Georgiy_Yudintsev_Data_Challenge_1

February 20, 2019

```
In [300]: import pandas as pd
          import numpy as np
          import matplotlib.pyplot as plt
          %matplotlib inline
```

Read in the data frame.

```
In [301]: Empl_reten = pd.read_csv("employee_retention_data.csv")
          Empl_reten.head(5)
```

```
Out[301]:    employee_id  company_id              dept  seniority    salary   join_date  \
          0      13021.0           7  customer_service         28   89000.0  2014-03-24
          1     825355.0           7         marketing         20  183000.0  2013-04-29
          2     927315.0           4         marketing         14  101000.0  2014-10-13
          3     662910.0           7  customer_service         20  115000.0  2012-05-14
          4     256971.0           2      data_science         23  276000.0  2011-10-17

              quit_date
          0  2015-10-30
          1  2014-04-04
          2         NaN
          3  2013-06-07
          4  2014-08-22
```

The next couple commands are to create new variables for duration: durtaion of employees still working (up to '2015-12-13') and duration of employees who quit.

```
In [302]: Empl_reten['still_working'] = np.where(pd.isnull(Empl_reten['quit_date']), ['2015-12-
```

```
In [303]: Empl_reten['join_date']= pd.to_datetime(Empl_reten['join_date'])
          Empl_reten['quit_date']= pd.to_datetime(Empl_reten['quit_date'])
          Empl_reten['still_working']= pd.to_datetime(Empl_reten['still_working'])
```

```
In [304]: Empl_reten.head(5)
```

```
Out[304]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
```

```
2     927315.0           4         marketing         14  101000.0 2014-10-13
3     662910.0           7  customer_service         20  115000.0 2012-05-14
4     256971.0           2      data_science         23  276000.0 2011-10-17

   quit_date still_working
0 2015-10-30           NaT
1 2014-04-04           NaT
2        NaT    2015-12-13
3 2013-06-07           NaT
4 2014-08-22           NaT
```

Compute the duration of employment for employees who quit. Add this varibale as a new column to the existing dataframe.

```
In [305]: Empl_reten['empl_quit_duration'] = (Empl_reten['quit_date'] - Empl_reten['join_date']
```

Compute the duration of employment for employees who are still working (up to '2015-12-13'). Add this varibale as a new column to the existing dataframe.

```
In [306]: Empl_reten['still_working_duration'] = (Empl_reten['still_working'] - Empl_reten['jo
```

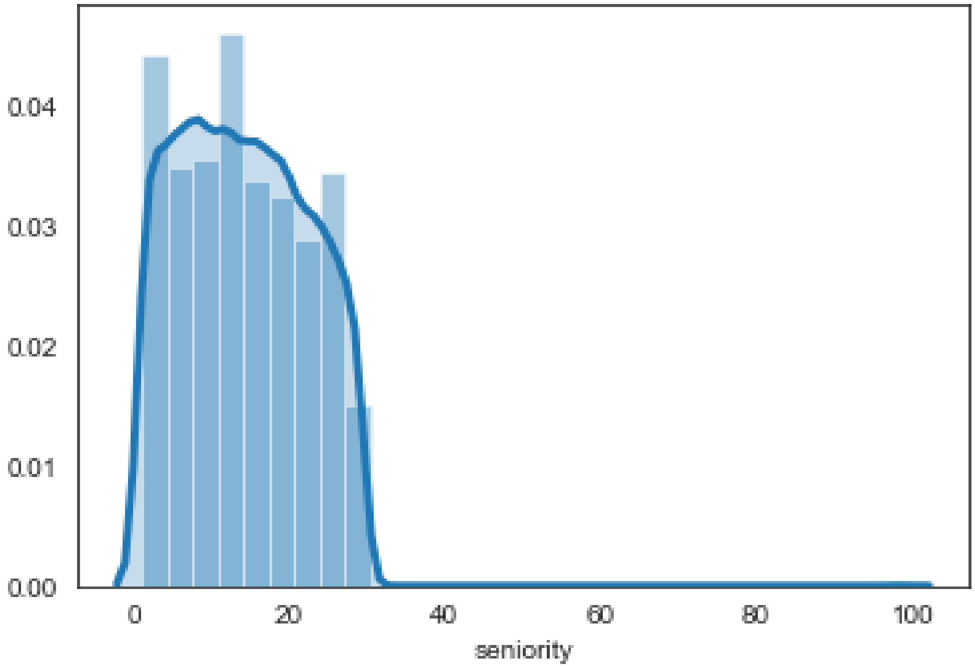
```
In [307]: Empl_reten.head(5)
```

```
Out[307]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
          2     927315.0           4         marketing         14  101000.0 2014-10-13
          3     662910.0           7  customer_service         20  115000.0 2012-05-14
          4     256971.0           2      data_science         23  276000.0 2011-10-17

             quit_date still_working empl_quit_duration still_working_duration
          0 2015-10-30           NaT           585 days                    NaT
          1 2014-04-04           NaT           340 days                    NaT
          2        NaT    2015-12-13                NaT               426 days
          3 2013-06-07           NaT           389 days                    NaT
          4 2014-08-22           NaT          1040 days                    NaT
```

Exploratory data analysis. Look at the distribution of seniority.

```
In [308]: import seaborn as sns

          sns.distplot(Empl_reten['seniority'], hist = True, kde = True, bins = 30,
                       kde_kws = {'shade': True, 'linewidth': 3})
```

```
Out[308]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1d4bc978>
```



```
In [309]: Empl_reten['seniority'].describe()

Out[309]: count    24702.000000
          mean        14.127803
          std          8.089520
          min          1.000000
          25%          7.000000
          50%         14.000000
          75%         21.000000
          max         99.000000
          Name: seniority, dtype: float64
```

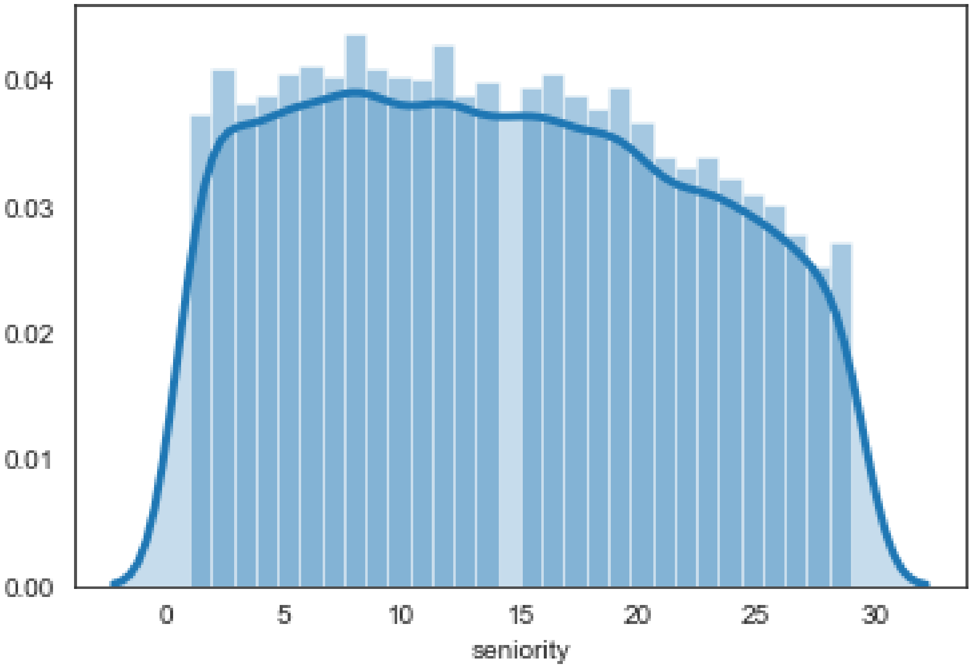
There appear to be some outliers - possibly data entry mistakes. It is highly unlikely that someone worked for 99 years prior to their new employment. Let's remove the outliers after calculating z-scores.

