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Invited Review

Operational research and financial management

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Abstract: The use of Operational Research in financial management is reviewed. Its application to both short term problems of cash management and long term problems of capital investment is critically examined. The contribution that Operational Research has made to modern theories of finance and their use is explored and differences in orientation are discussed. The increasing complexity of financial management problems facing many corporations is providing more opportunities for the operational researcher whose role in this area is being reappraised.

Keywords: Finance, investment, financial management, financial planning

1. Introduction: What is financial management?

Financial management in any organisation involves making decisions about how to raise and use finance, both in the short term and in the long term. The complexity of the decisions stems from the fact that they typically involve the certain sacrifice of resources now, in exchange for an uncertain, but hopefully larger, block of resources in the near or distant future. The key words in any discussion of financial management are then money, time, and risk.

There have been several studies of how financial managers in industry spend their time. A recent study by Gitman and Maxwell (1985) which relates to American firms produced the following findings: 14% of time spend on the raising of long term funds, 19% of time spent on managing capital expenditures, 32% of time spent on managing working capital and 35% of time spent on financial planning and budgeting. Survey respondents also indicated that more time was spent on asset management than on liability management (58% : 42%), and more on short term activities than on long term activities (60% : 40%).

There is, of course, no particular reason why these results should remain constant for different periods of history, or for different economies. However, the emphasis on short term asset and liability management (working capital management), and on managing capital expenditures, (capital budgeting), is similar to the findings of earlier studies. There is also the point that people other than designated financial managers are involved in financial decision making; engineers, for example, are involved in the design and costing of the plant and equipment that the firm acquires. This participation by non-specialists probably oc-

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curs least in decisions about raising long term finance. Thus, the view that financial management in practice emphasises asset acquisition and management, and short term activities, probably has widespread validity.

In order to make decisions managers need criteria of goodness, decision tools, and an understanding of the environment in which they operate. In the bulk of the mainstream literature dealing with financial management, whether textbook or journal, advice to management and academic research about these things occurs within a dominant paradigm. The main elements of this are that the right criterion of goodness is the maximisation of shareholder wealth and that firms operate in something close to a perfect capital market. A perfect capital market is one in which the size and riskiness of the cash flows which financial decisions produce are immediately and correctly reflected in the prevailing share price, and also one in which companies have no problems in raising finance at interest rates which reflect the riskiness of their activities. With criterion and environment so specified decision tools based on a Net Present Value (NPV) rule are appropriate. To take a simple example, an investment of an amount of cash I_0 now, in a piece of plant to generate expected cash flows C_1 in one year, and C_2 in 2 years would be acceptable if NPV > 0 where:

$$\text{NPV} = -I_0 + C_1/(1+r) + C_2/(1+r)^2.$$

Here r in the denominator is a discount rate designed to reflect not only the futurity of the expected cash flows, but also their riskiness.

There is a well developed body of theoretical and empirical results within this central paradigm. Firstly, the nature of capital markets has been widely researched and the major implications of the perfect market model, inclusion of relevant information in share prices and speed of adjustment to new information, have been widely found to hold. A classic summary of the research methods and findings of these 'efficient market' studies can be found in Fama (1970). Secondly, the way in which markets take into account the riskiness of corporate cash flows in setting share prices has been studied. The key result, known as the Capital Asset Pricing Model (CAPM), was proposed by Mossin (1966), among others. The basic idea is that shareholders' asset portfolios are well diversified and that, therefore, relevant risk measures are covariance based. This does away with the idea that a firm has a portfolio problem to deal with when it selects a group of investment projects; each project can be appraised individually. Much of the empirical testing of the CAPM has been shown to be of dubious value by Roll (1977). Alternative models, such as the Arbitrage Pricing Model of Ross (1976), have recently started to appear. However, covariance based risk measures retain a central role.

As far as financing decisions by corporations go a key theme in the literature is that of irrelevance. It can be shown that under 'ideal' conditions the proportion of debt a company has in its capital structure, and how much cash it pays out in dividends, have no effect on its value to its shareholders. The classical studies in this area are those of Miller and Modigliani (1961). Much recent work has concentrated on empirical testing of these ideas, and on analysing their sensitivity to the specific assumptions made.

For financial managers the overall implications of the central paradigm are that decisions on how cash is spent on real assets are the critical ones. Financing decisions have little impact on shareholder wealth.

