**20161342 KeonWooKim**

**Submit a pdf document to show your work. Put screenshots of your code and its results, and explain them.**

**1. (40 pts) Implement the financial planning example in Chapter 7. You may use any of the formulations given in pages 30 and 32. Show that the optimal decisions and outcomes for all scenarios and stages can be found as in page 34.**

First of all, ‘cvxpy’ and ‘numpy’ library are used on this assignment to solve out stochastic problem.

텍스트이(가) 표시된 사진

자동 생성된 설명

I set 14 variables on ‘x’ since we are on three-stage stochastic problem, 14 investments are executed.

x(1,1), x(2,1), x(1,2,1), x(2,2,1), x(1,2,2), x(2,2,2), x(1,3,1,1), x(2,3,1,1), x(1,3,1,2), x(2,3,1,2), x(1,3,2,1), x(2,3,2,1), x(1,3,2,2), x(2,3,2,2) -> 14 kinds of investment on problem

Then, I set 8 variables each on ‘y’ and ‘w’ because there are 8 number of scenarios possible to happen. ‘y’ refers to the amount of money exceeded the goal while ‘w’ refers to the amount of money short from the goal. And I also fixed the value of q as ‘1’ and r as ‘4’. They represent the piece-wise linear concave utility function on exceeding the goal or under the goal. They will be used on making objective function with ‘y’ and ‘w’.

Also, the return amount on ‘bull’ and ‘bear’ were fixed each on stock and bond. When ‘bull’ is executed, stock return is 25% while bond return is 14%. On the other hand, when ‘bear’ is executed, sock return is 6% while bond return is 12%.

And I also fixed the initial amount and goal amount as $55,000 and $80,000.

텍스트이(가) 표시된 사진

자동 생성된 설명

Second of all, I set the objective function as which means find out maximum value of sum of difference between the utility value when exceed the goal and the utility value when under the goal on each scenario with equal probability 0.125.

After setting the objective function, the constraints on three-stage stochastic problem were structured.

1. The sum of first and second term’s investment is equal to initial amount.
2. The sum of investment applying bull or bear return on investment at time ‘t’ should be equal to the sum of investment without applying bull or bear return at time ‘t+1’.
3. The sum of investment at time ‘3’ applying bull or bear return minus ‘y’ plus ‘w’ should be equal to goal amount on each scenario (1~8).
4. Non-negativity constraints

텍스트이(가) 표시된 사진

자동 생성된 설명

To sum up, the optimal decisions and outcomes for all scenarios from this python implementation got same value on ppt slides (page.34)**.** Since I treated ‘x\_0’ as cp.variable(14), its value form is 1D form. Thus, we should look at the index value on its array in order to compare the answer values on ppt slide. Changing this array into list structure, the comparison between the values I made and answers is

x\_0[0], x\_0[1] belongs to about (41500, 13500)

x\_0[2], x\_0[3] belongs to about (65100, 2170)

x\_0[4], x\_0[5] belongs to about (36700, 22400)

x\_0[6], x\_0[7] belongs to about (83800, 0)

x\_0[8], x\_0[9] belongs to about (0, 71400)

x\_0[10], x\_0[11] belongs to about (0, 71400)

x\_0[12], x\_0[13] belongs to about (64000,0)

Therefore, for each eight scenario’s outcomes would be calculated as same as ppt.