There are some outliers in this dataset - as it is highly unlikely someone worked for 99 years before getting hired for their current position. Need to get rid of the outliers.

```
In [310]: from scipy import stats

          z = np.abs(stats.zscore(Empl_reten['seniority']))
          Empl_reten['seniority_z_score'] = z
          Empl_reten = Empl_reten[Empl_reten['seniority_z_score'] < 4]
```

Seniority plot without outliers.

```
In [311]: sns.distplot(Empl_reten['seniority'], hist = True, kde = True, bins = 30,
                       kde_kws = {'shade': True, 'linewidth': 3})

Out[311]: <matplotlib.axes._subplots.AxesSubplot at 0x1a434a80b8>
```



Try removing rows with NaN values for employess who quit. Create a new data frame.

```
In [312]: empl_quit = Empl_reten.copy()

In [313]: empl_quit.head()

Out[313]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
          2     927315.0           4         marketing         14  101000.0 2014-10-13
          3     662910.0           7  customer_service         20  115000.0 2012-05-14
          4     256971.0           2      data_science         23  276000.0 2011-10-17

             quit_date still_working empl_quit_duration still_working_duration  \
          0 2015-10-30           NaT           585 days                    NaT
          1 2014-04-04           NaT           340 days                    NaT
          2        NaT    2015-12-13                NaT               426 days
          3 2013-06-07           NaT           389 days                    NaT
          4 2014-08-22           NaT          1040 days                    NaT

             seniority_z_score
```

```
         0          1.714870
         1          0.725916
         2          0.015799
         3          0.725916
         4          1.096774
```

```
In [314]: empl_quit = empl_quit.drop(labels = ['still_working', 'still_working_duration'], axi
```

```
In [315]: empl_quit.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 24700 entries, 0 to 24699
Data columns (total 9 columns):
employee_id            24700 non-null float64
company_id             24700 non-null int64
dept                   24700 non-null object
seniority              24700 non-null int64
salary                 24700 non-null float64
join_date              24700 non-null datetime64[ns]
quit_date              13508 non-null datetime64[ns]
empl_quit_duration     13508 non-null timedelta64[ns]
seniority_z_score      24700 non-null float64
dtypes: datetime64[ns](2), float64(3), int64(2), object(1), timedelta64[ns](1)
memory usage: 1.9+ MB
```

```
In [316]: empl_quit_no_na = empl_quit.dropna()
```

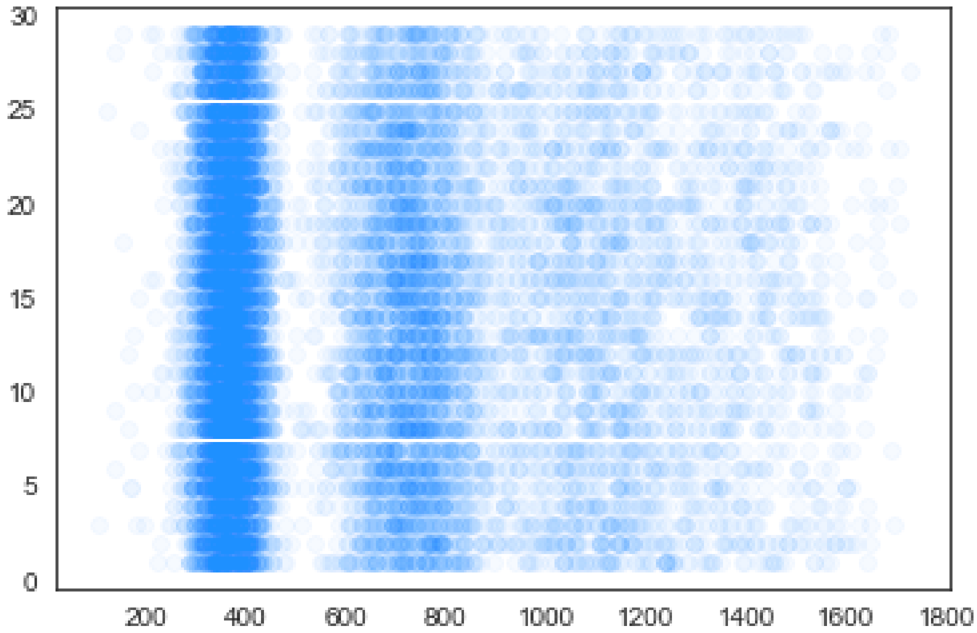
```
In [317]: empl_quit_no_na.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 13508 entries, 0 to 24699
Data columns (total 9 columns):
employee_id            13508 non-null float64
company_id             13508 non-null int64
dept                   13508 non-null object
seniority              13508 non-null int64
salary                 13508 non-null float64
join_date              13508 non-null datetime64[ns]
quit_date              13508 non-null datetime64[ns]
empl_quit_duration     13508 non-null timedelta64[ns]
seniority_z_score      13508 non-null float64
dtypes: datetime64[ns](2), float64(3), int64(2), object(1), timedelta64[ns](1)
memory usage: 1.0+ MB
```

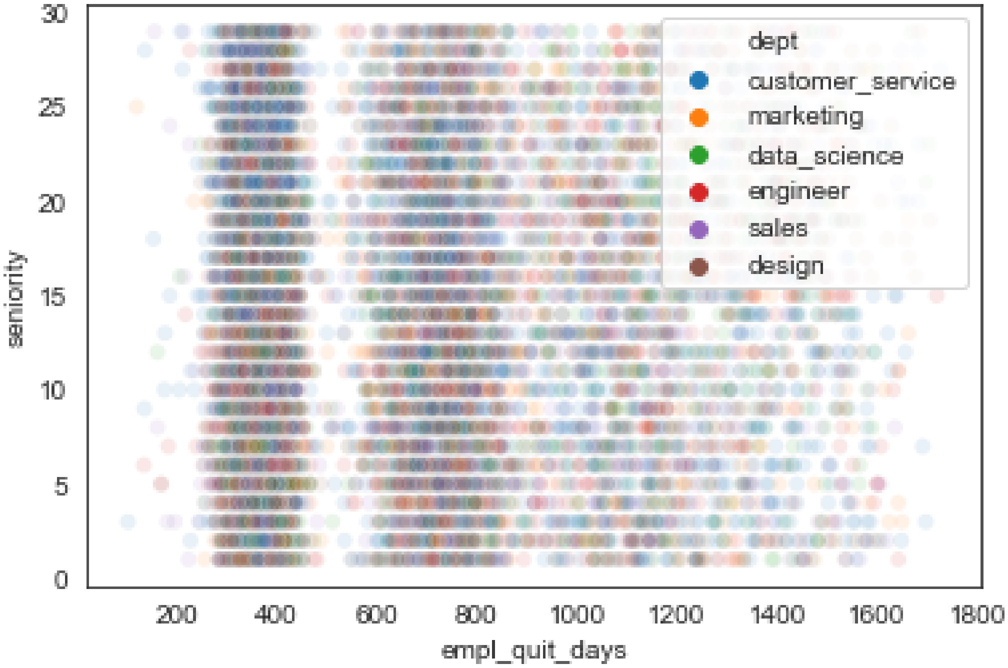
```
In [325]: empl_quit_no_na['empl_quit_days'] = empl_quit_no_na['empl_quit_duration'].astype('ti
          empl_quit_no_na['empl_quit_days'] = empl_quit_no_na['empl_quit_days'].astype(int)
```

```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:1: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:2: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

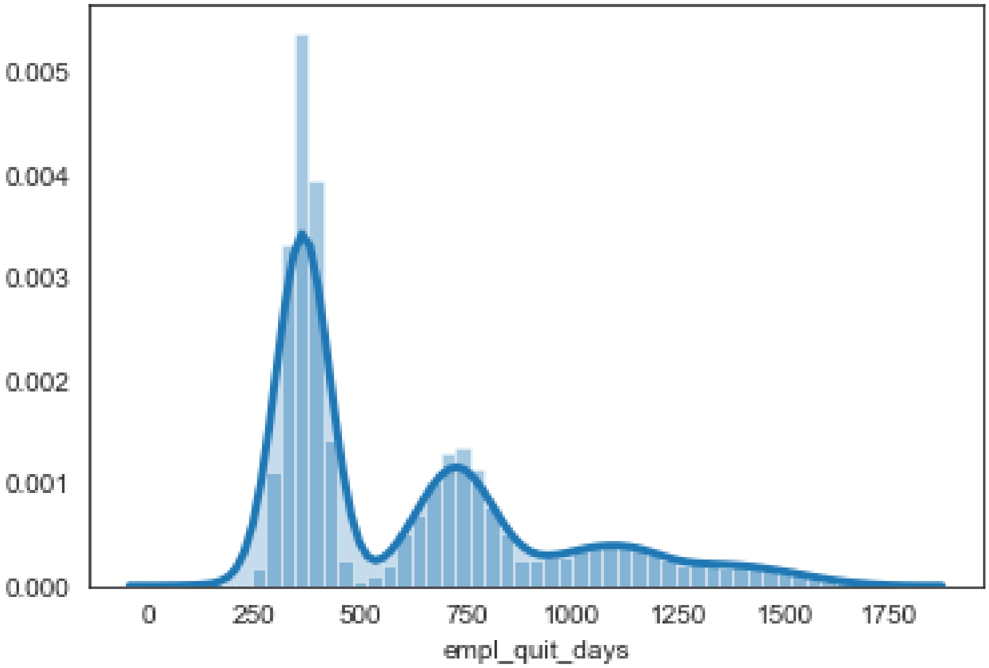
```
In [326]: plt.scatter(empl_quit_no_na['empl_quit_days'], empl_quit_no_na['seniority'],
                      color = 'dodgerblue', alpha = 0.04)
          plt.show() # Depending on whether you use IPython or interactive mode, etc.
```



```
In [327]: sns.scatterplot(empl_quit_no_na['empl_quit_days'],
                          empl_quit_no_na['seniority'], hue = empl_quit_no_na['dept'], alpha =

Out[327]: <matplotlib.axes._subplots.AxesSubplot at 0x1a42d25a20>
```



```
In [156]: sns.distplot(empl_quit_no_na['empl_quit_days'], hist = True, kde = True,
                       kde_kws = {'shade': True, 'linewidth': 3})

/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/scipy/stats/stats.py:1713: Fu
  return np.add.reduce(sorted[indexer] * weights, axis=axis) / sumval


Out[156]: <matplotlib.axes._subplots.AxesSubplot at 0x1a191f0f60>
```



It seems like there are three groups - maybe four. One group tends to leave after about a year (~375 days), a second group leaves after about 2 years (750 days), and a third group works for roughly 3 years (maybe ~1100 days). Then there is a fourth group that leaves maybe after 4 years or so (~1400 days).

Try removing rows with NaN values for employess who didn't quit. Create a new data frame.

