Assign#3

October 24, 2018

2.Simulating your income

(a)

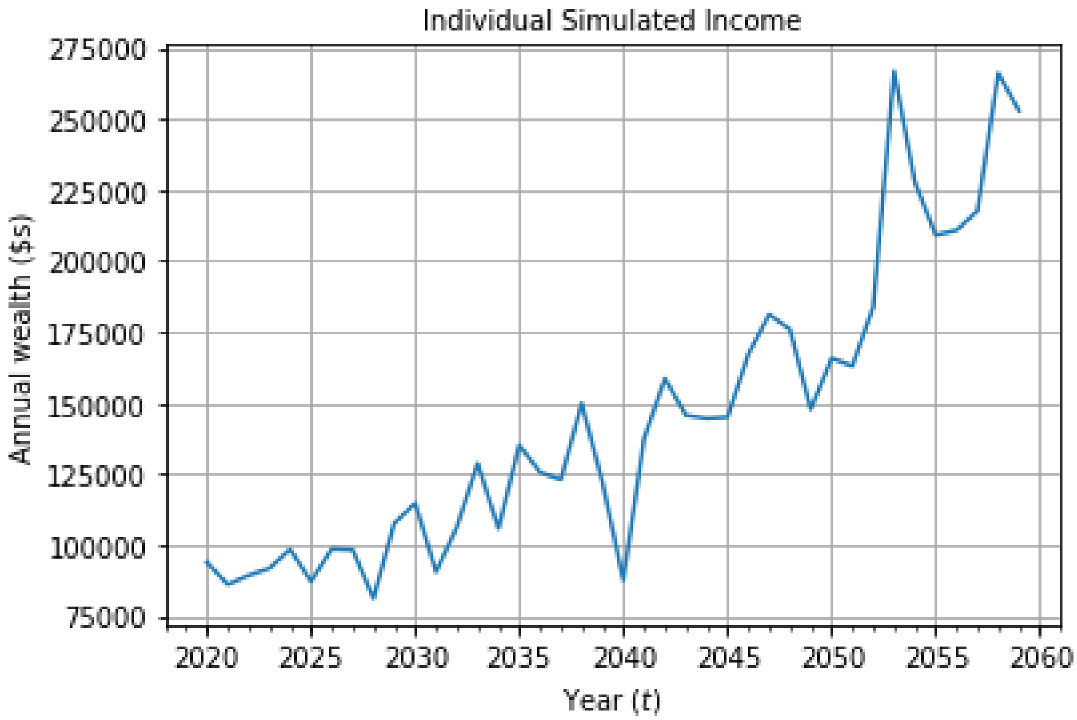
```
In [11]: # Import initial packages
         import numpy as np
         import matplotlib.pyplot as plt
         from matplotlib.ticker import MultipleLocator
         from scipy.stats import normaltest

In [12]: # Creating dictionary of parameters
         '''
         p = {
             'inc0'          : 80000,        #starting income
             'sigma'         : 0.13,         #sd of normal distributed error term
             'rho'            : 0.4,          #persistence
             'g'             : 0.025,        #growth rate
             'n_years'       : 40,           #years to work
             'base_year'     : int(2020),    #starting year
             'no_sim'        : 10000         #number of simulations
         }
         '''

         def income_gr(p):
             '''
             define a function that take in parameters from the dictionary p
             and returns a matrix of income
             '''

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

             log_errors = np.random.normal(0, p['sigma'], (p['n_years'], p['no_sim']))

             #create a matrix of dim (n_years, no_sim)
             log_income = np.zeros((p['n_years'], p['no_sim']))

             #fill the matrix
```

```
    log_income[0, :] = np.log(p['inc0']) + log_errors[0, :]

    #loop and apply model
    for yr in range(1, p['n_years']):
        log_income[yr, :] = ((1 - p['rho']) *(np.log(p['inc0']) + p['g'] * (yr))
                            + p['rho'] * (log_income[yr-1,:])
                            + log_errors[yr, :])


    income = np.exp(log_income)
    return income
```

In [13]:
```
# Input parameters and generate the matrix
para = {
    'inc0'          : 80000,        #starting income
    'sigma'         : 0.13,         #sd of normal distributed error term
    'rho'           : 0.4,          #persistence
    'g'             : 0.025,        #growth rate
    'n_years'       : 40,           #years to work
    'base_year'     : int(2020),    #starting year
    'no_sim'        : 10000         #number of simulations
}

income_mat = income_gr(para)
```

