run

February 20, 2019

1 Imports

```
In [1]: # Imports
        import csv
        import os
        import pandas as pd
        import copy
        import matplotlib.pyplot as plt
        import numpy as np

        # sklearn
        from sklearn.linear_model import LinearRegression
        from sklearn import preprocessing
        from sklearn.model_selection import KFold
        from sklearn.preprocessing import OneHotEncoder
```

2 Load data

```
In [2]: filename = os.path.join('data','employee_retention_data.csv')
        # Load data to pandas
        df = pd.read_csv(filename)
        df.head(5)
```

```
Out[2]:    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
```

3 Format Data & add additional columns

In [3]:
```
# Convert to date times
df['join_date'] = pd.to_datetime(df['join_date'])
df['quit_date'] = pd.to_datetime(df['quit_date'])
```

In [4]:
```
# Add column for still working
df['still_working'] = pd.isnull(df['quit_date'])
```

In [5]:
```
# Add a column for quit date_minus join_date
df['duration'] = df['quit_date'] - df['join_date']

# Convert to days
df['duration'] = df['duration'].dt.days
```

In [6]:
```
# Add "min" columns
# These columns assume the employee quits on the last day of the data set - 2015/12/13
# These will be used for later analysis

# Add quit_date_min
df['quit_date_min'] = df['quit_date']
df.loc[pd.isnull(df['quit_date']),['quit_date_min']] = pd.to_datetime('2015/12/13')
```

In [7]:
```
# Add duration_min
df['duration_min'] = df['quit_date_min'] - df['join_date']

# Convert to days
df['duration_min'] = df['duration_min'].dt.days
```

In [8]:
```
# Get rid of this, since we no longer need
df = df.drop('quit_date_min',1)
```

In [9]:
```
# Add columns for join year
#df['joined2011']
df['j2011'] = df['join_date'] < pd.to_datetime('2012')
df['j2012'] = (df['join_date'] >= pd.to_datetime('2012')) & (df['join_date'] < pd.to_da
df['j2013'] = (df['join_date'] >= pd.to_datetime('2013')) & (df['join_date'] < pd.to_da
df['j2014'] = (df['join_date'] >= pd.to_datetime('2014')) & (df['join_date'] < pd.to_da
df['j2015'] = (df['join_date'] >= pd.to_datetime('2015')) & (df['join_date'] < pd.to_da
```

In [10]:
```
df.head()
```

Out[10]:

	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  duration  duration_min  j2011  j2012  j2013  \
0  2015-10-30          False     585.0           585  False  False  False
1  2014-04-04          False     340.0           340  False  False   True
2         NaT           True       NaN           426  False  False  False
3  2013-06-07          False     389.0           389  False   True  False
4  2014-08-22          False    1040.0          1040   True  False  False

   j2014  j2015
0   True  False
1  False  False
2   True  False
3  False  False
4  False  False
```

In [ ]:

4 EDA - Exploratory Data Analysis

4.1 Basic data properties

In [11]:
```python
# Data types
print(df.dtypes)
```

```
employee_id              float64
company_id                 int64
dept                      object
seniority                  int64
salary                   float64
join_date         datetime64[ns]
quit_date         datetime64[ns]
still_working               bool
duration                 float64
duration_min               int64
j2011                       bool
j2012                       bool
j2013                       bool
j2014                       bool
j2015                       bool
dtype: object
```

In [12]:
```python
# Number of unique companies
print('Unique company ids')
print(df.company_id.unique())
print('Number of unqiue companies = {}'.format(str(len(df.company_id.unique()))))
```

```
Unique company ids
[ 7  4  2  9  1  6 10  5  3  8 11 12]
```

```
Number of unqiue companies = 12
```

In [13]:
```python
# Number of unique depts
print('Unique company ids')
print(df.dept.unique())
print('Number of unqiue depts = {}'.format(str(len(df.dept.unique()))))
```

```
Unique company ids
['customer_service' 'marketing' 'data_science' 'engineer' 'sales' 'design']
Number of unqiue depts = 6
```

In [14]:
```python
# Number of unique seniority
print('Unique company ids')
print(df.seniority.unique())
print('Number of unqiue seniorities = {}'.format(str(len(df.seniority.unique()))))
```

```
Unique company ids
[28 20 14 23 21  4  7 13 17  1 10  6 19 15 26 27  5 18 16 25  9  2 29  3
  8 22 24 12 11 98 99]
Number of unqiue seniorities = 31
```

In [15]:
```python
# Sort senorities
foo = df.seniority.unique()
foo.sort()
```

In [16]:
```python
print("Number of years experience when hired, sorted unique values: " + str(foo))
```

```
Number of years experience when hired, sorted unique values: [ 1  2  3  4  5  6  7  8  9 10 11
 25 26 27 28 29 98 99]
```

In [17]:
```python
# For some reason, some people hae 98 or 99 years experience? Look at these values...