So far, nothing has been said about working capital management, the short term activities on which financial managers supposedly spend so much time. In fact the mainstream finance literature has not really emphasised this area. Most text books simply offer a collection of decision tools based around the economic order quantity model. The basic idea is that the distinction between long term and short term is not critical. An NPV analysis is still appropriate even though the time periods are now months or days rather than years and the determination of discount rates is less clear cut.

Where is the operational researcher in all this? In fact his activities have perhaps mirrorred the emphasis found by Gitman and Maxwell better than those of the finance specialist. Where work has been done it has been largely in the areas of working capital management and capital budgeting and it is to these two areas we now turn.

2. Capital investment appraisal

Capital investment appraisal involves the financial evaluation of decisions involving major investments of capital. A capital investment typically involves a stream of cash flows with negative cash flows representing the investment at the early stage of a project, with positive cash flows occurring in later years. The purpose of capital investment appraisal is to help decide whether a particular cash stream and hence a particular investment is worth undertaking.

Although capital investment appraisals are often undertaken by accountants or finance specialists in organisations, Operational Researchers have been involved in both the practice and the theory of capital investment appraisal over the years. This is understandable, as appraisals typically involve the use of models and quantitative analysis, and are an important aspect of decision making, and thus represent a natural field of application for the Operational Researcher. This was recognised by Small (1956), writing in 'management's corner' of the journal *Operations Research*. He stated "many of OR's ideas involve a factor of capital investment, or perhaps the balancing of one present sum of money against another future sum of money. The mathematical models concerned, if well refined, must take into account the time utility of money." Small not only linked operational research and capital investment firmly, but also introduced the idea of the time value of money which is basic to discounted cash flow (DCF) techniques.

Summary measures and discounted cash flow techniques

The problem proposed in capital investment appraisal is to decide whether a particular stream of cash flows associated with some capital project is a sound investment. The natural tendency is to try to represent the stream of cash flows by a single summary measure and various such measures are available. The simplest such measure is the pay-back period. The assumption here is that cash outflows occur at the beginning of the cash stream and these are followed by cash inflows. The pay-back period is the number of years it takes for the inflows to recover the initial outflows. A decision rule related to the pay-back period would be to accept the capital investment, if the pay-back period were less than an agreed number of years. This is an attractively simple measure to calculate, but has disadvantages, including the fact that, it may not incorporate the whole cash stream in the measure, and it takes no account of the time value of money. Nevertheless, the pay-back period is frequently computed and has the big advantage that a project with a short pay-back will usually be of low risk as the returns are in the more immediate and reliable future.

The summary measure often preferred by financial theorists is net present value. This measure overcomes the two major weaknesses of the pay-back period. All cash flows are taken into account and so is the time value of money.

Other summary measures include the net terminal value, the internal rate of return (IRR), and the fixed interest equivalent rate of return. The net terminal value is very similar to the net present value apart from the fact that the cash flows are valued at some horizon point in the future rather than at the present time. The internal rate of return is also a discounted cash flow method, but involves the calculation of the interest rate that will result in a zero net present value. The attraction of the internal rate of return is that it yields a rate of return measure which can be interpreted as the highest rate of interest at which a company could afford to finance a project. However, a weakness is that it assumes that any surplus cash in the life of the project can be invested at the same rate of interest and for profitable projects this may not be possible. The internal rate of return can thus give an over-estimate of the value of a project. The fixed interest equivalent rate of return overcomes this problem by assuming that cash surpluses can only be invested at the usual discount rate used in the NPV calculation. (See Dyson and Berry, 1984).

Risk in capital investment appraisal

A major weakness of discounted cash flow methods is that they assume that the future cash flows can be forecast with certainty. This weakness was identified by David Hertz (1964) in his famous paper in *Harvard Business Review* as the Achilles' Heel of DCF methods. He proposed the use of simulation methods to quantify the uncertainty in the cash flows and this approach often

called risk analysis is well-known in Operational Research circles (Hertz and Thomas, 1983). The risk analysis approach essentially breaks down the cash stream into its fundamental factors such as market size, market share, useful life of the project and so on. Each of these factors is then represented by a probability density function and from this a probability density function of the cash stream is constructed using simulation. Simulation is then used to construct a probability density function of any required summary measure such as NPV or IRR. The method thus attempts to capture the uncertainty of the capital project and allows this uncertainty to be taken fully into account when deciding whether to accept or reject the proposal.