```
In [328]: empl_still_working = Empl_reten.copy()
```

```
In [329]: empl_still_working = empl_still_working.drop(labels = ['quit_date', 'empl_quit_durat
```

```
In [330]: empl_still_working.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 24700 entries, 0 to 24699
Data columns (total 9 columns):
employee_id                24700 non-null float64
company_id                 24700 non-null int64
dept                       24700 non-null object
seniority                  24700 non-null int64
salary                     24700 non-null float64
join_date                  24700 non-null datetime64[ns]
still_working              11192 non-null datetime64[ns]
still_working_duration     11192 non-null timedelta64[ns]
seniority_z_score          24700 non-null float64
dtypes: datetime64[ns](2), float64(3), int64(2), object(1), timedelta64[ns](1)
memory usage: 1.9+ MB
```

```
In [331]: empl_still_working_no_na = empl_still_working.dropna()
```

```
In [332]: empl_still_working_no_na.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 11192 entries, 2 to 24698
Data columns (total 9 columns):
employee_id                11192 non-null float64
company_id                 11192 non-null int64
dept                       11192 non-null object
seniority                  11192 non-null int64
salary                     11192 non-null float64
join_date                  11192 non-null datetime64[ns]
still_working              11192 non-null datetime64[ns]
still_working_duration     11192 non-null timedelta64[ns]
seniority_z_score          11192 non-null float64
dtypes: datetime64[ns](2), float64(3), int64(2), object(1), timedelta64[ns](1)
memory usage: 874.4+ KB
```

```
In [333]: empl_still_working_no_na['empl_still_working_days'] = empl_still_working_no_na['stil
```

```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:1: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
```

```
In [334]: empl_still_working_no_na['empl_still_working_days'] = empl_still_working_no_na['empl_
```

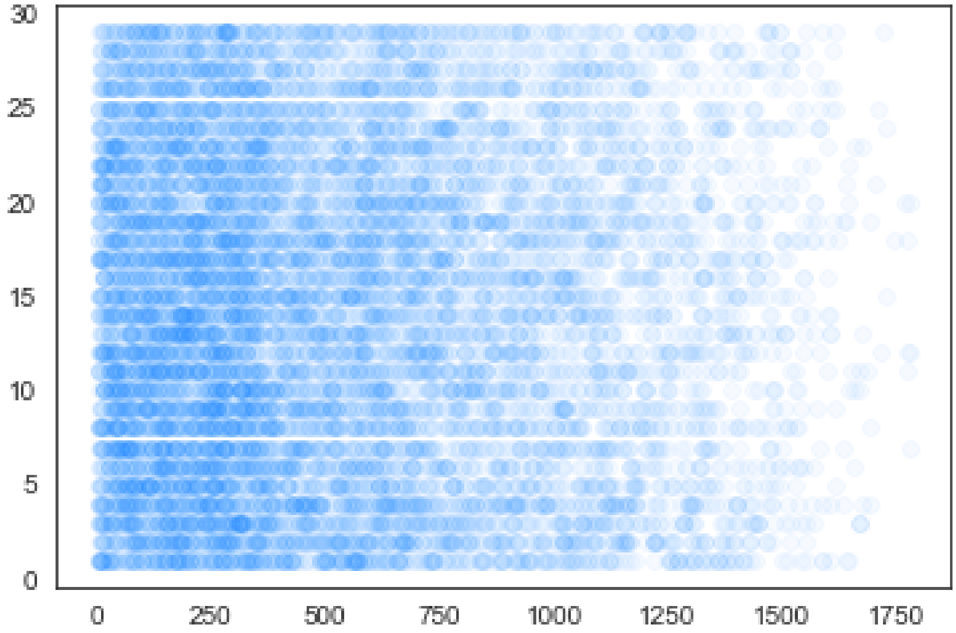
```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:1: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
```

```
In [335]: empl_still_working_no_na.info()
```

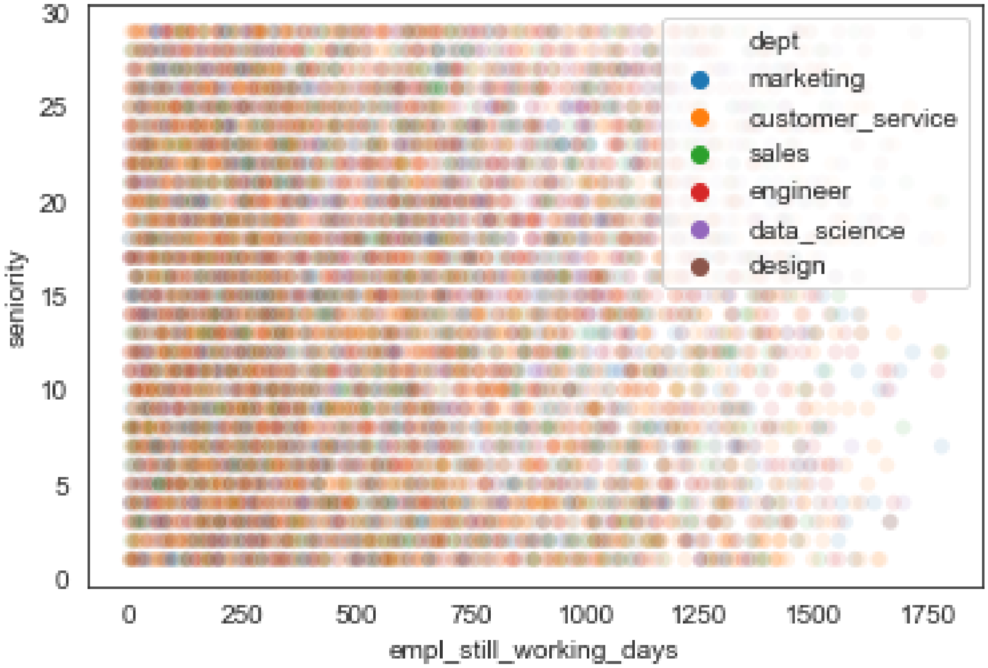
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 11192 entries, 2 to 24698
Data columns (total 10 columns):
employee_id                 11192 non-null float64
company_id                  11192 non-null int64
dept                        11192 non-null object
seniority                   11192 non-null int64
```

```
salary                     11192 non-null float64
join_date                  11192 non-null datetime64[ns]
still_working              11192 non-null datetime64[ns]
still_working_duration     11192 non-null timedelta64[ns]
seniority_z_score          11192 non-null float64
empl_still_working_days    11192 non-null int64
dtypes: datetime64[ns](2), float64(3), int64(3), object(1), timedelta64[ns](1)
memory usage: 961.8+ KB
```