# experience = 98 - one lucky engineer
df[df['seniority'] == 98]
```

Out[17]:
```
       employee_id  company_id      dept  seniority    salary  join_date  \
24700      97289.0          10  engineer         98  266000.0 2011-12-13

       quit_date  still_working  duration  duration_min  j2011  j2012  j2013  \
24700 2015-01-09          False    1123.0          1123   True  False  False

       j2014  j2015
24700  False  False
```

In [18]:
```python
# experience = 99
df[df['seniority'] == 99]
```

```
Out[18]:        employee_id  company_id       dept  seniority    salary  join_date  \
         24701     604052.0           1  marketing         99  185000.0 2011-07-26

                quit_date  still_working  duration  duration_min  j2011  j2012  j2013  \
         24701 2013-12-06          False     864.0           864   True  False  False

                j2014  j2015
         24701  False  False
```

```
In [19]: # Replace these values with more reasonable numbers

         df = df.replace({'seniority': 98}, 40)
         df = df.replace({'seniority': 99}, 40)
         # Verify it works
         df[24700:24704]
```

```
Out[19]:        employee_id  company_id       dept  seniority    salary  join_date  \
         24700      97289.0          10   engineer         40  266000.0 2011-12-13
         24701     604052.0           1  marketing         40  185000.0 2011-07-26

                quit_date  still_working  duration  duration_min  j2011  j2012  j2013  \
         24700 2015-01-09          False    1123.0          1123   True  False  False
         24701 2013-12-06          False     864.0           864   True  False  False

                j2014  j2015
         24700  False  False
         24701  False  False
```

```
In [ ]:
```

4.2 Number of goods vs bads (nans vs non-nans)

```
In [20]: # Save dataframs containing only nans and only non-nans
         df_good = df.dropna()
         df_bad = df[pd.isnull(df['quit_date'])]
```

```
In [21]: df_good.head(5)
```

```
Out[21]:    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  still_working  duration  duration_min  j2011  j2012  j2013  \
         0 2015-10-30          False     585.0           585  False  False  False
         1 2014-04-04          False     340.0           340  False  False   True
         3 2013-06-07          False     389.0           389  False   True  False
```

```
4 2014-08-22          False    1040.0          1040   True  False  False
5 2013-08-30          False     578.0           578  False   True  False

   j2014  j2015
0   True  False
1  False  False
3  False  False
4  False  False
5  False  False
```

```
In [22]: df_bad.head(5)
```

```
Out[22]:     employee_id  company_id              dept  seniority    salary  join_date  \
        2       927315.0           4         marketing         14  101000.0 2014-10-13
        6        88600.0           4  customer_service         21  107000.0 2013-10-21
        7       716309.0           2  customer_service          4   30000.0 2014-03-05
        9       504159.0           1             sales          7  104000.0 2012-06-12
        11      904158.0           2         marketing         17  230000.0 2015-05-11

           quit_date  still_working  duration  duration_min  j2011  j2012  j2013  \
        2        NaT           True       NaN           426  False  False  False
        6        NaT           True       NaN           783  False  False   True
        7        NaT           True       NaN           648  False  False  False
        9        NaT           True       NaN          1279  False   True  False
        11       NaT           True       NaN           216  False  False  False

            j2014  j2015
        2    True  False
        6   False  False
        7    True  False
        9   False  False
        11  False   True
```

```
In [23]: # Lengths
         N = len(df)

         Ngood = len(df_good)
         Nbad2 = N-Ngood
         Nbad = len(df_bad)
```

```
In [24]: print('N={}, Ngood={}, Nbad={}, Nbad2={}'.format(str(N),str(Ngood),str(Nbad),str(Nbad2
```

