# PLANFIN - A DECISION SUPPORT SYSTEM FOR BONDPORTFOLIO SELECTION

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Abstract. This paper presents a decision support system, running under Microsoft Windows, and implementing a linear programming model for bond portfolio selection. The program is part of the LINMOD package.

## 1. Introduction

There is no single universally accepted definition of a decision support system (DSS). For example, Turban [1988 and 1992], gives, among others, the following two: (1) A DSS is a form of computer software, designed and operated to model or otherwise represent the structure of a decision problem, and thus allow the user(s) to identify and select a preferred strategy or other course of action from two or more alternatives against a pre-determined set of criteria, and (2) A DSS is a set of systematically organised procedures whereby a decision maker can be assisted in capturing and analysing information relevant to a decision task. Such a process can be used repeatedly if required, and can assist any decision maker to anticipate the probable outcome of any given choice or strategy.

To overcome the lack of such an universally accepted definition, Turban proposes four main characteristics for a DSS: (1) DSS incorporate both data and models; (2) DSS are intended to assist managers in their decision making for tasks or decision problems that may have varying levels of structure; (3) DSS are designed to be used to support and not to replace managerial judgement and (4) DSS are designed with the objective of improving the effectiveness of decisions, they will also, generally also improve the efficiency of decision making through speed and the ease with which decision processes may be repeated at will.

Some decision problems are optimization problems, which can be solved using well-known mathematical models. This paper presents FINPLAN decision support system, part of the LINMOD computer package, aimed to help solving decision problems that can be modeled using linear programming techniques.

## 2. Mathematical background

### 2.1. The linear programming model
The general mathematical programming problem is stated as follows:

> **Maximize (minimize) the function:**
> $$f(x) = f(x_1, x_2, ..., x_n)$$
> **where** $x = (x_1, x_2, .., x_n)$ **is subject to:**
> $$g_i(x) = g_i(x_1, x_2, .., x_n) \leq 0, \ i = 1, 2, ..., m.$$

The variables $x = (x_1, x_2, ..., x_n)$ are known as *decision variables*, the function $f$ is called *objective function*, and $g_i(i = 1, 2, ..., m)$ are *constraints*.

When the objective function and the constraints are linear, the problem becomes the *linear programming problem*:

> **Maximize (minimize) the function:**
> $$f(x) = cx = \sum_{k=1}^{n} c_k x_k$$
> **subject to:**
> $$g_i(x) = \sum_{k=1}^{n} a_{ik} x_k - b_i \leq 0, \ i = 1, 2, ..., m.$$

The well-known method for solving linear programming problems is the Simplex algorithm [Dantzig, 1963].

### 2.2. Bond portfolio selection
Portfolio analysis was originally formulated by Markowitz in 1952 and involves the finding of the most desirable categories of stocks (bonds, investment projects) to hold, given the characteristics of each of them. The problem is how to split the investor's capital among these investment projects in order to maximize the expected return.

Each investment project has its own costs, risks, and profit. Another constraints refer to the amount spent on each such a project. For a detailed discussion of modeling such problems, see, for example [Zopounidis, 1998].

I. *Problem statement.* A financial investment company has an amount $S$ of capital to be invested in 5 different bonds. Bond characteristics on a one-year period are given in Table 1 below:

| Bond | Growth price rate (%) | Minimal growth price rate (%) | Risk index |
|------|-----------------------|-------------------------------|------------|
| 1 | $D_1$ | $M_1$ | $R_1$ |
| 2 | $D_2$ | $M_2$ | $R_2$ |
| 3 | $D_3$ | $M_3$ | $R_3$ |
| 4 | $D_4$ | $M_4$ | $R_4$ |
| 5 | $D_5$ | $M_5$ | $R_5$ |

Table 1. Bond characteristics

Risk index is a number defining the risk degree of the bond (small risk index denotes small risk), having the semantics of a cost index. The investment is governed by the following constraints:

- mean minimal grow price rate greater than $DM\%$ ,

- mean risk index less than $IR$,

- the amount spent on each bond should be less than $P\%$ of $S$.