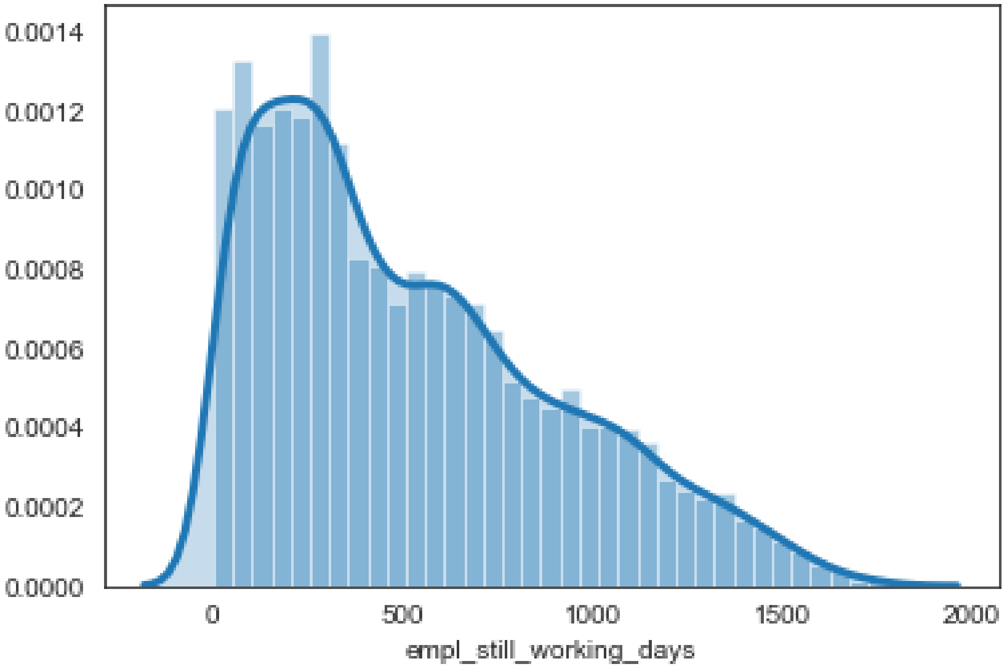
```
In [336]: plt.scatter(empl_still_working_no_na['empl_still_working_days'], empl_still_working_n
                      color = 'dodgerblue', alpha = 0.04)
          plt.show() # Depending on whether you use IPython or interactive mode, etc.
```



```
In [337]: sns.scatterplot(empl_still_working_no_na['empl_still_working_days'],
                          empl_still_working_no_na['seniority'], hue = empl_still_working_no_na

Out[337]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1d48edd8>
```

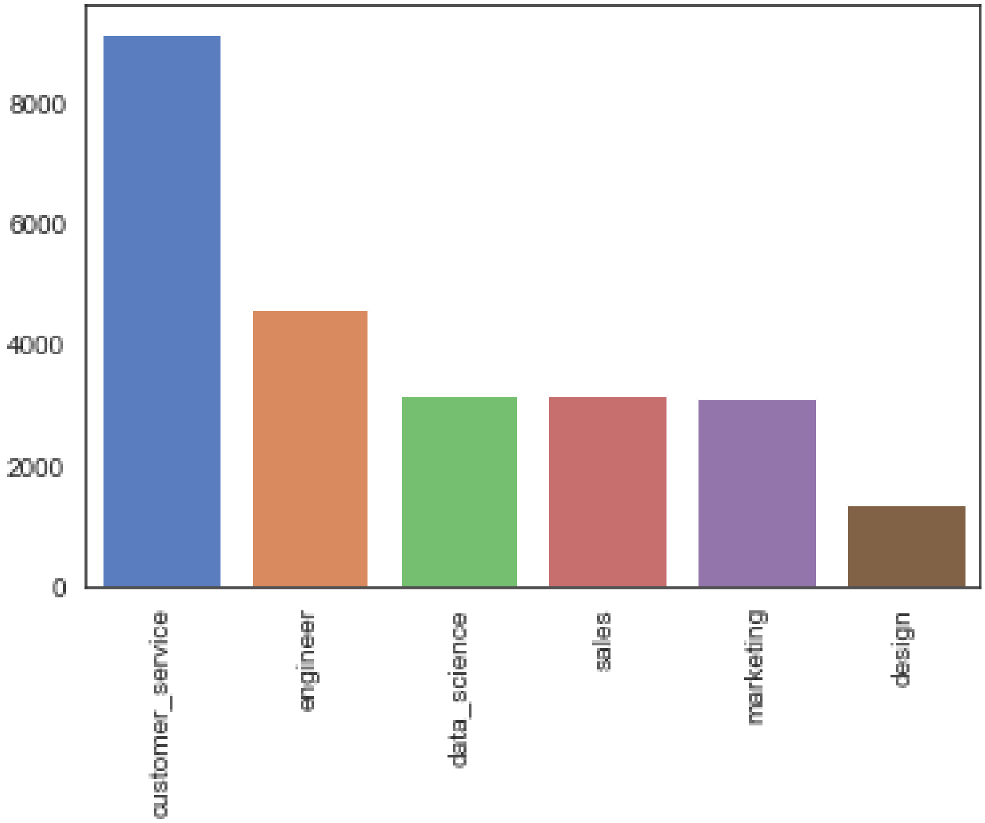


```
In [338]: sns.distplot(empl_still_working_no_na['empl_still_working_days'], hist = True, kde =
                          kde_kws = {'shade': True, 'linewidth': 3})

/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/scipy/stats/stats.py:1713: Fu
  return np.add.reduce(sorted[indexer] * weights, axis=axis) / sumval


Out[338]: <matplotlib.axes._subplots.AxesSubplot at 0x1a43cf0e80>
```



Look at the number of employees withing each department (customer_service, engineering, etc.)

```
In [339]: Empl_reten['dept'].value_counts()

Out[339]: customer_service    9180
          engineer            4612
          data_science        3190
          sales               3172
          marketing           3166
          design              1380
          Name: dept, dtype: int64

In [340]: sns.set_style("white")
          sns.barplot(x = Empl_reten['dept'].value_counts().index,
                      y = Empl_reten['dept'].value_counts().values,
                      palette='muted', errcolor='dimgray')

          plt.xticks(rotation=90) # rotates the labesl on the x-axis.

Out[340]: (array([0, 1, 2, 3, 4, 5]), <a list of 6 Text xticklabel objects>)
```



Sanity check: see if there are any missing values (NaN) in the data frame that includes employees who're still working.

```
In [341]: empl_still_working_no_na.isna().sum()
```

```
Out[341]: employee_id                 0
          company_id                  0
          dept                        0
          seniority                   0
          salary                      0
          join_date                   0
          still_working               0
          still_working_duration      0
          seniority_z_score           0
          empl_still_working_days     0
          dtype: int64
```

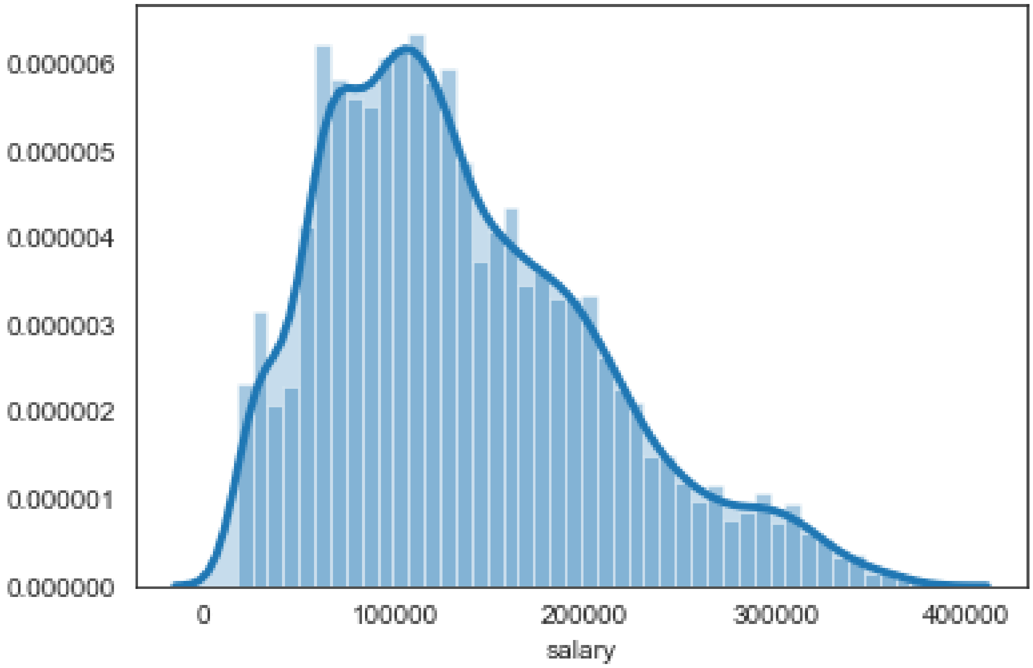
Sanity check: see if there are any missing values (NaN) in the data frame that includes employees who quit.

```
In [161]: empl_quit_no_na.isna().sum()
```

```
Out[161]: employee_id          0
          company_id           0
          dept                 0
          seniority            0
          salary               0
          join_date            0
          quit_date            0
          empl_quit_duration   0
          seniority_z_score    0
          empl_quit_days       0
          dtype: int64
```