Risk analysis involves modelling the project and constructing density functions. A difficulty with the approach involves the construction of the density functions and this becomes severe when distributions are correlated (see Hertz and Thomas).

In the previous year to the Hertz paper, Hillier (1963) took an analytical approach to the evaluation of risky investments. Hillier was essentially addressing the same problem as Hertz, but used methods of mathematical statistics to derive probabilistic information about capital investments, rather than to use simulation techniques. The Hillier approach was extended by Wagle (1967). Hespos and Strassman (1965) proposed the use of stochastic decision trees for the evaluation of risky investment with staged decision. The use of decision trees is a part of current practice (Phillips, 1982).

Adelson (1965) wrote the first substantial paper in *Operational Research Quarterly* on capital investment appraisal. He suggested that discounted cash flow methods were the correct approach to capital investment appraisal only in the sense that they seemed to make sense to their respective authors. He again raised the issue of risk and proposed that the Markowitz (1959) approach to the problem of share portfolio selection was appropriate and developed it for the similar problem of investment in capital equipment.

The above approaches to risk typify the work of operational researchers and can be characterised by the modelling of the project per se, on the assumption that management will in the end use their judgement and values to decide whether or not a project should be undertaken. This is in contrast to the finance specialists' assumption that shareholders' values are paramount.

Risk adjusted discount rates

The alternative to obtaining probabilistic information on a summary measure is to represent the uncertain future cash flows by their expected values and discount them at a rate which reflects the riskiness of the cash flow and management's or shareholders' attitude to risk. The approach is called risk adjusted discounting. This approach raises the question of what the appropriate discount rates should be and one resolution of this problem is to employ the capital asset pricing model (CAPM). This model was proposed again in the mid-sixties, as a theory behind the analysis of risk in share markets. It is also proposed as providing a rule for determining the value of a risk adjusted discount rate for capital investment appraisal.

The capital asset pricing model defines the required rate of return or the discount rate as

$$k_j = i + \beta_j [\mathrm{EV}\{R_m\} - i].$$

Here i is the risk free rate, or the discount rate used in a deterministic world, the term $[\mathrm{EV}\{R_m\} - i]$ is the return on a market portfolio over and above the risk free rate, and β_j is a measure of the share's risk relative to that of the market. Hence, k_j is equal to a risk free rate plus a risk premium. To determine k_j, the risk adjusted discount rate, for a particular capital project, it is necessary to obtain a value of β_j. This is obtained from an analysis of share behaviour and by comparing the capital project with companies in a similar business which should, thus, have a similar relationship to the market.

The CAPM is, thus, concerned with the variability of the project relative to market, whereas the risk analysis approach of Hertz concentrates on total variability of the capital project. There is also the assumption behind the CAPM that it is the shareholders' and not the manager's values that are relevant. The share market orientation of CAPM also carries over into the use of options to reduce risk. Although intended as a way of reducing the risk on a portfolio of shares, the company engaging in risky capital investments could also reduce its risk in a similar fashion.

Alternative approaches to risk

There are, thus, three basic approaches to accounting for risk in capital investment appraisals - risk analysis, analytical approaches, and market based approaches. These all originate from the 50's and 60's with risk analysis perhaps having the greatest immediate impact on the practice of Operational Research, whilst the market based approaches are more recent entrants into the field. This is perhaps explained by the fact that risk analysis involves no new theory and computer packages have been available since the 1960's. In contrast, the analytical approaches involve restrictive assumptions, whilst the market based approaches remained with the financial theorists until relatively recently. In the last few years, a fourth approach has emerged from the realms of strategic planning, which invariably involves capital investment appraisal. That is the use of scenarios to describe uncertainty. The approach here is to describe uncertainty by several contrasting scenarios, rather than by attempting a comprehensive quantification through probability density functions. This approach gains in appeal where major strategic decisions are being considered as it avoids the possibility of senior executives being blinded by the sophistication of the probabilistic methods.

Interdependencies

Capital Investment Appraisal often appears to assume that a project can be evaluated in isolation. This is particularly true of market based approaches.

In practice, this is rarely, if ever, the case, and one of the earliest interactions recognised was through the capital budget.

The use of linear programming for capital rationing was proposed by Weingartner (1963) and an early application in a practical situation is due to Chambers (1971). These models, by assuming that limited funds are available, are at variance with the assumptions of a perfect capital market which assumes that worthwhile projects will always be funded by the market.