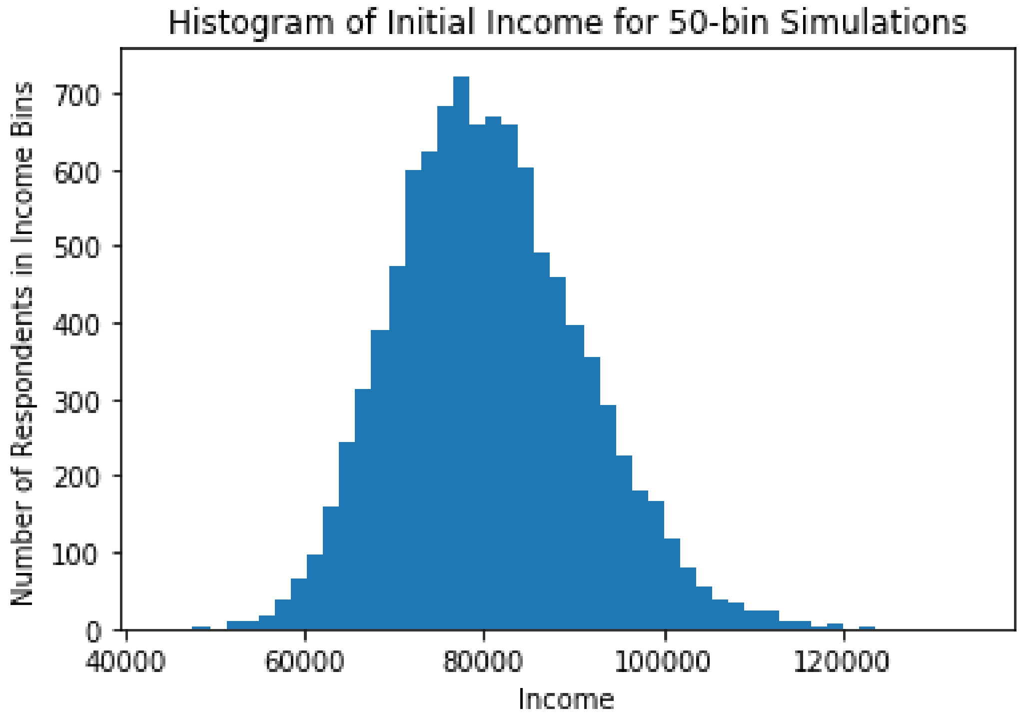
In [14]:
```
%matplotlib inline
p = para
year_vec = np.arange(p['base_year'], p['base_year'] + p['n_years'])
individual = 500
fig, ax = plt.subplots()
plt.plot(year_vec, income_mat[:, individual])
minorLocator = MultipleLocator(1)
ax.xaxis.set_minor_locator(minorLocator)
plt.grid(b=True, which='major', color='0.65', linestyle='-')
plt.title('Individual Simulated Income', fontsize=10)
plt.xlabel(r'Year ($t$)')
plt.ylabel(r'Annual wealth (\$s)')
```

Out[14]:
```
Text(0,0.5,'Annual wealth (\\$s)')
```



(b) 4% of the class will earn more than 100,000, and 15% of the class will earn less than 70,000.

```
In [15]: #Plot histograms for bins = 50
         plt.hist(income_mat[0,:], bins = 50)
         plt.xlabel("Income")
         plt.ylabel("Number of Respondents in Income Bins")
         plt.title("Histogram of Initial Income for 50-bin Simulations")

Out[15]: Text(0.5,1,'Histogram of Initial Income for 50-bin Simulations')
```




```
In [16]: #calculate the percentages
         income0 = np.ndarray.tolist(income_mat[0,:])
         print(len([i for i in income0 if i > 100000]) / len(income0))
         print(len([i for i in income0 if i < 70000]) / len(income0))
```

```
0.0417
0.1512
```

```
In [17]: #testing normality
         stat,p = normaltest(income_mat[0,:])
         print(stat,p)
         print(np.mean(income_mat[0,:]))
         print(np.median(income_mat[0,:]))
```

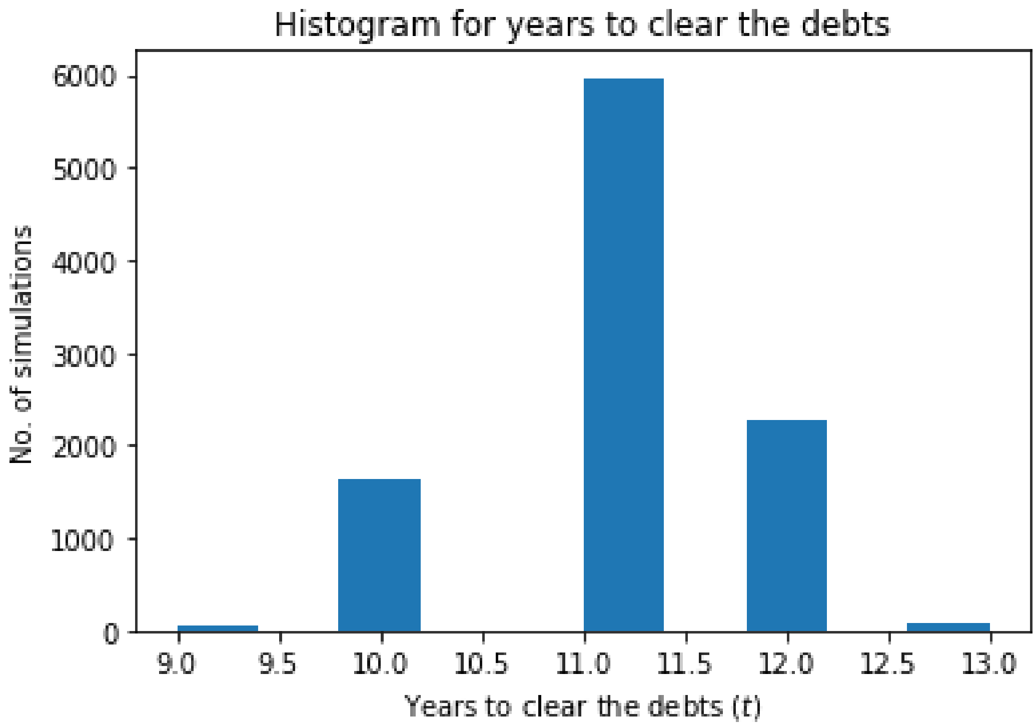
```
290.481782626689 8.369169350300544e-64
80653.27431763953
79865.11458578068
```