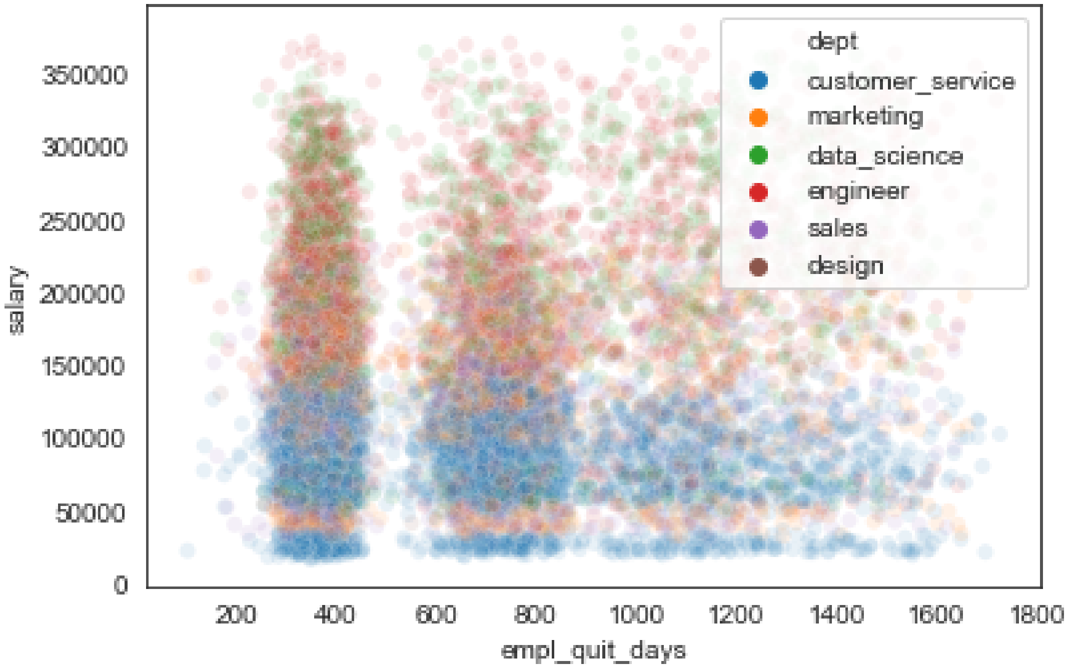
```
In [342]: sns.distplot(Empl_reten_no_na_no_out['salary'], hist = True, kde = True,
                       kde_kws = {'shade': True, 'linewidth': 3})
```

```
Out[342]: <matplotlib.axes._subplots.AxesSubplot at 0x1a442a3f28>
```



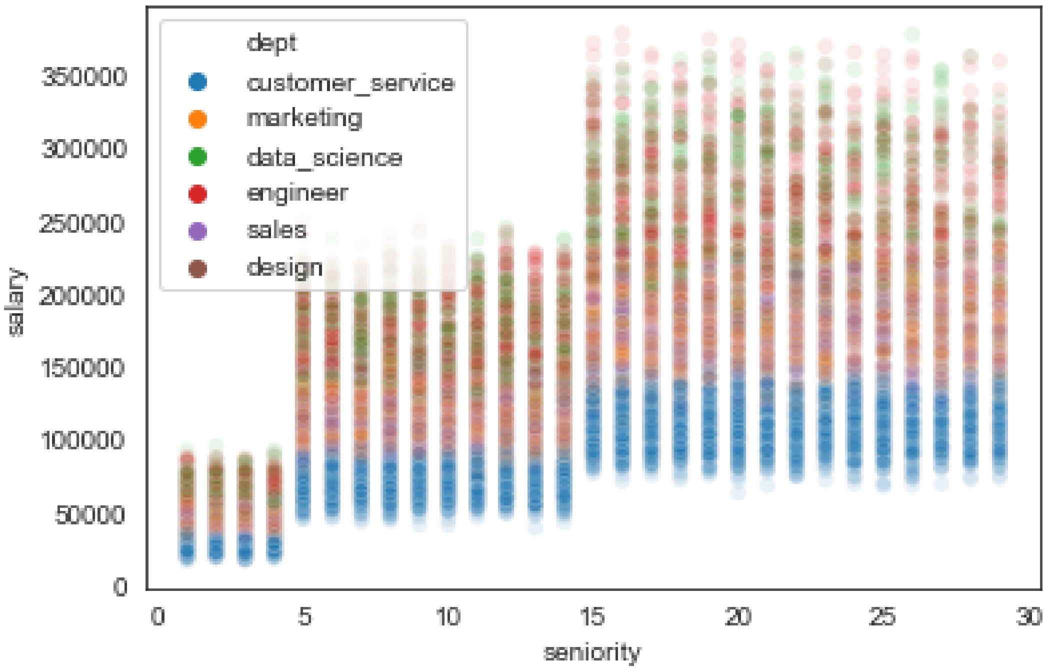
```
In [343]: sns.scatterplot(empl_quit_no_na['empl_quit_days'],
                          empl_quit_no_na['salary'], hue = empl_quit_no_na['dept'], alpha = 0.
```

```
Out[343]: <matplotlib.axes._subplots.AxesSubplot at 0x1a443c3a20>
```



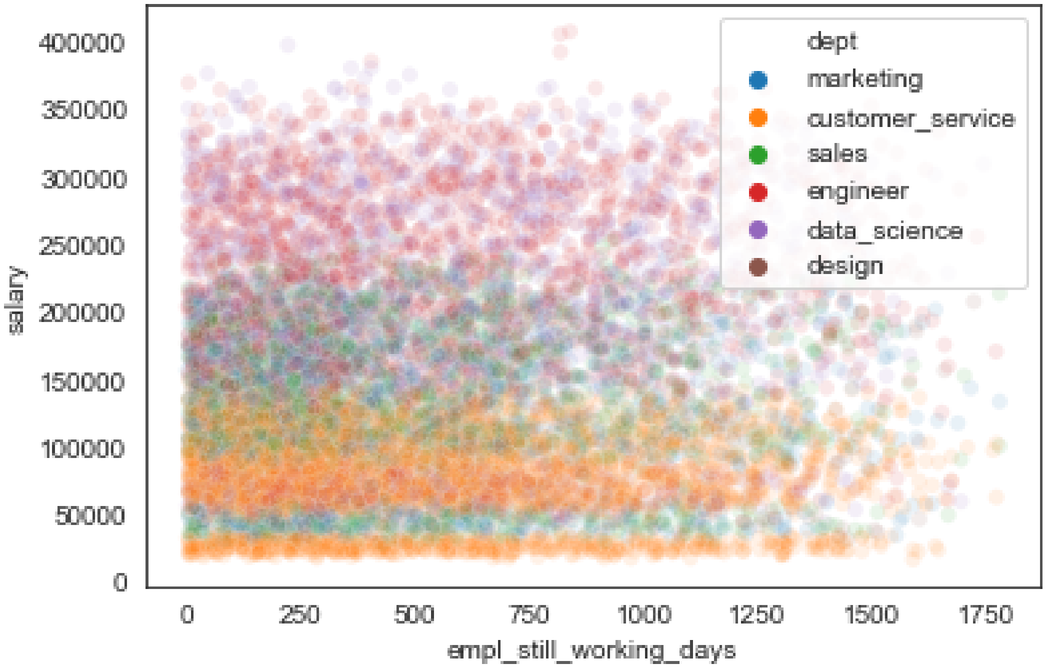
It looks like the average salary may stay to be about the same regardless of how long you've worked at a company. Break down the employment duration in categories, and see if the means for the categories are different.

```
In [344]: sns.scatterplot(empl_quit_no_na['seniority'],
                          empl_quit_no_na['salary'], hue = empl_quit_no_na['dept'], alpha = 0.

Out[344]: <matplotlib.axes._subplots.AxesSubplot at 0x1a44611240>
```

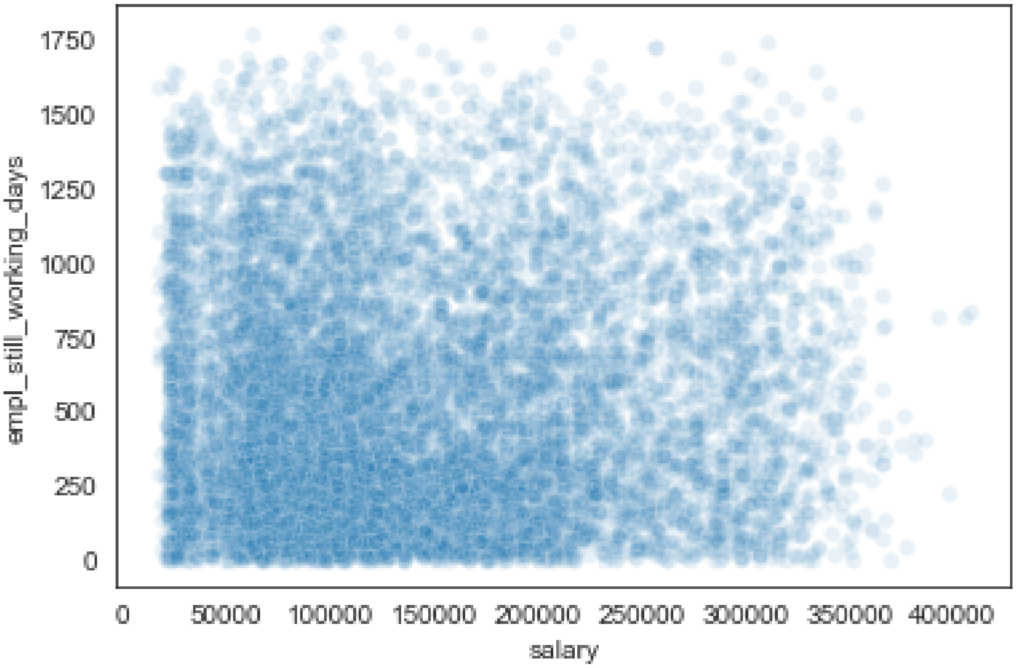


```
In [345]: sns.scatterplot(empl_still_working_no_na['empl_still_working_days'],
                          empl_still_working_no_na['salary'], hue = empl_still_working_no_na['
```

