Assignment3 part2

October 23, 2018

In [1]:
```
import numpy as np
import matplotlib.pyplot as  plt
from matplotlib.ticker import MultipleLocator
from scipy import stats
from numpy import cumsum

def normal_sim(p):

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

    p = {
        'inc0'     : 80000          #average starting income
        'g'        : 0.025          #rowth rate
        'rho'      : 0.4            #positive deopendence
        't'        : [2020, 2059]   #year t (t >= 2020)
        'num_draws': 10000          #simulations
        'mean'       : 0            #mean
        'sd'    : 0.13.             #standard deviation


    }

    """
    #set random seed
    np.random.seed(524)
    normal_errors = np.random.normal(p['mean'], p['sd'], (p['t'], p['num_draws']))
    #create a matrix of dim ((t - 2019), num_draws)
    ln_inc_mat = np.zeros((p['t'] - 2019, p['num_draws']))

    #fill in the first row
    ln_inc_mat [0, :] = np.log(p['inc0']) + normal_errors[0, :]

    #loop and apply model
    for yr in range(1, p['t'] - 2019):
         ln_inc_mat[yr, :] =(1 - p['rho']) * (np.log(p['inc0']) + p['g'] * yr)\
             + p['rho'] * ln_inc_mat[ yr - 1, :] + normal_errors[yr, :]
```

```
        income_mat = np.exp(ln_inc_mat)

        return income_mat
```

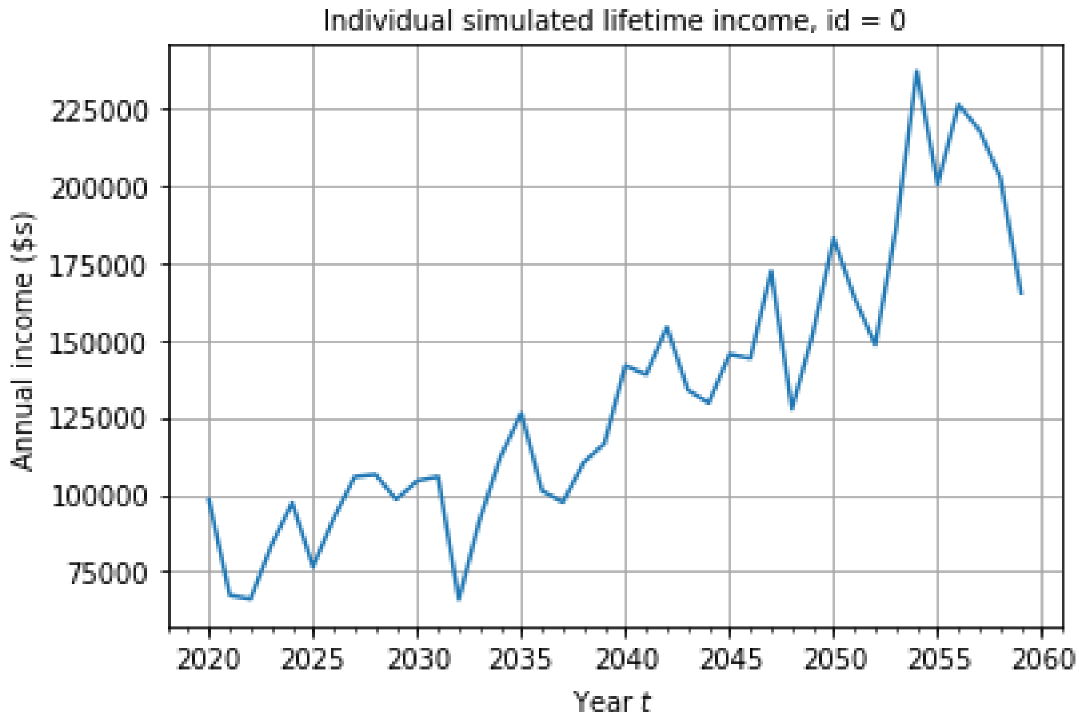
```
In [2]: sim_profile = {'inc0': 80000,
                       'g': 0.025,
                       'rho': 0.4,
                       't': 2059,
                       'num_draws': 10000,
                       'mean': 0,
                       'sd': 0.13
                      }

        income_mat = normal_sim(sim_profile)
        income_mat
```

```
Out[2]: array([[ 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]])
```