```
N=24702, Ngood=13510, Nbad=11192, Nbad2=11192
```

```
In [ ]:
```

5 Plot Histograms

```
In [25]: # Copy before messing
         df2 = df.copy();
```

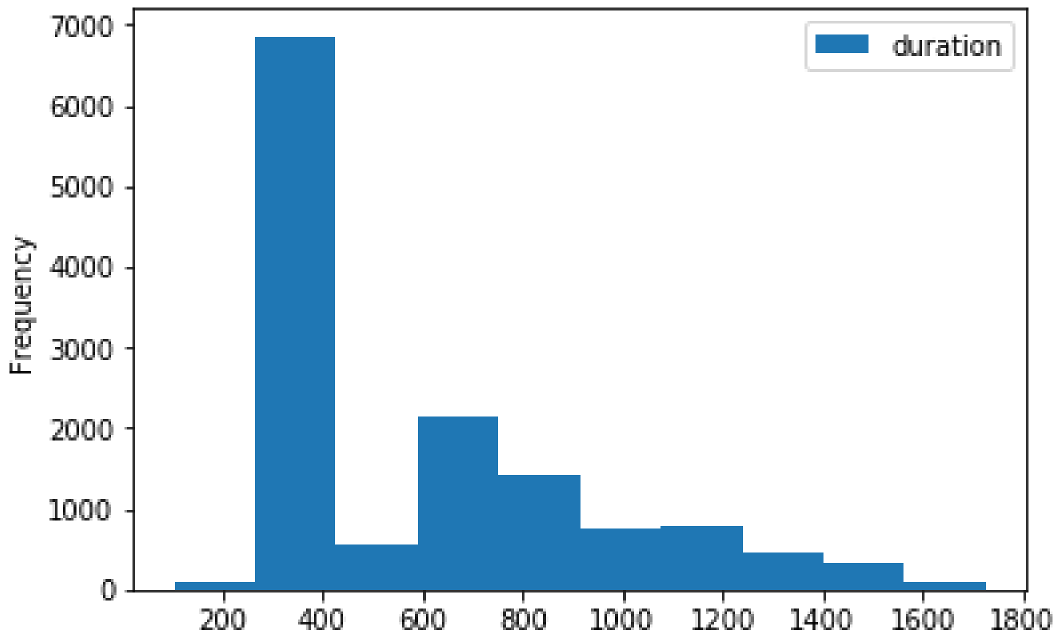
```
In [ ]:
```

```
In [26]: df2.head()
```

```
Out[26]:    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  duration  duration_min  j2011  j2012  j2013  \
         0 2015-10-30          False     585.0           585  False  False  False
         1 2014-04-04          False     340.0           340  False  False   True
         2        NaT           True       NaN           426  False  False  False
         3 2013-06-07          False     389.0           389  False   True  False
         4 2014-08-22          False    1040.0          1040   True  False  False

            j2014  j2015
         0   True  False
         1  False  False
         2   True  False
         3  False  False
         4  False  False
```

