Assignment 3

October 23, 2018

1 Assignment 3 Question 2

In [299]:
```
#Open packages
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.ticker import MultipleLocator
```

In [300]:
```
#Running a simulation model
def normal_income_sim(p):

    """
    Requires a simulation profile, p, structured as a dictionary

    p = {
        'mu'            : 0,            #mean of the standard normal distribution
        'sigma'         : 0.13,         #standard deviation
        'inc'           : 80000,        #starting income
        'gr'            : 0.025,        #growth rate
        'rho'           : 0.4,          #persistence
        'st_year'       : int(2018),    #start year
        'w_years'       : 40,           #no. of working years
        'num_draws'     : 10000         #simulations
    }
    """

    #set random seed
    np.random.seed(524)

    errors = np.random.normal(p['mu'], p['sigma'], (p['w_years'], p['num_draws']))

    #create a matrix (w_years, num_draws)
    income_sim_matrix = np.zeros((p['w_years'], p['num_draws']))

    #fill the matrix
    income_sim_matrix[0, :] = np.log(p['inc']) + errors[0, :]

    #loop and apply model
```

```
        for yr in range(1, p['w_years']):
            income_sim_matrix [yr, :] = (1 - p['rho'])*(np.log(p['inc']) + p['gr']*yr) +
        income_sim_mat = np.exp(income_sim_matrix) #dealing with large numbers so put in
        return income_sim_mat
```

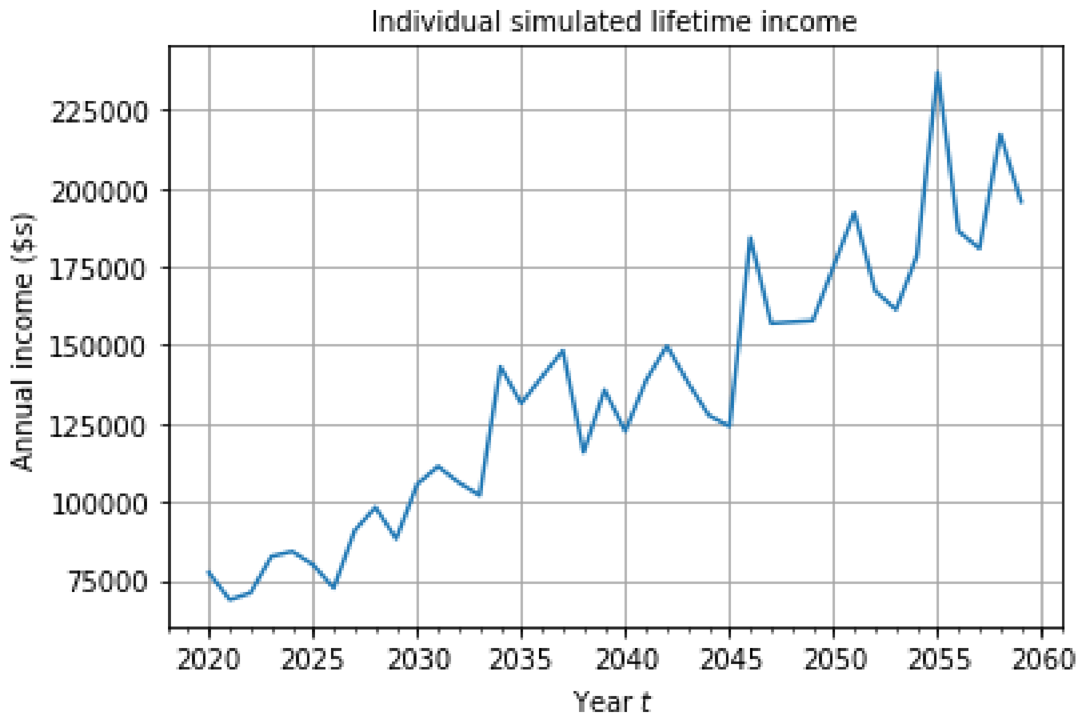
```
In [301]: simulation_profile = {
                  'mu'            : 0,           #mean of the standard normal distribution
                  'sigma'         : 0.13,        #standard deviation
                  'inc'           : 80000,       #starting income
                  'gr'            : 0.025,       #growth rate
                  'rho'           : 0.4,         #persistence
                  'st_year'       : int(2020),   #start year
                  'w_years'       : 40,          #no. of working years
                  'num_draws'     : 10000        #simulations
              }

          income = normal_income_sim(simulation_profile)
          print(income)
```

```
[[ 66409.15585396  98274.13534194 101939.81109509 ...  98720.39690442
   72404.51636886  68710.32820307]
 [ 80020.53020329  67383.19350738  84557.85626308 ...  68247.7770509
   74518.33613244  80555.96068584]
 [ 75805.26636606  66134.42494243  91458.20304692 ...  67268.53350159
   90012.42673528  80645.62355527]
 ...
 [272690.56519108 217821.73027242 184724.24512469 ... 159922.45424852
  253961.68337673 209741.55004062]
 [231539.17420799 202509.15149494 197955.96626493 ... 199502.43481758
  210951.71828579 205420.27946389]
 [197895.95201384 165115.10025278 172644.86927513 ... 248654.44847819
  234237.14656466 221566.29879732]]
```