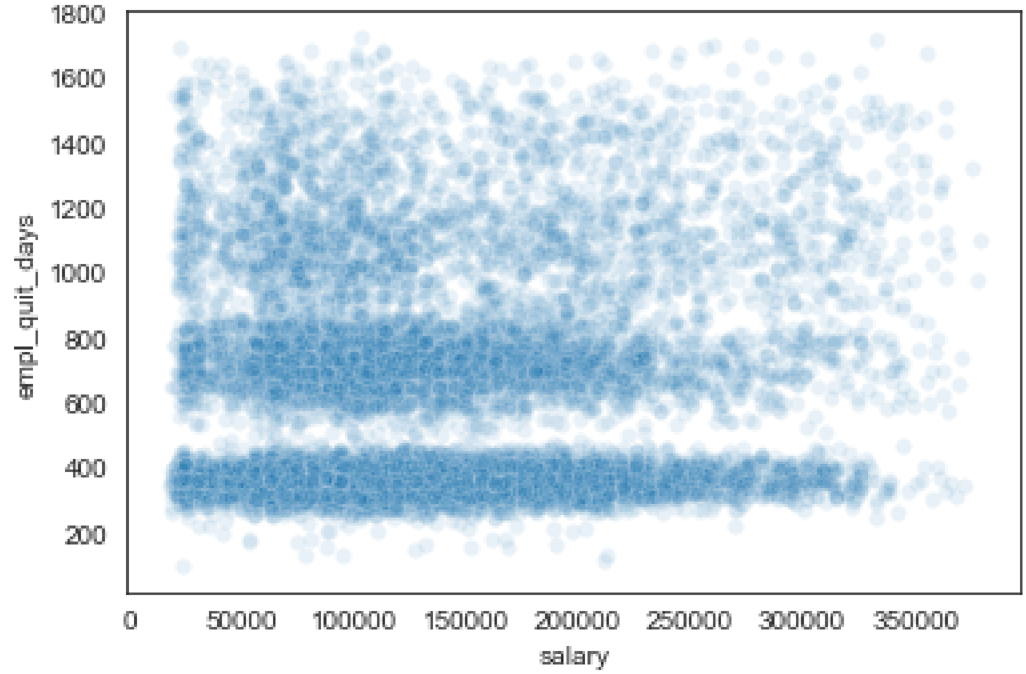
```
Out[345]: <matplotlib.axes._subplots.AxesSubplot at 0x1a4465aeb8>
```



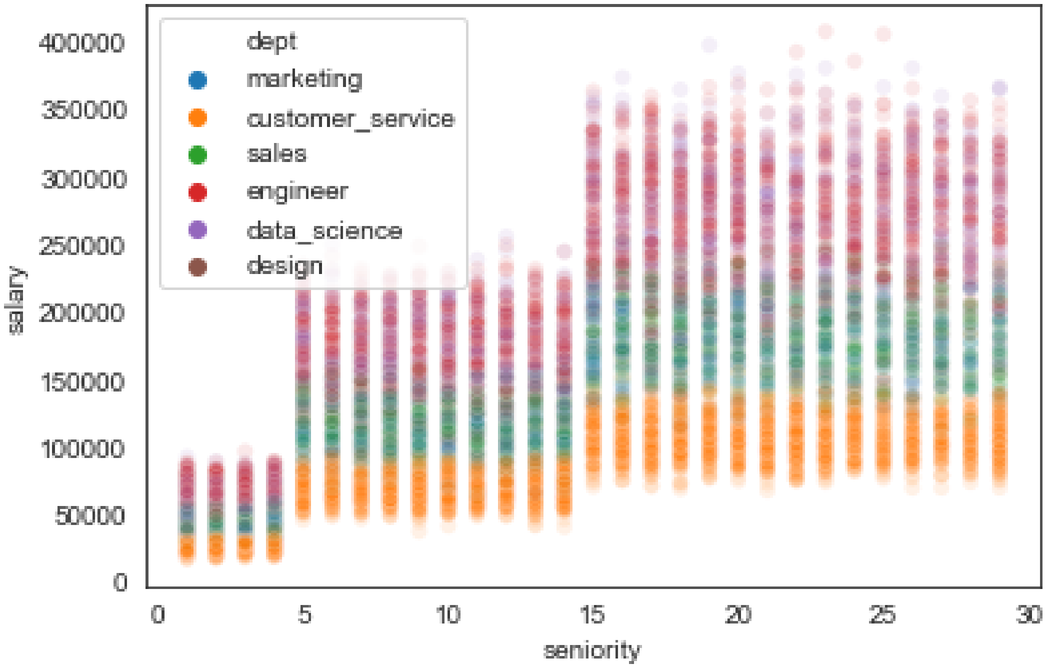
```
In [346]: sns.scatterplot(empl_still_working_no_na['salary'],
                          empl_still_working_no_na['empl_still_working_days'], alpha = 0.1)

Out[346]: <matplotlib.axes._subplots.AxesSubplot at 0x1a448b5a58>
```



```
In [347]: sns.scatterplot(empl_quit_no_na['salary'],
                          empl_quit_no_na['empl_quit_days'], alpha = 0.1)

Out[347]: <matplotlib.axes._subplots.AxesSubplot at 0x1a44a65b70>
```



```
In [348]: sns.scatterplot(empl_still_working_no_na['seniority'],
                          empl_still_working_no_na['salary'], hue = empl_still_working_no_na['d

Out[348]: <matplotlib.axes._subplots.AxesSubplot at 0x1a44483c88>
```



Let's look at any linear relationships between salary and duration of employment. Do salary increases increase employment duration?

```
In [349]: empl_quit_SLR_df = empl_quit_no_na[['salary', 'empl_quit_days']]

In [350]: X = empl_quit_SLR_df['salary']
          y = empl_quit_SLR_df['empl_quit_days']

          X = X.values
          y = y.values

In [351]: from sklearn.model_selection import train_test_split

          X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_stat

          X_train = X_train.reshape(-1, 1)
          X_test = X_test.reshape(-1, 1)

In [352]: from sklearn.linear_model import LinearRegression
          Model_1 = LinearRegression()
          Model_1.fit(X_train, y_train)

Out[352]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None,
                   normalize=False)

In [353]: y_pred_1 = Model_1.predict(X_test)

In [354]: from sklearn.metrics import r2_score

In [355]: r2 = r2_score(y_test, y_pred_1)
          r2

Out[355]: 0.006936262289984452

In [356]: empl_still_working_SLR_df = empl_still_working_no_na[['salary', 'empl_still_working_

In [357]: X_2 = empl_still_working_SLR_df['salary']
          y_2 = empl_still_working_SLR_df['empl_still_working_days']

          X_2 = X_2.values
          y_2 = y_2.values

In [358]: X_2_train, X_2_test, y_2_train, y_2_test = train_test_split(X_2, y_2, test_size=0.2,

          X_2_train = X_2_train.reshape(-1, 1)
          X_2_test = X_2_test.reshape(-1, 1)

In [359]: Model_2 = LinearRegression()
          Model_2.fit(X_2_train, y_2_train)
```

```
Out[359]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None,
                   normalize=False)
```

```
In [360]: y_pred_2 = Model_2.predict(X_2_test)
```

```
In [361]: r2_2 = r2_score(y_2_test, y_pred_2)
          r2_2
```

```
Out[361]: 0.001342894018013463
```

Need to normalize response variables - that could explain poor model fit.

```
In [362]: empl_quit_no_na['log_salary'] = empl_quit_no_na['salary'].apply(np.log)
```

```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:1: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
```