```
In [27]: # Plot durations of all still working
         foo = df.loc[df['still_working'] == False,['duration']]
         plt.figure();
         foo.plot.hist();
```

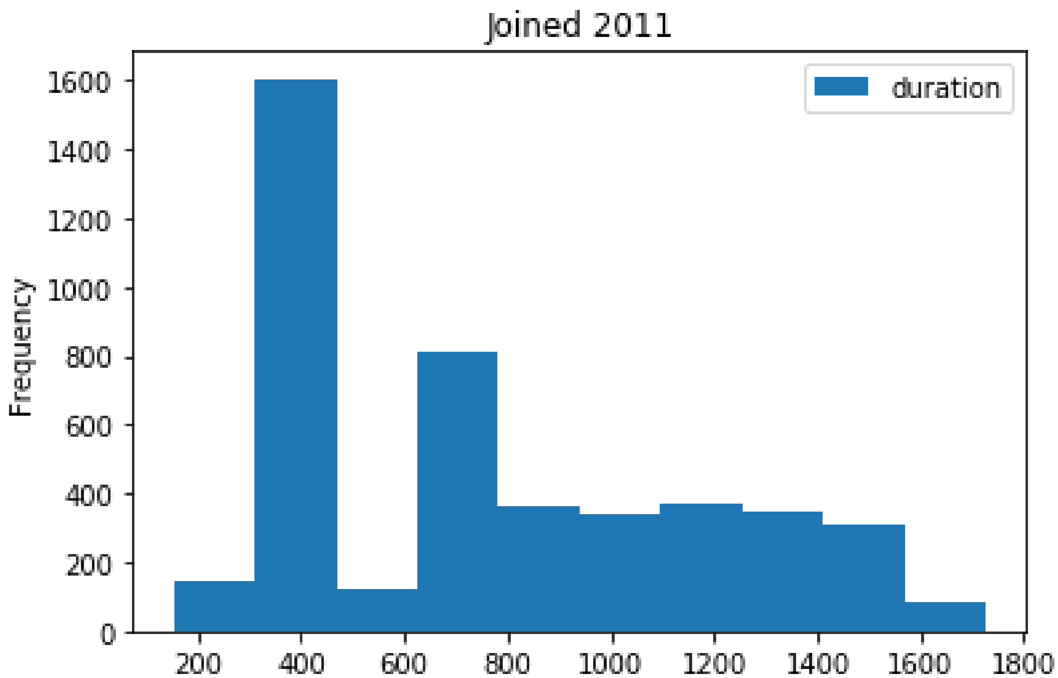
```
<Figure size 432x288 with 0 Axes>
```



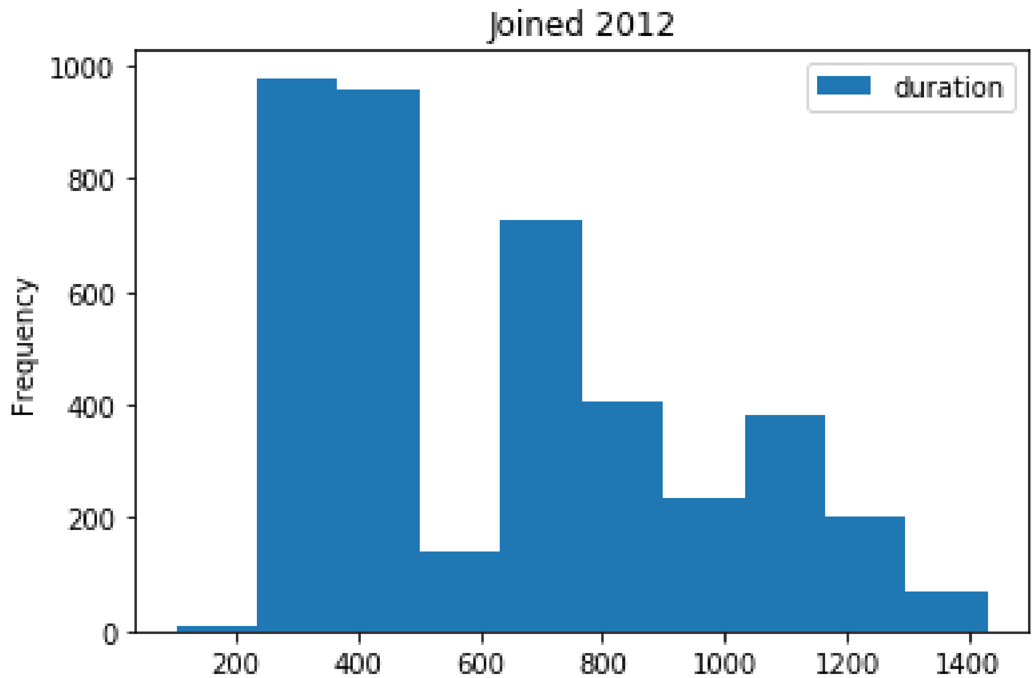

```
In [28]: # Joined in 2011
         foo = df.loc[(df['still_working'] == False) & (df['j2011']),['duration']]
         plt.figure();
         foo.plot.hist();
         plt.title('Joined 2011');

         # Joined in 2012
         foo = df.loc[(df['still_working'] == False) & (df['j2012']),['duration']]
         plt.figure();
         foo.plot.hist();
         plt.title('Joined 2012');

         # Joined in 2013
         foo = df.loc[(df['still_working'] == False) & (df['j2013']),['duration']]
         plt.figure();
         foo.plot.hist();
         plt.title('Joined 2013');

         # Joined in 2014
         foo = df.loc[(df['still_working'] == False) & (df['j2014']),['duration']]
         plt.figure();
         foo.plot.hist();
         plt.title('Joined 2014');

