Solution to Example 19.01 Using CVX

File: `Ch19_E01.m`

Demonstrate the solution of a linear programming problem for process operation.

Contents

Software requirements

This script requires CVX (download from http://cvxr.com) and access to the utility functions.

```
addpath('utilities')
```

Version 1

This first version is a straight translation of the problem using the CVX modeling syntax.

```
cvx_quiet TRUE;
cvx_begin

    variables x(4)

    x >= 0;
    x <= [40000; 30000; 30000; 30000];

    sales = 0.4*x(3) + 0.33*x(4);
    feedstock = 0.15*x(1) + 0.2*x(2);
    operating = 0.15*x(3) + 0.05*x(4) + 350 + 200;

    profit = sales - feedstock - operating;

    x(1) == 0.667*x(3) + 0.5*x(4);
    x(2) == 0.333*x(3) + 0.5*x(4);

    maximize profit

cvx_end

displaytable(profit,'Maximum Profit = ');
displaytable(x,{'A','B','E','F'},{'Value'});
```

```
Maximum Profit =   5100.5
```

```
   Value
A  35010
B  24990
E  30000
F  30000
```

Version 2

Sensitivity analysis determines the sensitivity of the objective to changes in parameters. In this case we are interested in the dependence of profit on the process capacity constraints. This information is important in many process situations.

In CVX, sensititivities are computed as the dual variables corresponding to constraints as demonstrated below.

```
cvx_begin

    variables x(4)
    dual variable y

    x >= 0;

    sales = 0.4*x(3) + 0.33*x(4);
    feedstock = 0.15*x(1) + 0.2*x(2);
    operating = 0.15*x(3) + 0.05*x(4) + 350 + 200;

    profit = sales - feedstock - operating;

    x(1) == 0.667*x(3) + 0.5*x(4);
    x(2) == 0.333*x(3) + 0.5*x(4);

    ub = [40000; 30000; 30000; 30000];

    y: x <= ub

    maximize profit

cvx_end

displaytable(profit,'Maximum Profit = ');
displaytable([x,ub,ub-x,y],{'A','B','E','F'},{'Opt','UB','Slack','Sens.'});
```

```
Maximum Profit =   5100.5

          Opt          UB       Slack       Sens.
A       35010       40000        4990  6.1999e-14
B       24990       30000        5010   5.789e-14
E       30000       30000   2.161e-09     0.08335
F       30000       30000  1.7317e-09       0.105
```

Observations

1. There are two active constraints.
2. Profit could be increased by investing in a process expansion.

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