Projects may interact for a variety of other reasons such as manpower rationing, logistics where common facilities may be used, taxation effects, correlations, and there may also be interactions through competitive reaction.

To allow for these interdependencies requires a corporate modelling approach in order to determine the true cash stream that results from a capital project. This should be a fertile area of activity for the broadly based modelling skills of Operational Research.

3. The management of working capital

A company's working capital may be defined as the difference between its current assets and current liabilities. Its management is an important function in any company. Current assets may be taken to be any assets which could be liquidated or converted into cash within a year, including cash itself. Thus its management covers many application areas of Operational Research. The most studied is perhaps inventory control, which is a major subject area in its own right. As such, it would not be appropriate to cover it here; there are many excellent textbooks on the subject such as Peterson and Silver (1979). Apart from inventories, working capital naturally divides into three areas: cash, receivables and current liabilities. It is appropriate to consider each in turn.

Cash

The state of a firm's cash balance and current cash flow may be managed by periodically adjusting company funds between available assets and debt. The crucial asset in this case is cash, which is costly if in too short or too great supply. In the former case the costs are those of acquiring short term funds or even bankruptcy, and in the latter costs arise from interest or opportunity payments foregone. This has been one of the early application areas of OR models.

To begin with, the cash balance problem is usually modelled as deciding the level of cash to hold at the start of each of a number of periods given the current cash level, transfer costs, cash out and holding costs, and the distribution function of cash changes before the start of the next period. In this context it closely resembles the inventory management problem apart from the existence of negative cash balances and the relative freedom in the choice of initial cash level. As such the early models applied, such as that of Eppen and Fama (1969), treated cash as a single

asset and relied on dynamic programming for their solution. Although the approach can be generalised to three assets and to a more general cost structure (Elton and Gruber, 1974), the paucity of asset types that can be treated in this way has remained a serious limitation and has severely restricted their application.

Multiple asset types are more easily handled by linear programming based models such as those of Mao (1968), Orgler (1969) or Maier and Van der Wiede (1978). These methods, at least superficially, provide the greater detail required for practical utility and have found widespread application in financial modelling, despite being poorly referenced in the finance literature. Indeed, the latter model is used by a New York bank as part of its cash management service. However, the major drawback of these models is the difficulty of treating the random variation in forecast cash flows, which is the cornerstone of the dynamic programming methods. Linear programs in which some data can be random are known as *stochastic programs* and are thus an attractive choice for cash balance models, but they are generally too expensive to solve computationally except in special cases. Kallberg et al. (1982) suggest using what is essentially a single period model and report some success in applying it.

The difficulties of analysing traditional 'hard' prescriptive OR models of the cash management problem that are sufficiently realistic to be useful has prompted some authors to propose stochastic simulation to explore their behaviour. Franks et al. (1974) suggest a time sliced model which uses a decision tree structure to handle choices available to the manager and possible outcomes of these choices. The merit of this approach is that the underlying model of the problem can be made very detailed and realistic; debtors, manufacturing and administration costs, creditors and tax can all be handled. A small disadvantage is the expense of sufficient runs of such a model to obtain reliable estimates of the distributions of cash flows. The major drawback, however, is that it is only a descriptive model and good as it may be for exploring alternative strategies, it cannot suggest ones of its own. This was recognised by Bell and Parker (1985) in their construction of a visual interactive simulation. They recognised the importance of good cash demand forecasts and incorporated analytical forecasting methods and cash balance algorithms in their system. Suggested strategies could then be explored and altered by the manager in the simulation context.

Receivables

These are short term debts owed to a company, such as money owed on credit sales. Their management concerns two distinct, but interrelated, issues: when to issue credit, how much, and on what terms, and how to deal with overdue accounts or bad debts. The latter issue has received more attention in the literature, being more clearly defined and less involved with corporate marketing policy.

The first problem in managing bad debts or 'doubtful accounts' is the estimation of their present worth. Cyert, Davidson and Thompson (1962) suggested modelling each overdue account as a Markov process in which the states were the number of months overdue, all debts over a given age were reckoned irredeemable (thus forming an absorbing state) and if paid the account leaves the system (so payment is another absorbing state). It and refinements of it such as those of Van Kuelen et al. (1981), have been well used in practice, but nevertheless suffer a number of drawbacks. It is essentially a steady state model and makes no explicit use of credit experience gained from individual customers. Moreover it treats each account holder as being independent, so would seriously undervalue the total risk in overdue accounts if many customers were subject to the same economic forces. This is likely to be the case if they are from the same industrial sector or geographical location. Of course, such valuation models do not answer the important decision about whether to give credit to a particular customer at all, and how much to give.