2(a) Plotting one person's income

```
In [302]: %matplotlib inline
          p = simulation_profile
          year_vec = np.arange(p['st_year'], p['st_year'] + p['w_years'])
          individual = 125
          fig, ax = plt.subplots()
          plt.plot(year_vec, income[:, individual])
          minorLocator = MultipleLocator(1)
          ax.xaxis.set_minor_locator(minorLocator)
          plt.grid(b=True, which='major', color='0.65', linestyle='-')
          plt.title('Individual simulated lifetime income', fontsize=10)
          plt.xlabel(r'Year $t$')
          plt.ylabel(r'Annual income (\$s)')
```

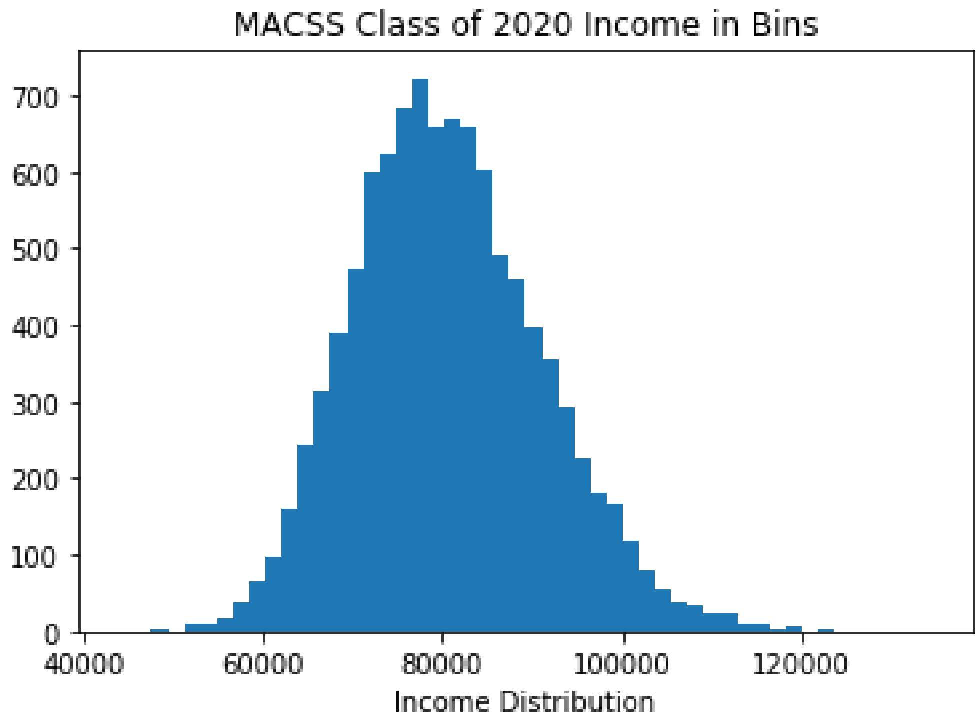
Out[302]: Text(0,0.5,'Annual income (\\$s)')



2(b) Plotting a histogram for year 2020

```
In [320]: plt.hist(income[0,:], bins=50)
          plt.xlabel("Income Distribution")
          plt.title("MACSS Class of 2020 Income in Bins")
```

Out[320]: Text(0.5,1,'MACSS Class of 2020 Income in Bins')




```
In [304]: len(income[0, :] [income [0, :] > 100000]) / len(income[0, :])
```

```
Out[304]: 0.0417
```