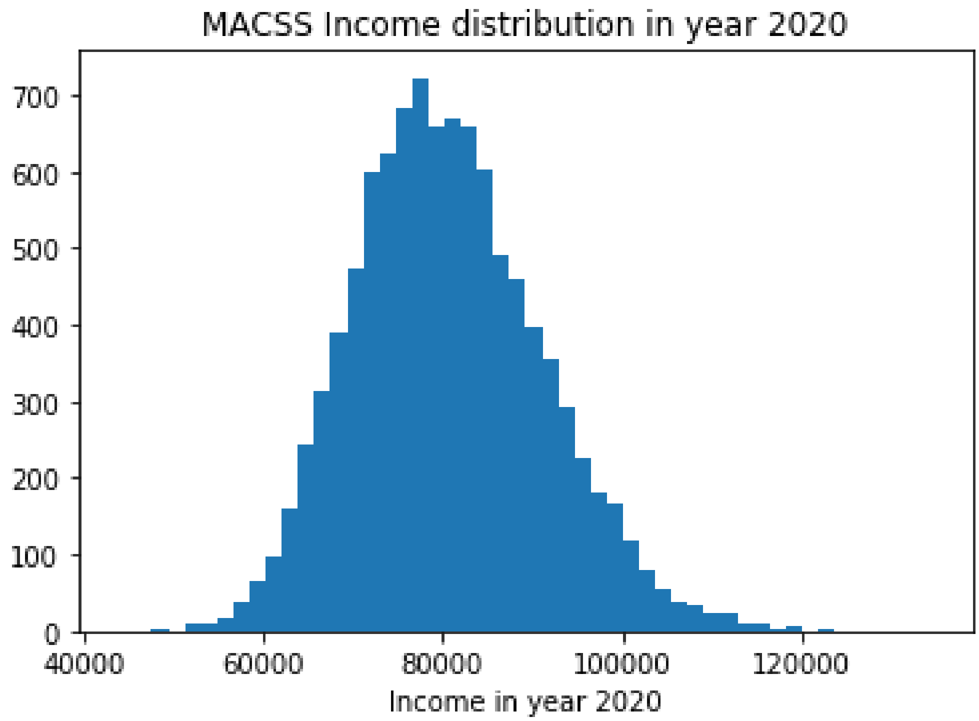
```
In [3]: # %matplotlib inline
        p = sim_profile
        year_vec = np.arange(2020, p['t']+1)
        individual = 1
        fig, ax = plt.subplots()
        plt.plot(year_vec, income_mat[:, individual])
        minorLocator = MultipleLocator(1)
        ax.xaxis.set_minor_locator(minorLocator)
        plt.grid(b=True, which='major', color='0.65', linestyle='-')
        plt.title('Individual simulated lifetime income, id = 0', fontsize=10)
        plt.xlabel(r'Year $t$')
        plt.ylabel(r'Annual income (\$s)')
```

```
Out[3]: Text(0,0.5,'Annual income (\\$s)')
```




```
In [4]: plt.hist(income_mat[0, :], bins=50)
        plt.xlabel("Income in year 2020")
        plt.title("MACSS Income distribution in year 2020")

Out[4]: Text(0.5,1,'MACSS Income distribution in year 2020')
```




```
In [5]: h = (income_mat[0, :] > 100000).sum()
        h/10000
```

```
Out[5]: 0.0417
```

```
In [6]: l = (income_mat[0, :] < 70000).sum()
        l/10000
```

```
Out[6]: 0.1512
```

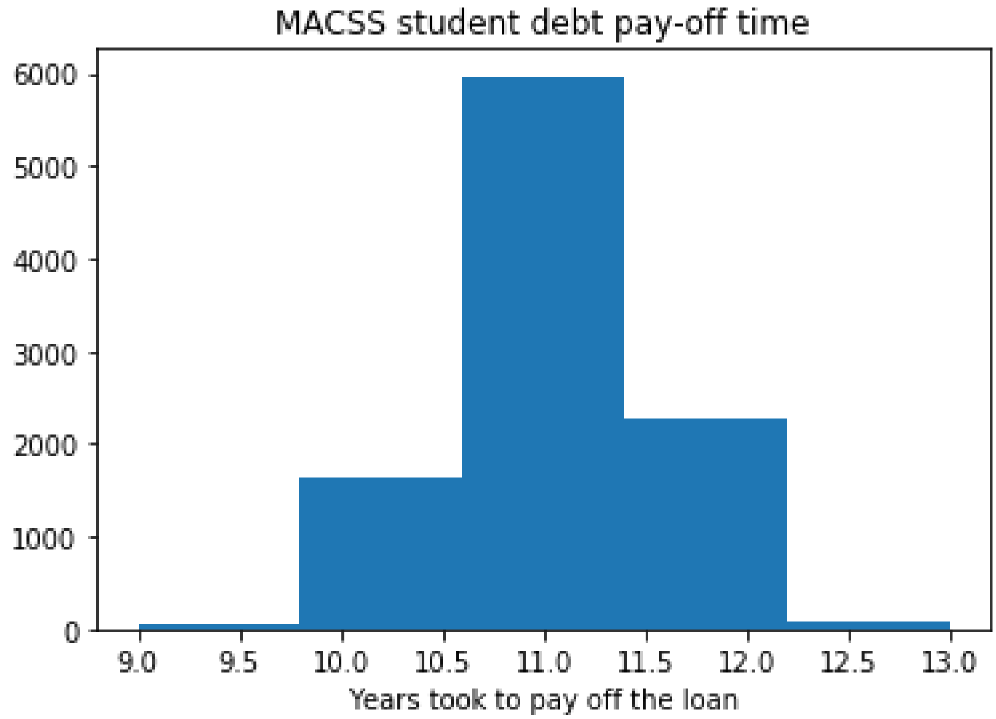
From the above calculation, we can see that 4.17% of my class will earn more than $100000 in the first year out of the program and 15.12% will earn less than $70000. From the graph above, the distribution is bell curved and normally distributed with a mean of 80000.

```
In [7]: a = np.zeros((40, 10000))
        for i in range(10000):
            a[:, i] =  0.1 * cumsum(income_mat[:, i])

        b = np.zeros((10000, 1))
        for i in range(10000):
            b[i, 0] = np.sum(a[:, i] < 95000) + 1
```

```
In [8]: plt.hist(b, bins = 5)
        plt.xlabel("Years took to pay off the loan")
        plt.title("MACSS student debt pay-off time")
```