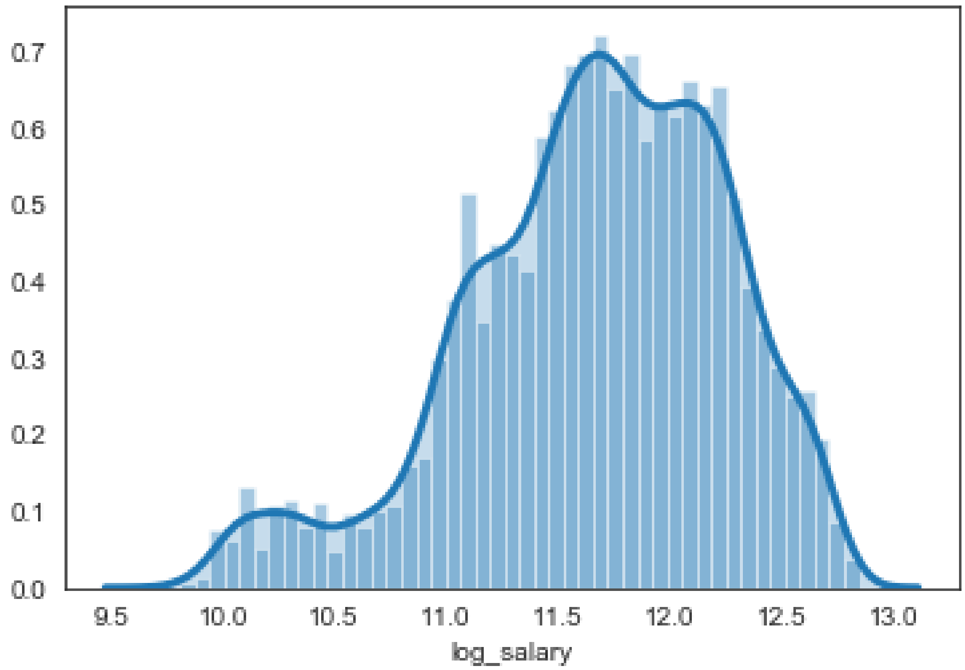
```
In [363]: empl_still_working_no_na['log_salary'] = empl_still_working_no_na['salary'].apply(np
```

```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/ipykernel_launcher.py:1: Set
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
```

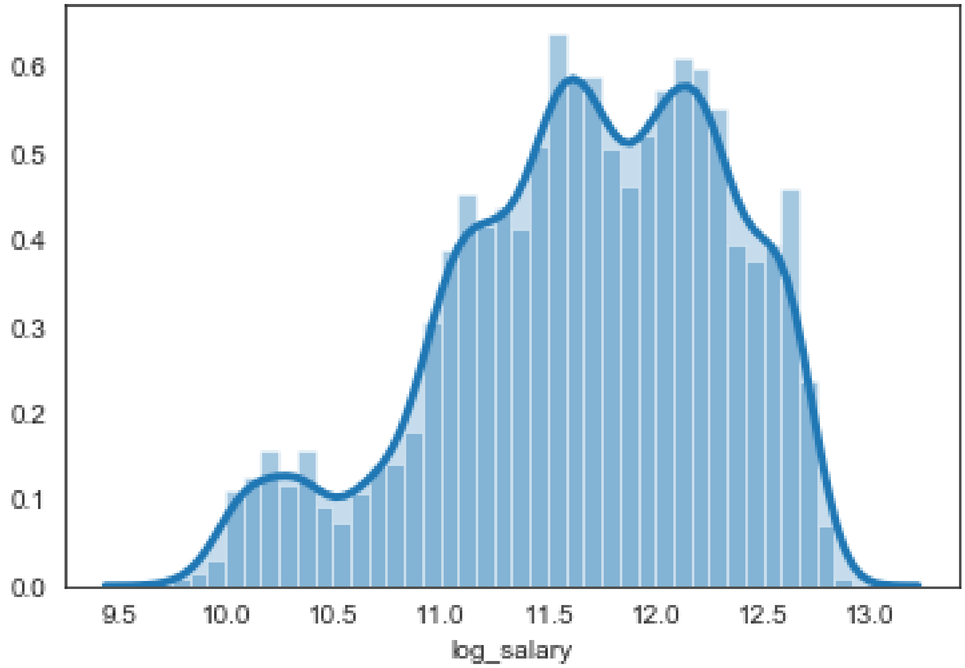
```
In [364]: sns.distplot(empl_quit_no_na['log_salary'], hist = True, kde = True,
                       kde_kws = {'shade': True, 'linewidth': 3})
```

```
/Users/Georgiy/anaconda3/envs/insight/lib/python3.7/site-packages/scipy/stats/stats.py:1713: Fu
  return np.add.reduce(sorted[indexer] * weights, axis=axis) / sumval
```

```
Out[364]: <matplotlib.axes._subplots.AxesSubplot at 0x1a44c48358>
```



```
In [365]: sns.distplot(empl_still_working_no_na['log_salary'], hist = True, kde = True,
                       kde_kws = {'shade': True, 'linewidth': 3})

Out[365]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1b4edc18>
```



```
In [366]: Empl_reten.info()

<class 'pandas.core.frame.DataFrame'>
Int64Index: 24700 entries, 0 to 24699
Data columns (total 12 columns):
employee_id               24700 non-null float64
company_id                24700 non-null int64
dept                      24700 non-null object
seniority                 24700 non-null int64
salary                    24700 non-null float64
join_date                 24700 non-null datetime64[ns]
quit_date                 13508 non-null datetime64[ns]
still_working             11192 non-null datetime64[ns]
empl_quit_duration        13508 non-null timedelta64[ns]
still_working_duration    11192 non-null timedelta64[ns]
seniority_z_score         24700 non-null float64
empl_quit_days            13508 non-null float64
dtypes: datetime64[ns](3), float64(4), int64(2), object(1), timedelta64[ns](2)
memory usage: 2.4+ MB
```

```
In [367]: Empl_reten['empl_still_working_days'] = Empl_reten['still_working_duration'].astype(

In [368]: Empl_reten['empl_still_working_days'] = Empl_reten['empl_still_working_days'].fillna

In [369]: Empl_reten.head(10)
```

```
Out[369]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
          2     927315.0           4         marketing         14  101000.0 2014-10-13
          3     662910.0           7  customer_service         20  115000.0 2012-05-14
          4     256971.0           2      data_science         23  276000.0 2011-10-17
          5     509529.0           4      data_science         14  165000.0 2012-01-30
          6      88600.0           4  customer_service         21  107000.0 2013-10-21
          7     716309.0           2  customer_service          4   30000.0 2014-03-05
          8     172999.0           9          engineer          7  160000.0 2012-12-10
          9     504159.0           1             sales          7  104000.0 2012-06-12

             quit_date still_working empl_quit_duration still_working_duration  \
          0 2015-10-30           NaT           585 days                    NaT
          1 2014-04-04           NaT           340 days                    NaT
          2        NaT    2015-12-13                NaT               426 days
          3 2013-06-07           NaT           389 days                    NaT
          4 2014-08-22           NaT          1040 days                    NaT
          5 2013-08-30           NaT           578 days                    NaT
```

```
6        NaT    2015-12-13               NaT             783 days
7        NaT    2015-12-13               NaT             648 days
8 2015-10-23           NaT         1047 days                  NaT
9        NaT    2015-12-13               NaT            1279 days

   seniority_z_score  empl_quit_days empl_still_working_days
0           1.714870           585.0                   False
1           0.725916           340.0                   False
2           0.015799             NaN                     426
3           0.725916           389.0                   False
4           1.096774          1040.0                   False
5           0.015799           578.0                   False
6           0.849536             NaN                     783
7           1.251991             NaN                     648
8           0.881134          1047.0                   False
9           0.881134             NaN                    1279
```

```
In [370]: Empl_reten['quit_date'] = Empl_reten['quit_date'].fillna(value = False)

In [371]: Empl_reten['still_working'] = Empl_reten['still_working'].fillna(value = False)

In [372]: Empl_reten['empl_quit_duration'] = Empl_reten['empl_quit_duration'].fillna(value = Fa

In [373]: Empl_reten['still_working_duration'] = Empl_reten['still_working_duration'].fillna(va

In [374]: Empl_reten['empl_quit_days'] = Empl_reten['empl_quit_days'].fillna(value = False)

In [375]: Empl_reten.head(10)
```

```
Out[375]:    employee_id  company_id             dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
          2     927315.0           4         marketing         14  101000.0 2014-10-13
          3     662910.0           7  customer_service         20  115000.0 2012-05-14
          4     256971.0           2      data_science         23  276000.0 2011-10-17
          5     509529.0           4      data_science         14  165000.0 2012-01-30
          6      88600.0           4  customer_service         21  107000.0 2013-10-21
          7     716309.0           2  customer_service          4   30000.0 2014-03-05
          8     172999.0           9          engineer          7  160000.0 2012-12-10
          9     504159.0           1             sales          7  104000.0 2012-06-12

                       quit_date        still_working  empl_quit_duration  \
          0  2015-10-30 00:00:00                False    585 days 00:00:00
          1  2014-04-04 00:00:00                False    340 days 00:00:00
          2                False  2015-12-13 00:00:00                False
          3  2013-06-07 00:00:00                False    389 days 00:00:00
          4  2014-08-22 00:00:00                False   1040 days 00:00:00
          5  2013-08-30 00:00:00                False    578 days 00:00:00
          6                False  2015-12-13 00:00:00                False
          7                False  2015-12-13 00:00:00               False
          8  2015-10-23 00:00:00                False  1047 days 00:00:00
          9                False  2015-12-13 00:00:00               False

            still_working_duration  seniority_z_score empl_quit_days  \
          0                  False           1.714870            585
          1                  False           0.725916            340
          2      426 days 00:00:00           0.015799          False
          3                  False           0.725916            389
          4                  False           1.096774           1040
          5                  False           0.015799            578
          6      783 days 00:00:00           0.849536          False
          7      648 days 00:00:00           1.251991          False
          8                  False           0.881134           1047
          9     1279 days 00:00:00           0.881134          False

            empl_still_working_days
          0                   False
          1                   False
          2                     426
          3                   False
          4                   False
          5                   False
          6                     783
          7                     648
          8                   False
          9                    1279
```

```
In [376]: Empl_reten = Empl_reten.drop(labels = ['empl_quit_duration', 'still_working_duration
```

```
In [377]: Empl_reten.head(10)
```

```
Out[377]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28    89000.0 2014-03-24
          1     825355.0           7         marketing         20   183000.0 2013-04-29
          2     927315.0           4         marketing         14   101000.0 2014-10-13
          3     662910.0           7  customer_service         20   115000.0 2012-05-14
          4     256971.0           2      data_science         23   276000.0 2011-10-17
          5     509529.0           4      data_science         14   165000.0 2012-01-30
          6      88600.0           4  customer_service         21   107000.0 2013-10-21
          7     716309.0           2  customer_service          4    30000.0 2014-03-05
          8     172999.0           9          engineer          7   160000.0 2012-12-10
          9     504159.0           1             sales          7   104000.0 2012-06-12

                       quit_date        still_working  seniority_z_score empl_quit_days  \
          0  2015-10-30 00:00:00                False           1.714870            585
          1  2014-04-04 00:00:00                False           0.725916            340
          2                False  2015-12-13 00:00:00           0.015799          False
```

```
3  2013-06-07 00:00:00                False         0.725916           389
4  2014-08-22 00:00:00                False         1.096774          1040
5  2013-08-30 00:00:00                False         0.015799           578
6                False  2015-12-13 00:00:00         0.849536         False
7                False  2015-12-13 00:00:00         1.251991         False
8  2015-10-23 00:00:00                False         0.881134          1047
9                False  2015-12-13 00:00:00         0.881134         False

  empl_still_working_days
0                   False
1                   False
2                     426
3                   False
4                   False
5                   False
6                     783
7                     648
8                   False
9                    1279
```

```
In [378]: Empl_reten['Class_quit'] = Empl_reten['empl_still_working_days'] == False

In [379]: Empl_reten['Class_quit'] = Empl_reten['Class_quit'].astype(int)
```

