USE OF A MICROCOMPUTER IN A DECISION ANALYSIS FOR INVESTMENT PORTFOLIO SELECTION

Jon R. Prescott,
Anderson Steel Buildings

ABSTRACT

Small businesses have needs and problems Chat are quite similar to those of larger businesses. In the past, some of these problems (such as computer simulation and ‘number crunching tasks) could only be solved on large computers that small businesses could not afford to use, let alone purchase. The coming and ever-increasing use of very low-cost microcomputers in government and industry have now made computing power available to small businesses in convenient and affordable form. This paper discusses the application of a microcomputer to decision making in investment portfolio selection for a small business. The author acted as a consultant to help evaluate the feasibility of this microcomputer-based application.

INTRODUCTION

The purpose of this article is to inform operations researchers (and other users) of an application package (software included) which has been designed for real world problem solving using a microcomputer system. This package implements a scientific approach for investment portfolio selection on a microcomputer, which is a somewhat new and very inexpensive computer technology. The methodology utilized to approach such problems is the operations research tool of linear programming (here, specifically the simplex algorithm).

PROBLEM DEFINITION AND DATA COLLECTION

An investment firm had approximately $200,000 (initially, depending on the success of this feasibility study:) for investment in different income-producing securities and government bonds 80 as to maximize the annual return to the firm. The specific problem was the determination of a system for scientifically computing what proportion of a fixed sum of money should be allocated to a given investment source to help achieve this maximum return to our firm. Further, five possible (actually more than five) or desirable sources of investment were considered by the firm, all of which were viewed (even conservatively) as having reasonably high yields and naturally, stability over time.

1. Oil company X stock, which pays 11¼ annual dividend.
2. Oil company Y stock, which pays 7.5% annual dividend.
3. Electric utility X stock, which pays 8% annual dividend.
4. Electric utility Y stock, which pays 6% annual dividend.
5. Government bonds paying 5% annual interest.

In this project there was very little concern with selling prices, since the firm had no plans whatsoever to sell any or all of these stocks in the near or foreseeable future. Based on the various risk levels involved (to provide a measure of the risk here, a sophisticated mathematical approach like a decision tree analysis or a more subjective one, or both may be applied here), the firm has made the following financial commitments on resource constraints:

1. The total investment in oil stocks cannot exceed $30,000;
2. The total investment in electric utilities cannot exceed $50,000;
3. The investment in oil company X may not exceed $20,000;
4. The investment in electric utility X cannot exceed $30,000;
5. The total investment in oil stocks cannot exceed the total investment in electric utilities;
6. The investment in oil company X and electric utility X combined may not exceed the investment in government bonds.

DEVELOPMENT OF A MATHEMATICAL MODEL OF THE INVESTMENT PROBLEM

Armed with the above data, the decision maker(s) (or author in this case) must at this point ascertain how much money to each type of investment in order to optimize the actual annual return (the reader should recognize that the time horizon could be different, e. g. monthly or perhaps quarterly).

The variables (defined below) will specify the amount of money invested in each alternative. Inasmuch as these variables will often be large values, the dimensional unit of each will be as thousands of dollars ($000). Hence,

X_1 - investment in oil company X ($000) (1)
X_2 - investment in oil company Y ($000) (2)
X_3 - investment in electric company X ($000) (3)
X_4 - investment in electric company Y ($000) (4)
X_5 - investment in government bonds ($000) (5)

Before proceeding further, for the benefit of the non-mathematically-oriented reader, it will be mentioned that the methodology of linear programming (and the simplex algorithm, in particular), as implemented on a microcomputer in a problem solving format, is a key point of this article. Also, it may be advisable for such a reader (depending on his level of interest in following the technical details here) that a mathematical or statistical text (or operations research) be kept at hand through this article. For those who are acquainted or versed (by accident or choice) in applied operations research or statistical analysis topics, it will likewise be commented that the real number of investments was much larger than 5, and in one special model formulation, another more financially-oriented factor was introduced (such as a less static investment horizon). But for presentation purposes, the above and ensuing discussions should suffice, so as to avoid obscuring the successful implementation of the investment or analytical model on a microcomputer system, rather than a mainframe. Frankly, a serious student or practitioner of operations research could do well to attempt to solve, at least in an approximate fashion, the problem presented in this article (or a two or three variable version of it) with only pencil, paper, and graphical methods, as taught in university operations research classes.

