# OPERATIONS RESEARCH PRESENTATION

Group 3:

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# Question 1: Linear programming problem

## (1.15) Mixed Investments

- The firm Inversiones Internacionales, S.A.U. has up to 5 million $ available to invest in six possible investments.

- The table shows the characteristics of each investment.

| Investments | Profitability (%) | Risk |
|---|---|---|
| Trade credits | 7 | 1.7 |
| Corporate bonds | 10 | 1.2 |
| Stocks of gold | 19 | 3.7 |
| Stocks of platinum | 12 | 2.4 |
| Mortgage bonds | 8 | 2.0 |
| Building loans | 14 | 2.9 |

## Decision variables:

- $x_1$ = Dollars invested in trade credits
- $x_2$ = Dollars invested in corporate bonds
- $x_3$ = Dollars invested in stocks of gold
- $x_4$ = Dollars invested in stocks of platinum
- $x_5$ = Dollars invested in mortgage bonds
- $x_6$ = Dollars invested in building loans

## Objective function (profitability gained in dollars):

- Maximize
- $z = 0.07x_1 + 0.01x_2 + 0.19x_3 + 0.12x_4 + 0.08x_5 + 0.14x_6$

# Constraints:

- $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6) \le \$5{,}000{,}000$

From experience in such investments, the firm knows it is not recommended to invest more than 25 % of the total investment in any of these investment options.

- $x_1 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

- $x_2 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

- $x_3 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

- $x_4 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

- $x_5 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

- $x_6 \le (25/100)(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)$

# Constraints:

Besides, it is necessary to invest at least 30 % in precious metals, and at least 45 % between trade credits and corporate bonds.

**For at least 30 % in precious metals:**

- $x3 + x4 >= 0.30 (x1 + x2 + x3 + x4 + x5 + x6)$

**For at least 45 % between trade credits and corporate bonds:**

- $x1 + x2 >= 0.45 (x1 + x2 + x3 + x4 + x5 + x6)$

# Constraints:

▶ Finally, an overall risk limit of no more than 2.0 is required.

$1.7x1 + 1.2x2 + 3.7x3 + 2.4x4 + 2.0x5 + 2.9x6 <=$

$2.0 (x1+ x2+ x3+ x4+ x5+ x6)$

▶ **Non negativity constraint:**

x1, x2, x3, x4, x5, x6 >=0

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# Classifying the problem:

▶ **Based on the nature of equations involved:**

    Linear programming problem

▶ **Based on the decision variable:**

    Real valued programming problem

▶ **Based on no. of objective functions:**

    Single objective problem

▶ **Based on constraints involved in the problem:**

    Multiple constrained optimization problem

# USING AMPL

```
var x1;
var x2;
var x3;
var x4;
var x5;
var x6;
maximize z: 0.07*x1+0.01*x2+0.19*x3+0.12*x4+0.08*x5+0.14*x6;
subject to con1: x1+x2+x3+x4+x5+x6<=5000000;
subject to con2: x1<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con3: x2<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con4: x3<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con5: x4<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con6: x5<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con7: x6<=(25/100)*(x1+x2+x3+x4+x5+x6);
subject to con8: x3+x4>=(0.30)*(x1+x2+x3+x4+x5+x6);
subject to con9: x1+x2>=(0.45)*(x1+x2+x3+x4+x5+x6);
subject to con10: 1.7*x1+1.2*x2+3.7*x3+2.4*x4+2.0*x5+2.9*x6<=2*(x1+x2+x3+x4+x5+x6);
solve;
display x1,x2,x3,x4,x5,x6,z;
```

# USING AMPL

```
ampl: model lppOR.mod;
MINOS 5.51: optimal solution found.
6 iterations, objective 411666.6667
x1 = 1250000
x2 = 1e+06
x3 = 250000
x4 = 1250000
x5 = 972222
x6 = 277778
z = 411667
```