INSTITUTO SUPERIOR DE AGRONOMIA

Applied Operations Research

**Goal programming – Exercises**

1) The Dewright Company problem includes all three possible types of goals: a lower, one-sided goal (long-term profit); a two-sided goal (employment level); and an upper, one-sided goal (capital investment). Letting the decision variables *x*1, *x*2, *x*3 be the production rates of products 1, 2, and 3, respectively, we see that these goals can be stated as

profit goal is a lower one-sided goal: 12 x1 + 9 x2 + 15 x3 ≥ 125

employment goal is a two-sided goal: 5 x1 + 3 x2 + 4 x3 = 40

investment goal is an upper one-sided goal: 5x 1 + 7 x2 + 8 x3 ≤ 55

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Factor** | **Unit contribution** | | | **Goal Unit** | | | **Penalty Weight** |
| **Product** | | |
| **1** | **2** | **3** |
| Long-term profit | 12 | 9 | 15 | ≥ | 125 | (millions of dollars) | 5 |
| Employment level | 5 | 3 | 4 | = | 40 | (hundreds of employees) | 2(+), 4(-) |
| Capital investment | 5 | 7 | 8 | ≤ | 55 | (millions of dollars) | 3 |

Given the penalty weights incurred by missing these goals shown in the rightmost column of the table, find the production rates of the 3 products that minimize the sum of weighted penalties.

2) Reconsider the original version of the Dewright Co. problem presented in exercise 1 and summarized in the table below. After further reflection about the solution obtained by the simplex method, management now is asking some what-if questions.

a)Management wonders what would happen if the penalty weights in the rightmost column of the table were to be changed to 7, 4, 1, and 3, respectively. Would you expect the optimal solution to change? Why?

b) Management is wondering what would happen if the total profit goal were to be increased to at least $140 million (without any change in the original penalty weights). Solve the revised model with this change.

c) Solve the revised model if both changes are made.

3) Solving the Keeping the river clean problem using goal programming. A pulp mill makes mechanical and chemical pulp. The owners would like to:

* Pollution goal: 1 ton of mechanical pulp produces 1 unit of biological oxygen demand – BOD, 1 ton of chemical pulp produces 1.5 units. The mill environmental department would like to stay close to 400 BOD;
* Revenue goal: Chemical pulp sells at 200€/ton, mechanical at 100€/ton and the mill aims to generate around 40000€ of revenue per day (don’t mind it the revenue is higher);
* Labour goal: both chemical and mechanical pulp require the labor of one worker for about 1 day, or 1 workday (wd), per ton produced and the mill human resources wish, if possible, to keep at least 300 people employed at the mill;
* The maximum capacity of the mill to make mechanical pulp is 300 tons/d and 200 tons/d for chemical pulp (the mechanical pulp line cannot be used to make chemical pulp, and vice-versa)

3.1) Formulate the goal programing problem writing the goals in the form of constraints

3.2) Specify the objective function so that the weighted sum of the deviations from all

the goals are minimized

3.2.1) reduce the objective function to the simplest expression, ie, variables are needed (e.g. in our example, if the concern is about falling short of the employment goal but not about exceeding it, leave the positive deviation out)

3.2.2) solve the problem using EXCEL solver considering that **all deviations are equally important**. Note that it is advisable to consider relative deviations since each goal has its own unit

3.2.3) ) solve the problem using EXCEL solver considering that **all deviations are equally important** but this time, instead of being conservative, be bolder and rise the revenue and labour goals to 60000 and 600, respectively

3.2.4) solve the problem using EXCEL solver considering that **all deviations are equally important** varying the targets to see if you manage to find null deviations to all goals