Problem description

You are the director of Clever and Very Complex Machines (or short: CVCM), a company producing advanced machinery using even more advanced machinery.

The old production machinery has broken down, so you need to buy new production machines for the company. Your goal is to make as much money as possible during the restructuring period.

During this period you will be able to buy and sell machines and operate them for profit while CVCM owns them. Due to space restrictions, CVCM can own at most one machine at a time.

During the restructuring period, there will be several machines for sale. Being an expert in the advanced machines market, you already know the price `P_i` and the availability day `D_i` for each machines `M_i` .

Note that if you do not buy machine `M_i` on day `D_i` then somebody else will buy it and it will not be available later.

Needless to say, you cannot buy a machine if CVCM has less money than the price of the machine. If you buy a machine `M_i` on day `D_i` then CVCM can operate it starting on day `D_i` + 1.

Each day that the machine operates, it produces a profit of `G_i` dollars for the company.

You may decide to sell a machine to reclaim a part of its purchase price any day after you've bought it.

Each machine has a resale price `R_i` for which it may be resold to the market. You cannot operate a machine on the day that you sell it, but you may sell a machine and use the proceeds to buy a new machine on the same day. Once the restructuring period ends, CVCM will sell any machine that it still owns.

Your task is to maximize the amount of money that CVCM makes during the restructuring.

Strategy-1

Buy and Sale on Same Day

It is mentioned in the problem description that the director may sell a machine and proceeds to buy a new machine on the same day.

Assumptions:

Remaining machines will be sold at the end of restructuring period. Earning from the resale of machines will be added to the profit. Profit obtained from the use of old machines during the restructuring period is not considered. Several other factors are usually consider to make buy and sale decisions. It is not considered in the proposed method.

Methodology:

Proposed method is based on simulation or simple logic. Exact method is also used to compare the optimality of the obtained result. In the given dataset, multiple buy and sale is mentioned on same day in Case#5 & 6. Considering the input data provision has been given to create to different set of mathematical model. Open source "mip" package is required to solve simple mixed integer model. Exact method is used for validation of result. **Simulation is the main approach.** The proposed approach can help us to compare different buy and sale strategies.

System Requirements and Packages:

- **Python 3.6 or 3.8**
- **MIP package**
- **Windows 10 64 bit**

Mathematical Model:

The simplest mathematical model would be as follows:

$$P_k^A: Set\ of\ available\ days\ in\ case\ k\ in\ the\ give\ data\ i.e\ \{6,1,3,8,4,2\} for\ Case\ 1$$

$$I_k : Set\ of\ restructuring\ days\ in\ case\ k\ i.e.\{0,1,2,\dots\dots,20\} for\ Case\ 1$$

K: Set of cases in the given data i.e. {1,2,3,4,…,7}

x_i : $1\ if\ a\ machine\ is\ purchased\ on\ i^{th}\ day. On\ the\ same\ day\ an\ old\ machine\ will\ be\ sold.$

Where $i\ \in\ P_k^A\ and\ P_k^A\ \subseteq I_k$

N_k : Number of machines to be sold in case k

C_k: Budget in case k

D_k: Restructuring Period in case k

$D_{i,k}$: the day on which the machine is for sale in case k

$P_{i,k}$: the dollar price for which it may be bought in case k

$R_{i,k}$: the dollar price for which it may be resold in case k

$G_{i,k}$: the daily profit generated by operating the machine in case k

$Indx_k$
: $Set\ of\ available\ index\ for\ case\ k\ in\ the\ given\ data.\ It\ baically\ maps\ available\ day\ of\ a\ particular\ case\ with\ row\ number\ of\ the\ given\ data$

Objective:

$$Maximize \sum_{i \in P_k^A, k \in K, j \in Indx_k} x_i * G_{j,k} * (D_k - D_{j,k} - 1) - \sum_{i \in P_k^A, k \in K, j \in Indx_k} x_i * (P_{j,k} - R_{j,k})$$

s.t

$$\sum_{i \in P_k^A, k \in K, j \in Indx_k} x_i * (P_{j,k} - R_{j,k}) \leq Budget$$

$$x_i \in \{0,1\}$$

Solver will work for each cases one after another automatically and generate the below result.

Result:

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STRATEGY : Buy and Sale on Same Day

Solution Using Exact and Simulation Method

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N C D ROI(Exact) ROI(Simulation)

6 10 20 Case 1 : 83.0 Case 1 : 83

0 11 30 Case 2 : 0.0 Case 2 : 0

1 12 30 Case 3 : -2 Case 3 : -2

1 10 2 Case 4 : -6 Case 4 : -6

2 10 11 Case 5 : 59.0 Case 5 : 59

2 10 11 Case 6 : 59.0 Case 6 : 59

0 0 0 Case 7 : 0.0 Case 7 : 0

Note: ROI is not considering allocated budget

Strategy-2

Buy First and Sale Later

This is strategy is not effective as factory space is a major concern and at the same time very less number of machines will be purchased.

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STRATEGY : Buy First and Sale Later

Solution Using Exact and Simulation Method

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N C D ROI(Exact) ROI(Simulation)

6 10 20 Case 1 : 58.0 Case 1 : 58

0 11 30 Case 2 : 0.0 Case 2 : 0

1 12 30 Case 3 : -2 Case 3 : -2

1 10 2 Case 4 : -6 Case 4 : -6

2 10 11 Case 5 : 36.0 Case 5 : 36

2 10 11 Case 6 : 36.0 Case 6 : 36

0 0 0 Case 7 : 0.0 Case 7 : 0

Best strategy is - Buy and Sale on Same Day