II. *Notations.* Let (where not explicitly stated, $i = 1, 2, ..., 5$):

- $x_i$– be the amound spent on bond $i$,

- $PM_i$ – be minimal return obtained from bond $i$,

- $DMIN$ – be minimal grow price rate,

- $IRISC$ – be maximal risk index,

- $PR_i$ – be return on investments of bond $i$,

- $PR$ – be total return on investments.

Using the above notations, we compute the following quantities as follows:

- minimal return of bond $i$ $PMi = x_i \cdot M_i$ ,

- minimal grow price rate (weighted average of individual minimal grow price rates, where the weights are the invested amounts):

$DMIN = (PM_1 + PM_2 + PM_3 + PM_4 + PM_5)/S$
or
$DMIN = (x_1 \cdot M_1 + x_2 \cdot M_2 + x_3 \cdot M_3 + x_4 \cdot M_4 + x_5 \cdot M_5)/S$

- mean risk index (weighted average of individual risk indices, the weights being the invested amounts): $IRISC = (x_1 \cdot R_1 + x_2 \cdot R_2 + x_3 \cdot R_3 + x_4 \cdot R_4 + x_5 \cdot R_5)/S$ ,

- return on investments of bond $i$: $PR_i = x_i \cdot D_i$,

- total return of investments: $PR = PR_1 + PR_2 + PR_3 + PR_4 + PR_5$.

III. Constraints refer to:

- *all available capital should be invested*: $x_1 + x_2 + x_3 + x_4 + x_5 =_S$,

- *specific constraints*

- mean minimal grow price rate greater than $DM\%$

$DMIN \geq DM$
i.e.
$(PM_1 + PM_2 + PM_3 + PM_4 + PM_5)/S \geq DM$
or
$PM_1 + PM_2 + PM_3 + PM_4 + PM_5 \geq S \cdot DM$
or
$x_1 \cdot M_1 + x_2 \cdot M_2 + x_3 \cdot M_3 + x_4 \cdot M_4 + x_5 \cdot M_5 \geq S \cdot DM$

- mean risk index less than $IR$

$IRISC \leq IR$
i.e.
$(x_1 \cdot R_1 + x_2 \cdot R_2 + x_3 \cdot R_3 + x_4 \cdot R_4 + x_5 \cdot R_5)/S \leq IR$
or
$x_1 \cdot R_1 + x_2 \cdot R_2 + x_3 \cdot R_3 + x_4 \cdot R_4 + x_5 \cdot R_5 \leq S \cdot IR$

- the amount spent on each bond should not be greater than $P\%$ of $S$
  $x_i S \cdot P/100, \ i = 1, 2, ..., 5,$

- nonnegativity restrictions for problem variables: $x_i \geq 0, \ i = 1, 2, ..., 5.$

IV. *Objective function*:
$PR \rightarrow MAX$, i.e.
$PR_1 + PR_2 + PR_3 + PR_4 + PR_5 \rightarrow MAX$ .

V. *Mathematical programming formulation*:
$PR_1 + PR_2 + PR_3 + PR_4 + PR_5 \rightarrow MAX$
subject to:
$x_1 + x_2 + x_3 + x_4 + x_5 = S$ ,
$x_1 \cdot M_1 + x_2 \cdot M_2 + x_3 \cdot M_3 + x_4 \cdot M_4 + x_5 \cdot M_5 \geq S \cdot DM,$
$x_1 \cdot R_1 + x_2 \cdot R_2 + x_3 \cdot R_3 + x_4 \cdot R_4 + x_5 \cdot R_5 \leq S \cdot IR,$
$x_i \leq S \cdot P/100, \ i = 1, 2, ..., 5,$
$x_i \geq 0, \ i = 1, 2, ..., 5$
where all $M_i, D_i, R_i (i = 1, 2, 3, 4, 5)$, as well as $S, DM, IR, P$, are known quantities.