Mechanisms for determining whether to issue credit and how much to issue were often based on the results of statistical discriminant analysis and derived credit scoring methods such as those of Myers and Forgy (1963). A single period model is used to determine the relevant cut-off scores, which takes no account of the possible future benefits in giving credit to worthy customers. This prompted Bierman and Hausman (1970) to propose a multi-period model of the behaviour of individual customers in which their pay/don't pay decision was treated as a Bernoulli trial with probability p.

A Bayesian approach to updating a prior beta distribution for p enabled experience with the customer to be directly incorporated. Dynamic programming was used to determine the credit giving policy that maximised long run profit.

The above studies use very simple credit terms that do not include cash discounts, and they pay little attention to credit collection mechanisms. This limits their practical utility, although credit scoring methods such as those of Myers and Forgy and the Markovian valuation methods of Cyert et al. are often used. In an attempt to embody practical realism, Lieber and Orgler (1975) proposed a continuous time steady state model that included both credit granting and collection variables. Unfortunately, it proved too complicated to analyse except in rather heavily simplified versions.

Credit collection models have been driven by the need to decide what should be done with overdue accounts: whether to pass them to banks, collection agencies or pursue the matter 'in house'. Each incurs a different set of costs and has a different success profile. The problem of assigning accounts to collectors to minimise the interest tied up in such accounts and the cost of collecting them may be modelled as a pure integer program known as the lock box problem. As such it has received considerable attention in the literature, particularly as regard to practical ways of obtaining good solutions (Stone, 1981, Fielitz and White, 1981). These models can readily incorporate sufficient detail to be useful—at least in their formulation. Good solution heuristics are however required for obtaining optimal or near optimal solutions to models of a practicable size.

Current liabilities

These are a company's currently outstanding short term debts, which in practice would arise from, for example, having received stock that has not yet been paid for and from having borrowed funds to cover a short term liquidity problem. The latter aspect is part of the cash balance problem and can be treated as such; for example, Daellenbach and Archer (1969) extend a dynamic programming model to do just that, and deterministic linear programming models have been used too (Cohen and Hammer, 1967). Again, as with the cash balance problem, stochastic programs provide a good modelling framework but pose formidable computational problems. Kusy and Ziemba (1986) use an aggregation scheme to approximate such a stochastic programming model of bank assets and liabilities by one which is computationally tractable. They report its successful application within the Vancouver City Savings Credit Union.

Stock purchase on trade credit changes the structure of stockholding costs. It is possible to modify standard inventory models to take account of this. Haley and Higgins (1973) propose a modified Economic Order Quantity model, but others are clearly possible.

4. Financial planning and budgeting

A substantial portion of the time spent of financial managers was identified in the introduction as being spent on planning and budgeting. This rather loose terminology covers a variety of activities, most of them linked to the monitoring of the company's cash balance and the prediction of future needs for external finance. These activities have tended to be in the realm of the accountant rather than the OR analyst.

When this monitoring and forecasting covers a short time horizon, the activity links to working capital management. However the models utilised are much cruder. Their essence is the accounting identity

$$\text{CASH BALANCE}_t = \text{CASH IN}_t - \text{CASH OUT}_t + \text{CASH BALANCE}_{t-1}.$$

These models disaggregate cash inflows and outflows by source, paying particular attention to timing. For example cash inflow from sales might be disaggregated into

$$\text{CASH SALES}_t + \text{CREDIT SALES}_{t-1}.$$

This assumes a one month credit period being offered to customers, no early payments and no delayed payments.

This area of financial management lends itself to a model building approach. However no major OR activity is reported in the literature. The availability of spreadsheet packages may have persuaded OR workers that they have little to offer. However this would be to confuse model solution mechanisms with model building skills.

If a longer time horizon is adopted for the prediction process the modelling component of the activity is more significant. The style of modelling which is used and reported in the literature seems however to be that of the economist/econometrician rather than the operational researcher. This distinction may be unimportant given that many researchers straddle the boundaries of OR and economics. Surveys of these models appear frequently in the literature. Naylor (1979) reports on the U.S. situation while Grinyer and Wooler (1978) deal with the British scene.