4.17% of the class will earn more than $100,000 in the first year of the program.

```
In [305]: len(income[0, :] [income [0, :] < 70000]) / len(income[0, :])
```

```
Out[305]: 0.1512
```

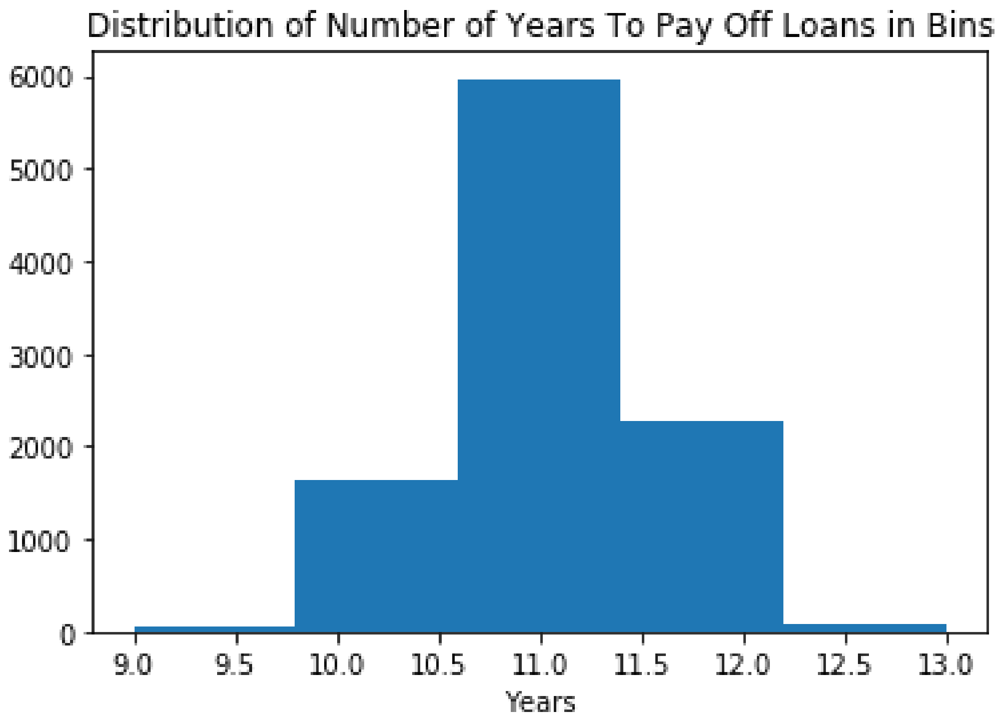
15.12% of the class will earn less than $70,000 in the first year of the program.
The distribution of the curve is slightly not normal and it is slightly rightly skewed.

2(c) Plotting histogram of how many years it takes to pay $95,000

```
In [322]: loan=0.1*income
          t=[]
          for i in range(10000):
                  paid=loan[:,i][0]
                  for j in range(1,40):
                      if paid<95000:
                          paid=paid+loan[:,i][j]
                      else:
                          t.append(j)
                          break

          print(t)
```

```
[11, 11, 10, 10, 11, 11, 11, 11, 12, 12, 12, 10, 12, 10, 11, 11, 10, 11, 11, 11, 10, 11, 11, 12
```

```
In [314]: #As there are 5 unique years (9, 10, 11, 12, 13) in which people pay off their debt,
          plt.hist(t, bins=5)
          plt.xlabel("Years")
          plt.title("Distribution of Number of Years To Pay Off Loans in Bins")

Out[314]: Text(0.5,1,'Distribution of Number of Years To Pay Off Loans in Bins')
```




```
In [315]: perc = 0
          for i in range(10000):
              if t[i] <= 10:
                  perc += 1
          perc/10000

Out[315]: 0.1678
```

16.78% of the simulations are able to pay off the loan in 10 years.

