksurv/linear_model/co
Ill-conditioned matrix detected. Result is not guaranteed to be accurate.
Reciprocal condition number1.667913e-26
  overwrite_a=False, overwrite_b=False, check_finite=False)
/home/vladimir/anaconda3/envs/datachallenges/lib/python3.6/site-packages/sksurv/linear_model/co
Ill-conditioned matrix detected. Result is not guaranteed to be accurate.
Reciprocal condition number1.067659e-25
  overwrite_a=False, overwrite_b=False, check_finite=False)
/home/vladimir/anaconda3/envs/datachallenges/lib/python3.6/site-packages/sksurv/linear_model/co
Ill-conditioned matrix detected. Result is not guaranteed to be accurate.
Reciprocal condition number8.696647e-26
  overwrite_a=False, overwrite_b=False, check_finite=False)
```

```
Out[20]: CoxPHSurvivalAnalysis(alpha=0, n_iter=1000, tol=1e-06, verbose=0)
```

```
In [21]: # print out the result of fitting
         # float values are the log hazard ratio
         pd.Series(estimator.coef_, index=data_x.columns)
```

```
Out[21]: company_id_1            -0.337295
         company_id_10           -0.341651
         company_id_11           -0.129383
         company_id_12           -0.325045
         company_id_2            -0.393370
         company_id_3            -0.331348
         company_id_4            -0.319797
         company_id_5            -0.355249
         company_id_6            -0.351104
         company_id_7            -0.365287
         company_id_8            -0.344233
         company_id_9            -0.361593
         dept_customer_service    1.464326
         dept_data_science        1.507931
         dept_design              1.549541
         dept_engineer            1.480378
         dept_marketing           1.571853
         dept_sales               1.618501
         seniority                0.009686
         salary                  -0.000002
         dtype: float64
```

```
In [22]: print(
             """
             There's little difference among log hazard ratios
             by company, department, seniority or salary. None
```

```
        of the variables appear to be predictive.
        """
    )
```

```
There's little difference among log hazard ratios
by company, department, seniority or salary. None
of the variables appear to be predictive.
```