## 3. The program

The current version of LINMOD package contains five computer applications: **ProdPlan**, **DietMix**, **Transport**, **Blending**, and **FinPlan** (see, for details, [3]-[7]). All are implemented in Microsoft Visual Basic.

### 3.1. Common User Interface Features
The user interface of the programs is using Romanian language. All programs in the package have some common features with respect to the user interface, as follows:

- input data from keyboard can be stored in a file, and can be reloaded later;

- the results are displayed in a separate window.

The above features are implemented by the following elements in the main window (Figure 2):

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- separate text boxes for the number of rows/columns;

- a table-like presentation of input data;

- six command buttons: **Încarcă** (**Load**) and **Salvează** (**Sav**e) – loading and saving the current data in a file; **Prelucrează** (**Process**) – performing the computations and displaying the results; **Afişeazã** (**Display**) – activating the **Results Window** (see below); **Ajutor** (**Help**) and **Închide** (**Close**).

The **Results Window** contains a text box which fills all its client area and a menu **Fişiere** (**File**). The text box shows all the results produced by the program; the user can scroll in both horizontal and vertical directions. The **Fişiere** menu (Figure 1) has the following menu options: **Încarcă** (**Load**), **Salvează** (**Save**), **Listează** (**Print**), and **Închide** (**Close**).



Figure 1: The **Results Window** with its menu visible

The programs automatically generate the corresponding mathematical programming (LP) model and then solve it, producing the results in natural language form, using notations specific to the problem being solved. By pressing the **Ajutor** button, the user receives a short description of the problem and the corresponding linear programming model. The main window provides a range of display options, grouped under the title **Parametri de afisare**.

### 3.2. The FinPlan Program

The program builds the corresponding mathematical model of the bond portfolio selection problem described in 2.2 and then solve it by using the SIMPLEX algorithm. Its main window, shown in Figure 2, considers as parameters the number of bonds; after this information is supplied by the user, the button **Seteaza** (**Set**) will configure the data table corresponding to Table 1.

Besides this table, the main window contains text fields for other problem parameters $S$, $IR$, $P$, and $DM$.
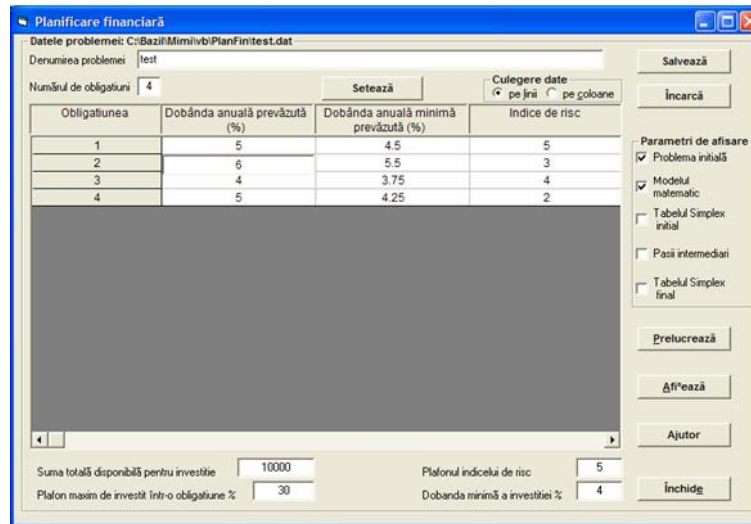
Figure 2: The main window of **FinPlan** program

### 4. Conclusion and future work

The programs in the LINMOD package are intended to ease the way a user uses modeling tools to solve decision problems. Pidd (1999) discusses six principles of modeling: (1) simplicity vs complexity, (2) gradual development of models, (3) division of larger models into smaller components, (4) use of analogies, (5) proper use of data, and (6) ordered process. Our opinion is that the programs presented comply with these principles, and help the user to better understand the modeling process.

Our future plans include the development of new computer programs as parts of the LINMOD package, for solving other decision problems like master production schedule, materials requirement planning, factory planning and so on.

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