The Application of Operations Research Techniques to Finance Sector

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ABSTRACT: Operations research as a branch of comprehensive and multidisciplinary cross science, there are two types of decision problems. The first one is how to make use of resource to fulfill the tasks as much as possible. The other one is how to Using the least amount of resources to complete a certain task. This paper reviews the application of Operations Research to financial markets. After considering reasons for the attractiveness of general finance problems to OR researchers, the main types of financial market problem amenable to OR are identified, and some of the many problems solved using OR are documented. While mathematical programming is the most widely applied technique, OR now plays an important role in the operation of financial markets and this importance is likely to increase, creating the opportunity for OR (and operations researchers) to play an even greater role.

KEY WORDS: Finance, mathematical programming, simulation, modeling, application

1. INTRODUCTION:
There is an even larger number of papers on the application of OR techniques to finance in the finance, mathematics, engineering and other literatures, so that, in total, there are several thousand papers which apply OR techniques to finance in academic journals. Equally, OR has played a part in the adoption by the financial markets of the new finance theories. This paper considers the application of OR techniques to finance. This covers decisions concerning trading by decision makers in financial markets (e.g. the debt, equity and foreign exchange markets and the corresponding derivatives markets), and represents a more recent and still growing area for the application of OR techniques to finance. This paper does not consider the more traditional applications of OR to the management of the firm’s finances: working capital management (which can be subdivided into the management of cash, receivables and liabilities), capital investment (including the appraisal and implementation of sets of large interdependent investments).

After considering some of the reasons for the attractiveness of finance problems for the application of OR techniques, this paper identifies the main types of problem that are amenable to OR analysis, and documents some of the many problems in financial markets which have been addressed using Operations Research techniques.

2. MAIN TYPES OF FINANCE PROBLEMS:
1. Attractiveness of Finance Problems:
An important distinguishing feature of problems in financial markets is that they are generally separable and well defined. The objective is usually to maximize profit or minimize risk, and the relevant variables are amenable to quantification, almost always in monetary terms. In contrast to some other OR applications, the investigator has few worries about ensuring that they have identified the correct question (i.e.
there is no need to consider whether the problem is to reschedule the company’s vehicle fleet to meet customer needs, rather than the broader question of whether it needs to operate a fleet of vehicles at all). In finance problems, the relationships between the variables are usually well defined, so that, for example, the way in which an increase in the proportion of a portfolio invested in a particular asset affects the mean and variance of the portfolio is clear. Thus the resulting OR model is a good representation of reality, particularly as the role of non-quantitative factors is often small. Finance problems also have the advantage that any solution produced by the analysis can probably be implemented, while in other areas there may be unspecified restrictions concerned with human behavior and preferences that prevent the implementation of some solutions. Furthermore, finance practitioners are accustomed to the quantitative analysis of problems. Thus, because finance applications (especially applications to financial markets) are largelynumerical problems with well-defined boundaries and objectives, clear relationships between the variables, large benefits from very small improvements in the quality of decision making and excellent data, they are well suited to OR analysis. This paper analyses the application of OR techniques to financial markets in more detail by considering some of the major types of problems in financial markets, and the OR techniques that have been used to analyse them.

2. Funding Decisions:
OR techniques have also been used to help firms to determine the most appropriate method by which to raise capital from the financial markets to finance their activities. Brick, Mellon, Surkis and Mohl (1983) put forward a chance constrained linear programming model to compute the values of the debt-equity ratio each period that maximize the value of the firm. Other studies have specified the choice between various types of funding as a linear goal programming problem (Hong, 1981; Lee and Eom, 1989). Ness (1972) used linear programming to find the least cost financing decision for an investment project by a multi-national company. Kornbluth and Vinso (1982) modeled the financing decision of a multi-national corporation as involving two goals - minimizing the overall cost of capital and achieving target debt/equity ratios in each country. Since the debt/equity goals involve ratios of the decision variables, the model becomes a fractional linear goal programming problem. An important question when appraising investment projects is determining the appropriate cost of capital, i.e. the price which must be paid in the financial markets to finance the project. Boquist and Moore (1983) proposed the use of linear goal programming to estimate the cost of capital for divisions by incorporating corporate prior beliefs concerning betas.