Out[8]: Text(0.5,1,'MACSS student debt pay-off time')




```
In [9]: num = (b <= 10).sum()
        num/10000
```

Out[9]: 0.1678

In 16.78% of the simulations, I can pay off the debt in ten years.

```
In [10]: sim_profile2 = {'inc0': 90000,
                        'g': 0.025,
                        'rho': 0.4,
                        't': 2059,
                        'num_draws': 10000,
                        'mean': 0,
                        'sd': 0.17
                       }

         income_mat2 = normal_sim(sim_profile2)
         income_mat2
```

```
Out[10]: array([[ 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]])
```

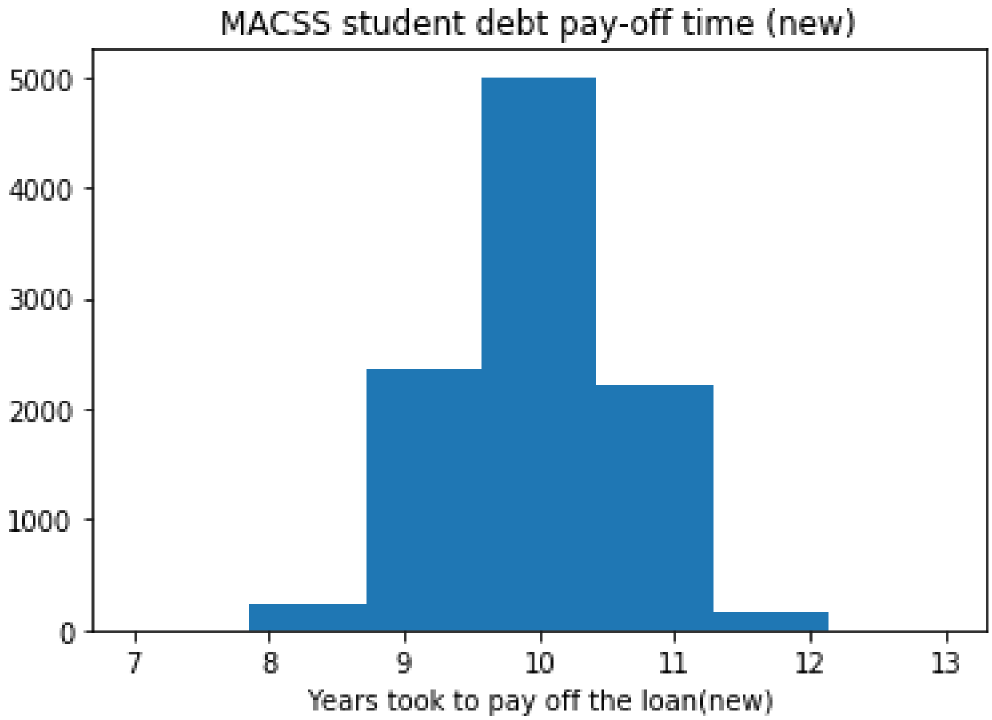
In [11]:
```python
a2 = np.zeros((40, 10000))
for i in range(10000):
    a2[:, i] =  0.1 * cumsum(income_mat2[:, i])

b2 = np.zeros((10000, 1))
for i in range(10000):
    b2[i, 0] = np.sum(a2[:, i] < 95000) + 1
stats.describe(b2)
```

Out[11]:
```
DescribeResult(nobs=10000, minmax=(array([7.]), array([13.])), mean=array([9.9733]), v
```

In [12]:
```python
plt.hist(b2, bins = 7)
plt.xlabel("Years took to pay off the loan(new)")
plt.title("MACSS student debt pay-off time (new)")
```

Out[12]:
```
Text(0.5,1,'MACSS student debt pay-off time (new)')
```



```
In [13]: num2 = (b2 <= 10).sum()
         num2/10000

Out[13]: 0.7602
```

In the new simulation, in 76.02% of the simulations, I can pay off the debt in ten years.