Create dummy variables for different departments

```
In [380]: Empl_reten = pd.get_dummies(Empl_reten, prefix = ['dept_dummy'], columns = ['dept'],

In [381]: Empl_reten.head()

Out[381]:    employee_id  company_id  seniority    salary  join_date  \
          0      13021.0           7         28   89000.0 2014-03-24
          1     825355.0           7         20  183000.0 2013-04-29
          2     927315.0           4         14  101000.0 2014-10-13
          3     662910.0           7         20  115000.0 2012-05-14
          4     256971.0           2         23  276000.0 2011-10-17

                       quit_date        still_working  seniority_z_score empl_quit_days  \
          0  2015-10-30 00:00:00                False         1.714870           585
          1  2014-04-04 00:00:00                False         0.725916           340
          2                False  2015-12-13 00:00:00         0.015799         False
          3  2013-06-07 00:00:00                False         0.725916           389
          4  2014-08-22 00:00:00                False         1.096774          1040

            empl_still_working_days  Class_quit  dept_dummy_data_science  \
          0                   False           1                        0
          1                   False           1                        0
          2                     426           0                        0
          3                   False           1                        0
```

```
4                   False           1                        1

   dept_dummy_design  dept_dummy_engineer  dept_dummy_marketing  \
0                  0                    0                     0
1                  0                    0                     1
2                  0                    0                     1
3                  0                    0                     0
4                  0                    0                     0

   dept_dummy_sales
0                 0
1                 0
2                 0
3                 0
4                 0
```

```
In [391]: X_rf = Empl_reten[['seniority', 'salary', 'company_id', 'dept_dummy_data_science', 'd
                             'dept_dummy_engineer', 'dept_dummy_marketing', 'dept_dummy_sales']]
          y_rf = Empl_reten['Class_quit']
```

```
In [392]: from sklearn.ensemble import RandomForestClassifier
```

```
In [393]: rf = RandomForestClassifier(n_estimators = 1000, random_state = 42)
```

```
In [394]: X_rf_train, X_rf_test, y_rf_train, y_rf_test = train_test_split(X_rf, y_rf, test_size
```

```
In [395]: rf.fit(X_rf_train, y_rf_train)
```

```
Out[395]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                      max_depth=None, max_features='auto', max_leaf_nodes=None,
                      min_impurity_decrease=0.0, min_impurity_split=None,
                      min_samples_leaf=1, min_samples_split=2,
                      min_weight_fraction_leaf=0.0, n_estimators=1000, n_jobs=None,
                      oob_score=False, random_state=42, verbose=0, warm_start=False)
```

```
In [396]: predictions_rf = rf.predict(X_rf_test)
```

```
In [397]: errors = abs(predictions_rf - y_rf_test)
```

```
In [398]: print('Mean Absolute Error:', round(np.mean(errors), 2))
```

```
Mean Absolute Error: 0.5
```

```
In [399]: # Calculate mean absolute percentage error (MAPE)
          mape = 100 * (errors / y_rf_test)
          # Calculate and display accuracy
          accuracy = 100 - np.mean(mape)
          print('Accuracy:', round(accuracy, 2), '%.')
```

```
Accuracy: -inf %.


In [400]: empl_quit_no_na.head()

Out[400]:    employee_id  company_id              dept  seniority    salary  join_date  \
          0      13021.0           7  customer_service         28   89000.0 2014-03-24
          1     825355.0           7         marketing         20  183000.0 2013-04-29
          3     662910.0           7  customer_service         20  115000.0 2012-05-14
          4     256971.0           2      data_science         23  276000.0 2011-10-17
          5     509529.0           4      data_science         14  165000.0 2012-01-30

              quit_date empl_quit_duration  seniority_z_score  empl_quit_days  log_salary
          0 2015-10-30           585 days           1.714870             585   11.396392
          1 2014-04-04           340 days           0.725916             340   12.117241
          3 2013-06-07           389 days           0.725916             389   11.652687
          4 2014-08-22          1040 days           1.096774            1040   12.528156
          5 2013-08-30           578 days           0.015799             578   12.013701

In [401]: empl_quit_no_na = pd.get_dummies(empl_quit_no_na, prefix = ['dummy'], columns = ['dep

In [420]: empl_quit_no_na = pd.get_dummies(empl_quit_no_na, prefix = ['dummy'], columns = ['com

In [403]: from sklearn.ensemble import RandomForestRegressor

In [405]: rf_1 = RandomForestRegressor(n_estimators = 1000, random_state = 42)

In [423]: X_rf_1 = empl_quit_no_na[['seniority', 'salary', 'dummy_2', 'dummy_3', 'dummy_4', 'du
                                    'dummy_6', 'dummy_7', 'dummy_8', 'dummy_9', 'dummy_10', 'dum
          y_rf_1 = empl_quit_no_na['empl_quit_days']

In [424]: X_rf_1_train, X_rf_1_test, y_rf_1_train, y_rf_1_test = train_test_split(X_rf_1, y_rf_

In [425]: rf_1.fit(X_rf_1_train, y_rf_1_train)

Out[425]: RandomForestRegressor(bootstrap=True, criterion='mse', max_depth=None,
                     max_features='auto', max_leaf_nodes=None,
                     min_impurity_decrease=0.0, min_impurity_split=None,
                     min_samples_leaf=1, min_samples_split=2,
                     min_weight_fraction_leaf=0.0, n_estimators=1000, n_jobs=None,
                     oob_score=False, random_state=42, verbose=0, warm_start=False)

In [426]: predictions_rf_1 = rf_1.predict(X_rf_1_test)

In [427]: r_sq = rf_1.score(X_rf_1_test, y_rf_1_test)

In [428]: r_sq

Out[428]: -0.21540098526269236
```