3. Strategic Problems:
In recent years, some of the decisions facing traders and market makers in financial markets have been analysed using game theory (O’Hara, 1995; Dutta and Madhavan, 1997). These models typically involve one or more market makers, and traders who may be informed or uninformed, and discretionary or non-discretionary. Traders in stock markets seek to trade at the most attractive prices and large trades are often broken up into a sequence of smaller trades in an effort to minimize the price impact. This can be viewed as a strategic problem with the aim of devising a strategy for trading the block of shares. The initial trades influence the price of subsequent trades, and so executing the large trade at the lowest cost is a dynamic problem. Bertsimas and Lo (1998) use stochastic
dynamic programming to define “best execution” and to compute an optimal trading strategy.

4. Regulatory and Legal Problems:
Financial regulators have become increasingly concerned about financial markets with their very large and rapid international financial flows. OR techniques have proved useful in regulating the capital reserves held by banks and other financial institutions to cover their risk exposure. OR techniques have also been used to ensure compliance with various legal requirements by designing appropriate strategies and to solve other legal problems relating to financial markets.

A key regulatory issue is determining the capital required by financial institutions to underpin their activities in financial markets. An increasingly popular approach to this problem is to quantify the value at risk (VAR). If the specified period and probability are 1 day and 1% respectively, then the VAR is the largest loss that will occur due to market risk 99% of the time. Thus, VAR involves quantification of the lower tail of the probability distribution of outcomes from the firm’s portfolio. A particular problem with measuring risk exposure is that portfolios usually include options (or financial securities with option-like characteristics), and options have highly asymmetric payoffs. For such securities, analytical solutions to finding the probabilities in the lower tail of the payoff distribution are unreliable. Traders are required to put up margin when they trade options, and there are complicated rules for determining the total margin required on a portfolio of options and shares. Traders wish to minimize their margin payments, and Rudd and Schroeder (1982) have developed a linear programming model in which the problem was modeled as a transportation problem for determining the minimum required margin.

5. Economic Understanding:
In addition to its traditional role of improving the quality of decision making, OR can also help in trying to understand the economic forces shaping the finance sector. Financial innovation may occur when there is an exogenous change in the constraints or in the costs of meeting existing constraints. Using a linear programming model of a bank, Ben-Horim and Silber (1977) employed annual data to compute movements in the shadow prices of the various constraints. They suggested that a rise in the shadow price of the deposits constraint led to the financial innovation of negotiable CDs.

3. CONCLUSIONS:
Mathematical programming is the OR technique that has been most widely applied in financial sectors. Most types of mathematical programming have been employed - linear, quadratic, non-linear, integer, goal, chance constrained. Mathematical programming has been used to solve a considerable range of problems in financial markets - forming portfolios of equities, bonds, loans and currencies, generalized hedging, immunization, equity and bond index tracking, estimating the implied risk neutral probabilities for options, devising a schedule of coupons for municipal bond bids, identifying underpriced bonds, setting the firm’s debt-equity ratio, deciding when to refinance outstanding bonds, estimating the divisional cost of capital, determining the required minimum option margin, structuring MBS and CMO securitisations, creating a trading strategy to execute a block trade, designing leveraged leases, computing the maximum loss sustained by shareholders, spotting insolvent banks, sorting out the failure of a stock exchange and understanding the forces leading to financial innovations.
This paper indicates that OR techniques play an important role in financial markets and, with the recent dramatic improvements in the real time availability of data and in computer speed, this role will increase. This will create the opportunity for OR techniques to play an even greater role in financial markets.

REFERENCES:


