**ASSIGNMENT 3**

**Advanced mathematical modeling for managerial decisions**

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Date: August 8, 2021

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**Q1**

**Parameters:**

: Number of jobs.

: Set of jobs.

: Non crash time of job “j”.

: Normal cost of job “j”.

: Minimum process time of job “j” post crashing.

: Crash time.

: Crash cost per week for job “j”.

: Precedence Matrix, 1 if “j” immediately precedes “k”.

: Maximum time before penalty kicks in.

*:*  Penalty rate per week beyond deadline “T”.

*m:* Small m, to find obtain slack

**Variables:**

**Variables that are part of the original model:**

: Crash time for job “j”.

: End time for job “j”.

: Start time for job “j”.

: Lateness (days beyond deadline T) >0.

**Variables in addition to the original model for critical path calculation:**

: 1 if job “j” is ***not*** critical (binary).

: Slack value of job “j”.

**Objective Function**

**Minimize**

**Constraints**

**Constraints that are part of the original model**



**New constraints added to the original model**



Explanation: Calculates slack value based on gaps in front and back of job “j”.

**Result:**

SL [\*] :=

0 0

1 0

2 0

3 1

4 0

5 1

6 0

7 0

8 0

;

As can be seen the jobs “3” and jobs “5” **are not** critical. The same can also be seen by simply obtaining the shadow prices of the third constraint in the original model. The results of the same shown below:

The numbers mentioned below are the shadow prices obtained using the 3rd constraint in the original model (please check code files). As can be seen the shadow prices of the 3rd and the 5th job are 0. The shadow prices can be obtained by using the “ display “constraint name”” in the run file.

End\_start [\*] :=

0 0

1 7000

2 3000

3 0

4 4000

5 0

6 3000

7 7000

8 10000

**Q2**

**Parameters:**

: Number of mines.

: Set of mines.

: Number of years of the simulation (corresponding set is “*Years*”).

: Maximum number of mines that can be operated in any given year.

: Profit per ton.

: Discount rate

: Royalties for keeping mine “m” open.

: Quality of ore produced from mine “m”.

: Stipulated quality for year “y”.

: Maximum extraction of ore from mine “m”.

*:*  Big M (Maximum of the production capacities per year across mines).

**Variables**

: 1 if mine “m” if kept open in year “y”.

: 1 if mine “m” if used in year “y”.

: Amount of ore extracted from mine “m” in year “y”.

: Profit margin from extraction alone in year “y”.

: Royalties paid in year “y”.

: Revenue – Cost for year “y”.

**Objective function**

**Maximize**

**Constraints**

The first 3 constraints basically model the cash flow variables.

The below constraint states that to use a mine “m” in year “y” the mine needs to be open.

The below constraint models the fact that if there has been any extraction from mine “m” in year ”y” then the mine must have been kept open for all years “k” before the year “y” (Note there is a commented out alternate version of the constraint in the code files)

The below constraint models the fact that to extract any ore from mine “m” from year “y” the mine must have been used.

Stipulated quality constraint:

Maximum extraction constraint:

Maximum mines use constraint:

**Results:**

objective: Profits

Profits = 146.862

**Mines operated matrix (Mines\_Use):**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Mines operated** | | | | | | |
|  | | **Years** | | | | |
| **1** | **2** | **3** | **4** | **5** |
| **Mines** | **1** | 1 | 0 | 1 | 1 | 1 |
| **2** | 0 | 1 | 0 | 1 | 1 |
| **3** | 1 | 1 | 1 | 0 | 1 |
| **4** | 1 | 1 | 0 | 1 | 0 |

**Amount of ores extracted across mines and years (Extract):**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tons of ore extracted** | | | | | | |
|  | | **Years** | | | | |
| **1** | **2** | **3** | **4** | **5** |
| **Mines** | **1** | 2.00 | 0.00 | 1.95 | 0.13 | 2.00 |
| **2** | 0.00 | 2.50 | 0.00 | 2.50 | 2.17 |
| **3** | 1.30 | 1.30 | 1.30 | 0.00 | 1.30 |
| **4** | 2.45 | 2.20 | 0.00 | 3.00 | 0.00 |