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***BUS 443—Business Analytics***

**Linear Programming Assignment 4: Binary Models**

**The Marr Corporation: Capital Budgeting Problem**

Companies and committees often find themselves facing a problem of allocating a capital budget. As the problem arises in many firms, there is a specified budget for the year, to be invested in multi-year projects. There are also several proposed projects under consideration.

The committee’s job is to determine how to maximize the value of the projects selected, subject to the limitation on expenditures represented by the capital budget. In the classic version of the capital budgeting problem, each project is described by two values: the expenditure required and the value of the project. As a project is typically a multi-year activity, its value is represented by the net present value (NPV) of its cash flows over the life of the project. The expenditure, combined with the expenditures of other projects selected, cannot be more than the budget available.

Division A of the Marr Corporation has been allocated $160 million for capital projects this year. Managers in Division A have examined various possibilities and have proposed five projects for Marr’s capital budgeting committee to consider. The projects cover a variety of activities, as listed below:

Project 1: Implement a new information system

Project 2: License a new technology from another firm

Project 3: Build a state-of-the-art recycling facility

Project 4: Install an automated machining center in production

Project 5: Move the receiving department to new facilities on site

There is just one project of each type. Each project has an estimated NPV and each requires a capital expenditure, which must come out of the budget for capital projects. The following table summarizes the possibilities, with all figures in millions of dollars:

**PROJECT**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Project 1** | **Project 2** | **Project 3** | **Project 4** | **Project 5** |
| NPV | 10 | 17 | 16 | 8 | 14 |
| Expenditure | 48 | 96 | 80 | 32 | 64 |

The committee would like to maximize the total NPV from projects selected, subject to the budget limit of $160 million. **The decision problem is to determine which projects to select**; that is, to maximize Marr’s profit for the year by choosing each possible project with a yes or a no. We can formulate this problem as an allocation model with one business constraint. To construct the algebraic model, we let: y = 1 if the project is accepted, and 0 otherwise.

An algebraic statement of the model is the following:

Maximize z (profit) = 10y1 + 17y2 + 16y3 + 8y4 + 14y5

subjectto:

48y1 + 96y2 + 80y3 + 32y4 + 64y5 <= 160

Open a new spreadsheet and use the SUMPRODUCT function to calculate cell results in the model.

1. Create the model using an integer model constraint on the decision variables. What is your result?
2. Modify the model to use “one-of-a-kind projects”; that is, none can be implemented more than once. What are the maximum profit and corresponding project “go / no go” decisions?
3. Now that you know about integer optimization, modify the Veerman and Acme LP models to only use integers instead of fractional values.

Source: Management Science: The Art of Modeling with Spreadsheets, Third Edition, Powell and Baker.