         # Joined in 2015
         foo = df.loc[(df['still_working'] == False) & (df['j2015']),['duration']]
```

```
plt.figure();
foo.plot.hist();
plt.title('Joined 2015');
```

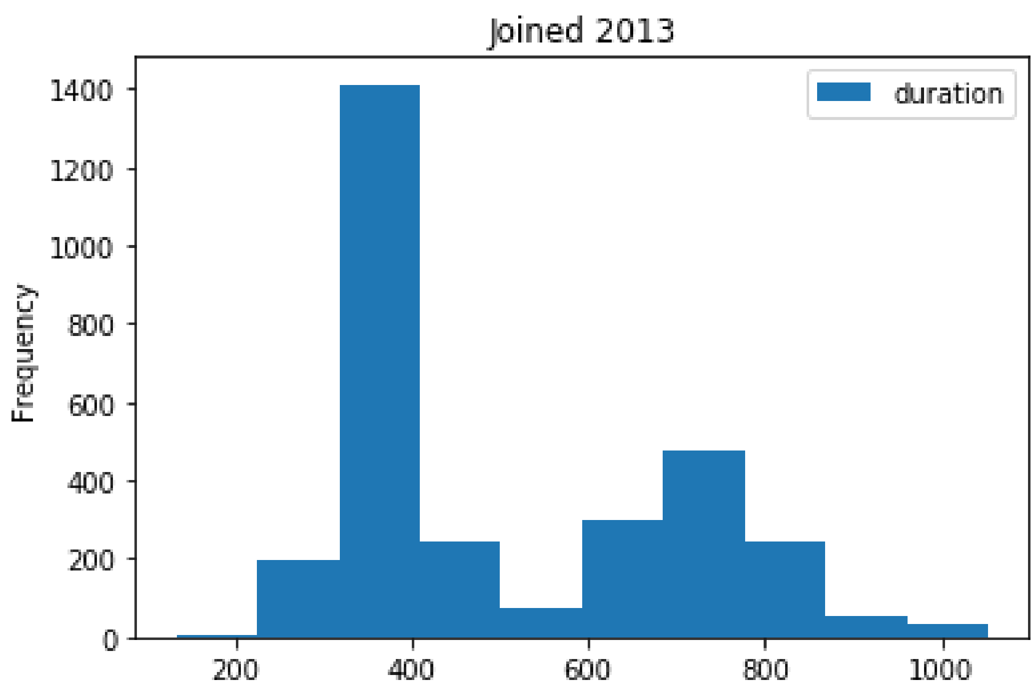
```
<Figure size 432x288 with 0 Axes>
```



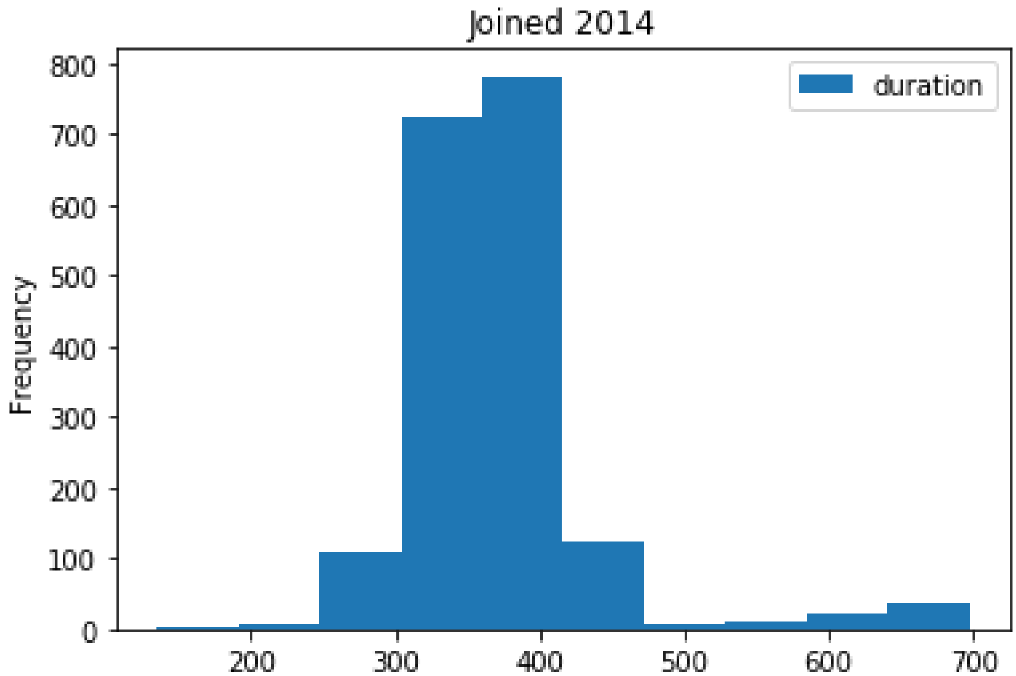