2 (d) Running the new model

```
In [316]: simulation_profile = {
                  'mu1'          : 0,          #mean of the standard normal distribution
```

```
                'sigma1'        : 0.17,         #standard deviation
                'inc1'          : 90000,        #starting income
                'gr1'           : 0.025,        #growth rate
                'rho1'          : 0.4,          #persistence
                'st_year1'      : int(2018),    #start year
                'w_years1'      : 40,           #no. of working years
                'num_draws1'    : 10000         #simulations
            }

        new_income = new_normal_income_sim(simulation_profile)
        print(new_income)
```

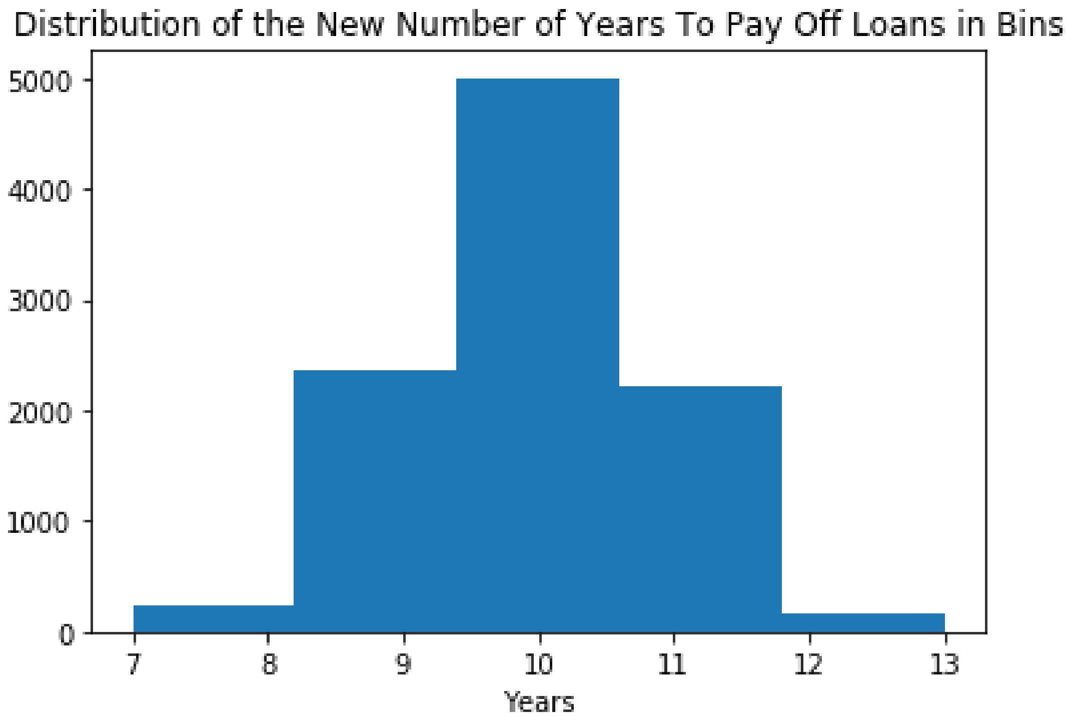
```
[[ 70550.46142451 117783.33011091 123561.20729139 ... 118483.24080508
   78992.81966812  73764.25171169]
 [ 89615.63768821  71575.56495871  96317.75493523 ...  72778.88084775
   81644.3347736   90400.57899801]
 [ 82955.30101689  69396.06916251 106035.55593099 ...  70956.3661129
  103848.93176006  89949.09077038]
 ...
 [338309.11761165 252187.52025149 203293.03644369 ... 168361.21927259
  308250.29858492 240024.49205936]
 [271061.07048342 227502.32436192 220836.5697397  ... 223095.32811759
  239983.96514044 231788.44418303]
 [219057.46748997 172865.33333479 183245.71710131 ... 295275.8618388
  273090.00167035 253934.86273481]]
```

```
In [325]: loan=0.1*new_income
          m=[]
          for i in range(10000):
                  paid=loan[:,i][0]
                  for j in range(1,40):
                      if paid<95000:
                          paid=paid+loan[:,i][j]
                      else:
                          m.append(j)
                          break
          print(m)
```

```
[10, 10, 9, 9, 11, 10, 10, 10, 11, 10, 12, 9, 11, 9, 10, 10, 9, 9, 11, 9, 9, 10, 9, 11, 9, 11,
```

```
In [326]: #As there are 5 unique years (8, 9, 10, 11, 12) in which people pay off their debt,
          plt.hist(m, bins=5)
          plt.xlabel("Years")
          plt.title("Distribution of the New Number of Years To Pay Off Loans in Bins")
```

```
Out[326]: Text(0.5,1,'Distribution of the New Number of Years To Pay Off Loans in Bins')
```




```
In [327]: perc = 0
          for i in range(10000):
              if m[i] <= 10:
                  perc += 1
          perc/10000

Out[327]: 0.7602
```

76.02% of the simulations are able to pay off the loan in 10 years.