According to observation and the test performed, the distribution is normally distributed. But because the median of this distribution is less than the mean, I would say that the distribution is slightly right skewed.

(c) Only in about 16.78% of the simulations that I will be able to pay off the loan in 10 years.

In [18]:
```
def years_to_pay_off(mat):
    '''
    Define a function that will return a histogram and a percentage for both question
    '''

    #create a payment matrix
    pay_mat = mat * 0.1
    pay_yr = []

    for i in range(len(pay_mat[0,:])):
        yr = 1
        while sum(pay_mat[:,i][:yr]) < 95000:
            yr += 1
            if sum(pay_mat[:,i][:yr]) >= 95000:
                pay_yr.append(int(yr))
                #pay_yr returns a list with 10,000 entries of the years needed to cle
                break

    # plot the histogram
    plt.hist(pay_yr)
    plt.xlabel("Years to clear the debts ($t$)")
    plt.ylabel("No. of simulations")
    plt.title("Histogram for years to clear the debts")

    #calculating percentage
    print(len([i for i in pay_yr if i <= 10])/len(pay_yr))

years_to_pay_off(income_mat)
```

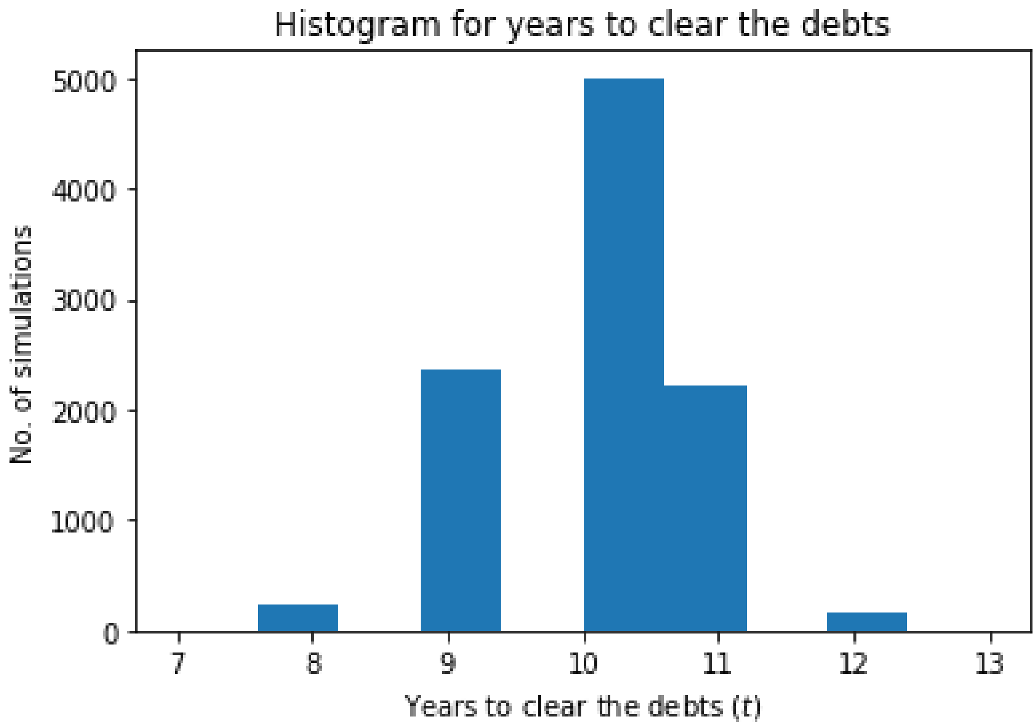
```
0.1678
```



(d) In this case, the parameters that I would use for my simulations would change to:

```
In [19]: #new dictionary with new parameters
         para_new = {
             'inc0'          : 90000,        #starting income
             'sigma'         : 0.17,         #sd of normal distributed error term
             'rho'           : 0.4,          #persistence
             'g'             : 0.025,        #growth rate
             'n_years'       : 40,           #years to work
             'base_year'     : int(2020),    #starting year
             'no_sim'        : 10000         #number of simulations
         }

         #calling functions defined in previous questions
         income_mat_new = income_gr(para_new)
         years_to_pay_off(income_mat_new)
```

```
0.7602
```



In this case, 76% of the simulations would be able to pay off the loan in 10 years.