The flavour of this style of modelling is perhaps best demonstrated by an example. Consider the following simple, dated company balance sheet

EQUITY$_{t-1}$	FIXED ASSETS$_{t-1}$
LONG TERM DEBT$_{t-1}$	
CURRENT LIABILITIES$_{t-1}$	CURRENT ASSETS$_{t-1}$

Simple behavioural equations can be used to project this balance sheet into the future. For example given a forecast of next period's sales. $\hat{S}_t$, fixed assets for the next period $\widehat{\mathrm{FA}}_t$, can be forecast by

$$\widehat{\mathrm{FA}}_t = \mathrm{FA}_{t-1}\hat{S}_t/S_{t-1}.$$

There are of course very strong assumptions underpinning this simple relationship. However more appropriate relationships can be developed.

If similar relationships are used to predict next period's current assets, $\widehat{\mathrm{CA}}_t$, and next period's current liabilities, $\widehat{\mathrm{CL}}_t$, then because balance sheets must balance there is an implication for next period's equity and/or long term debt.

The simple '% of sales' model can be found in most financial management texts, for example Brigham and Gapenski (1985). More complex models together with a discussion of estimation methods and solution procedures can be found in Naylor.

5. Conclusions

This paper has been concerned with the role of OR in financial management. The emphasis has been on financial management in 'fund using' organisations, manufacturers and retailers, rather than in 'fund providers' such as banks. Our conclusions should be read with this point in mind. Another point to bear in mind is that we have concentrated on work that has appeared in the mainstream OR literature. We have been concerned with what people who see themselves as OR specialists are doing rather than with work done by others which might be interpreted as OR. The OR literature has furnished little in the way of case studies. Therefore comments about patterns of use of tools and techniques are based on our own experience and hearsay.

We have found that OR in finance is a distinctive activity, set apart from the mainstream of financial management. Firstly the OR approach adopts the viewpoint of the manager within the firm rather than the shareholder outside the firm. As a result of this, in the OR approach decision consequences tend to be evaluated by reference to a utility function, or to ad hoc criteria such as robustness which can be linked to individual attitudes to risk. In the finance literature the valuation mechanism is the efficient capital market; the key question is how much an asset is worth in the market, not how desirable a manager feels it is. This is not a trivial distinction. A manager has the greater part of his wealth locked in to the firm he works for; he holds an undiversified portfolio of assets. The shareholder on the other hand typically has his wealth invested in many assets. Inevitably managers and shareholders will differ in their attitudes to risk.

The second major difference between the OR and finance approaches is the attitude to the capital market. The OR literature, following Weingartner (1963), tends to view the market as imperfect and imposing capital rationing on firms. This view offers an explanation why market valuations have been ignored; in an imperfect market they are not unique. It also provides a role for the constrained optimisation techniques utilised in OR. The finance specialist refers to the empirical evidence and interprets it as supporting the existence of smooth well functioning capital markets. Thus he believes market valuations can be trusted and constrained optimisation is unnecessary.

A third major difference between the OR and finance literatures is the type of decisions they emphasise. The OR literature focuses on both the short term, working capital type decision and the long term investment decision while the finance literature emphasises only long term decisions concerning investment in plant and equipment and corporate capital structures. The balance of

activity apparent from the OR literature is more consistent with the time spent on these activities by financial managers.

The differences between the OR and finance approaches are perhaps surprising since OR can be seen as a precursor of modern financial management, offering a rational approach to decision making to an application area which in the years after the second world war lacked a developed body of theory. Since that time the development of the discipline of finance has been rapid and OR has lost some ground. OR practitioners must now take on a substantial body of theoretical and empirical results for their model building skills to be fully effective.

However a new phase in the relationship between OR and finance may now be developing. The simple market based models of finance have been shown to need supplementing by broader based OR modelling; linear and integer programming (IP) approaches are once again appearing in the finance literature. The application of IP to tax and investment by Berry and Dyson (1978) is a case in point. Furthermore the finance literature now includes a model, Agency theory, as described by Jensen and Meckling (1976) which deals with the potential conflict between managers and shareholders. Consequently the manager has now reappeared in the finance literature as an actor of interest. At the same time market valuation models have started to appear in the OR literature. Anvari (1987), for example, proposes a use for the capital asset pricing model and identifies other recent papers in the same mould. This coming together of the finance and OR approaches can only be of benefit, both to the development of financial management and for OR involvement in financial management.

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