CONTINUATION OF MODEL FORMULATION

Our investment firm has only $200,000 to invest, so

$$X_1 + X_2 + X_3 + X_4 + X_5 \le 200 \qquad (6)$$

(recall that variables are defined in terms of thousands of dollars)

The investment in oil stocks cannot exceed $30,000:

$$X_1 + X_2 \le 30 \qquad (7)$$

The investment in electric utility stocks must not exceed $50,000:

$$X_3 + X_4 \le 50 \qquad (8)$$

The investment in oil company X cannot exceed $20,000:

$$X_1 \le 20 \qquad (9)$$

The investment in electric utility X may not exceed $30,000:

$$X_3 \le 30 \qquad (10)$$

The total investment in oil stocks must not exceed the total investment in electric utilities:

$$X_1 + X_2 \le X_3 + X_4 \text{, or as is necessary in a typical formulation of a linear programming model,} \qquad (11)$$

$$X_1 + X_2 - X_3 - X_4 \le 0, \qquad (12)$$

The investments in oil company X and electric utility X combined may not exceed the investment in government bonds:

$$X_1 + X_3 \le X_5 \text{, or as above,} \qquad (13)$$

$$X_1 + X_3 - X_5 \le 0 \qquad (14)$$

The objective function must express the annual return, in this case, to the firm:

$$Z = 0.11X_1 + 0.075X_2 + 0.08X_3 + 0.06X_4 + 0.05X_5 \qquad (15)$$

Again, remember that since the individual constraint is measured in terms of thousands of dollars, so must also be the objective function.

Finally, the complete linear programming model is depicted below:

Maximize

$Z = 0.11X_1 + 0.075X_2 + 0.08X_3 + 0.06X_4 + 0.05X_5$: Return ($000)

Subject to:	Resource Constraints
1. Cash	$X_1 + X_2 + X_3 + X_4 + X_5 \le 200$
2. Max oil	$X_1 + X_2 \le 30$
3. Max electric	$X_3 + X_4 \le 50$
4. Max oil co. X	$X_1 \le 20$
5. Max electric X	$X_3 \le 30$
6. Oil-utility	$X_1 + X_2 - X_3 - X_4 \le 0$
7. Bonds	$X_1 + X_3 - X_5 \le 0$,

Where (as outlined before):

X_1 = investment in oil company X ($000)
X_2 = investment in oil company Y ($000)
X_3 = investment in electric utility X ($000)
X_4 = investment in electric utility Y ($000)
X_5 = investment in government bonds ($000)

IMPLEMENTATION ON A MICROCOMPUTER

This linear programming model of the investment portfolio selection problem is now in acceptable format for input to a BASIC computer program and run on an IMSAI microcomputer (with an 8080 chip). This program should work for 'inequality" constraints (<) only (BASIC code for the above model with inequality and equality constraints is currently available). The author also has an interactive mathematical programming program which allows for a non-linear objective function with which the author is now working to assess its usefulness here. Advantages to an interactive mathematical programming code for investment type problem solving are that (1) user input errors are quite readily corrected, and (2) the user is literally forced to structure his problem carefully so that he, not the computer, finds whatever solution may exist.

As a technical comment on a possible problem of success fully applying this mathematical tool for problem solving in generals I know from experience That success in computing a solution at times depends on some capability with numerical analysis (specifically in the simplex algorithm). and matrix algebra) more precisely, the tolerance value). Interestingly enough, an intriguing article published in a computer journal brought attention to a problem of using an LP package (IBM MPS/360) to a data base. All the technical details are available in the February 1977 issue of the Communications of the ACM ("Occurrences of Cycling and Other Phenomena Arising in a Class of Linear Programming Models"). Consider here possible problems in the manufacturer's software as well as possible round-off problems in the actual computations.