```
<Figure size 432x288 with 0 Axes>
```



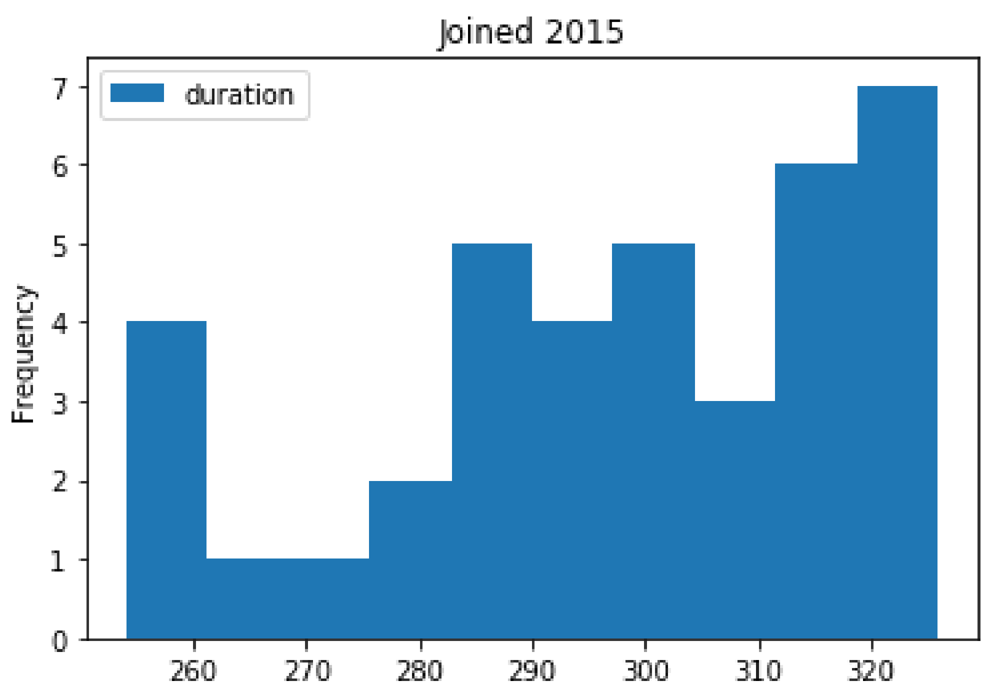
<Figure size 432x288 with 0 Axes>



<Figure size 432x288 with 0 Axes>



<Figure size 432x288 with 0 Axes>



In [29]:
```
# Appears that one group tends to quit after around 300-400 days; some stragglers (lo
# The data for employees that join in 2015 is highly biased.
```

In [ ]:

6 Fit Model A

In [30]:
```
# Generate X variable
# Drop columns we don't want to include as regressors
foo = df_good
foo = foo.drop(['employee_id'],1)
foo = foo.drop(['company_id'],1)
foo = foo.drop(['join_date'],1)
foo = foo.drop(['quit_date'],1)
foo = foo.drop(['still_working'],1)
foo = foo.drop(['duration'],1)
foo = foo.drop(['duration_min'],1)
X = foo

# Genreate Y variable
y = pd.DataFrame(df_good['duration_min'])
```

In [31]:
```
X.head()
```

Out[31]:

	dept	seniority	salary	j2011	j2012	j2013	j2014	j2015
0	customer_service	28	89000.0	False	False	False	True	False
1	marketing	20	183000.0	False	False	True	False	False
3	customer_service	20	115000.0	False	True	False	False	False
4	data_science	23	276000.0	True	False	False	False	False
5	data_science	14	165000.0	False	True	False	False	False

In [32]:
```
y.head()
```

Out[32]:

	duration_min
0	585
1	340
3	389
4	1040
5	578

In [33]:
```
model = LinearRegression()
# model.fit(X,y)
```

For the next steps, I would convert the dept info to use one hot encoding and run the model.

7 Fit Model B

Now that Model A is working (the model trained on just the "good" data - e.g., the data associated with employees who have already quit), I will then train a second model, model B. For this model, I will populate the nan values of the duration column using the following algorithm.

1) For each nan value, use model A to predict the duration
2) If the predicted duration is longer than 2015/12/13 - join_date (e.g. their time worked up until 2015/12/13), I will substitute the nan with the predicted value. If the predicted duration is shorter, I will then use the value 2015/12/13 - join_date. This will partially correct for bias in the model associated with dropping these data points in model A.