SOLUTION OF SYSTEM

The Solution for the following investments:

TABLE 1
SOLUTION OF SYSTEM

Variable	Investment	Amount
1.	Oil company X	$ 40,000
2.	Oil company Y	13,334
3.	Electric utility X	53,334
4.	Electric utility Y	0
5.	Government bonds	93,334
		$200,002

with an annual return of $14,334 or 14.334% (the above total, which is not $200,000, is due to rounding). If the firm was required to invest in $1,000 units, that is, it could invest $13,000 or $14,000, but not $13,334. He could be tempted to round each answer to the nearest thousand and invest $40,000, $13,000~ $53,000, and $93,000. These investments would add to $200,002 and would technically be infeasible. The real or exact solution would very likely call for a mathematical programming technique known as integer programming (which will be the subject of a future article of mine). Furthermore, this particular technique generally is more difficult to apply to problem solving (and certainly in problem formulation), whether it be in investment situations or not. The firm in this case would (or could) probably adjust the $93,334 investment in government bonds to $93,000 with little (or no change) to the objective function of annual return of $14,167.

Examining the solution one notes that the cash investment has been entirely spent, which is to be expected. Further, the investment in oil company X has been entirely accounted for, which would not be very easily anticipated. By contrast, the others (other solutions) permit some slack, as an operations researcher, linear programmer, or some such mathematically-inclined professional would understand or put it.

REMARKS ON THE MICROCOMPUTER SYSTEM

Microcomputer buffs or specialists would undoubtedly be interested in one specific operating system statistic, i.e., approximate running time for the linear programming model with the 7 constraints is about 64 seconds (utilizing an INTEL 8080 chip micro- processor), Since the data matrix used in this microcomputer system (at this point for illustrative needs) could hardly be called large by any standards, one tentative conclusion is that the micro is pretty slow in today's typically high-paced data processing environment. On the other hand, for the small or medium-sized (let alone large) investment firm that can indeed afford such turnaround times it should be clear that this somewhat unique (or at least reported) application of a microprocessor could be well worth pursuing (which the author and other organizations are already doing).

Although not directly related to the subject of a microcomputer-based linear programming investment portfolio model, it may be of more than passing interest to some that the harnessing of mainframe (and mini-) computer power for portfolio models has been and continues to receive attention from economists, large banks, consulting firms, and of course, financial institutions or brokerage houses. Several issues of Institutional Investor during the past year have covered either certain individuals or trends related to the development of investment portfolio models (and especially the apparently zealous marketing of the alleged virtues of such models).

One most appealing question concerning the micro system (and its emergence into the portfolio spotlight has been raised repeatedly) namely, what is the approximate limit on it with respect to either a data base or computer program or both in a given microcomputer application? Based on my experience using an INTEL 8080 chip, an investment model similar to the one above with 30 variables and 35 constraints, 9.5 minutes of total running time were required to provide a solution. (It is still a matter of research importance to me to find the total CPU time with an 8080 chip for a comparably large investment model which actually has no real solution infeasible solution" , let alone an unbounded one") Needless to say, it is still very difficult to even try to answer the above question, and it is safe to comment here that it will be a matter of time before real progress is made in this area. It also goes without saying that perhaps another operations researcher in the reader audience or elsewhere may help address this point. A strong incentive to additional research in this area that the total expense of such microcomputer simulation activity is so low, for example, $30-40 for a computer run (which is an "average charge' from my experience), and even then, the bulk of such cost i8 largely attributable to the data entry function, e. g. matrix generation.

FUTURE RESEARCH

Any planned experimentation with this micro system for investment selection could certainly prove to be beneficial to the investment firm (or investor) with an eye for his return and/or sensitivity analyses, given marginal or incremental increases (or decreases) in one (or more) of the various investment types. For the technical specialist with a keen eye for analyzing such linear programming concepts as shadow prices or non-linear relationships in the constraints (or objective function), this investment model research does, of course, offer fruitful (and quite inexpensive) options.