The Relevance of MCDM for Financial Decisions

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The Relevance of MCDM for Financial Decisions

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Abstract

For people working in finance, either in academia or in practice or in both, the combination of 'finance' and 'multiple criteria' is not obvious. However, we believe that many of the tools developed in the field of MCDM can contribute both to the quality of the financial economic decision making process and to the quality of the resulting decisions. In this paper we answer the question *why* financial decision problems should be considered as multiple criteria decision problems and should be treated accordingly.

1. Introduction

This special issue is devoted to MCDM and finance. For people working in finance, either in academia or in practice or in both, the combination of 'finance' and 'multiple criteria' is not obvious. For many years, we have been involved in the study and practice of financial economic decision making. Our main focus was and is on financial management science, the development of tools and frameworks to support financial decision making. We are convinced that many financial decision problems are in fact multiple criteria decision problems. In addition, we believe that many of the tools developed in the field of MCDM contribute both to the quality of the financial economic decision making process and to the quality of the resulting decisions. In this paper we answer the question *why* financial decision problems should be considered as multiple criteria decision problems and should be treated accordingly.

The central issue in financial economics is the efficient allocation of scarce capital and resources over alternative uses. The allocation (and redistribution) of capital takes place on financial markets and is termed 'efficient' when market value is maximized. Just as water will flow to the lowest point, the capital will flow to the uses that offer the highest return. Therefore it seems that the criterion to guide financial decisions is uni-dimensional: maximize the market value or maximize future return.

From a financial economic perspective the goal of the corporate firm, for example, is very much single objective. Management should maximize the firm's contribution to the financial wealth of its shareholders. Also the shareholders are considered to be myopic. Their only objective is to maximize their single dimensional financial wealth. The link between the shareholders and the corporate firm is footed in law. Shareholders are the owners of the firm. They possess the property rights of the firm and are thus entitled to decide what the firm should aim for, which in this line of thinking is the same for all shareholders, i.e. maximization of the contribution to the financial wealth of the shareholders. The firm can accomplish this by engaging in investment projects with positive net present value. This is a neo-classical view on the role of the firm and the relationship between the firm and its shareholders in a capitalist society. Figure 1 depicts a simplified graphical representation of this line of thought.

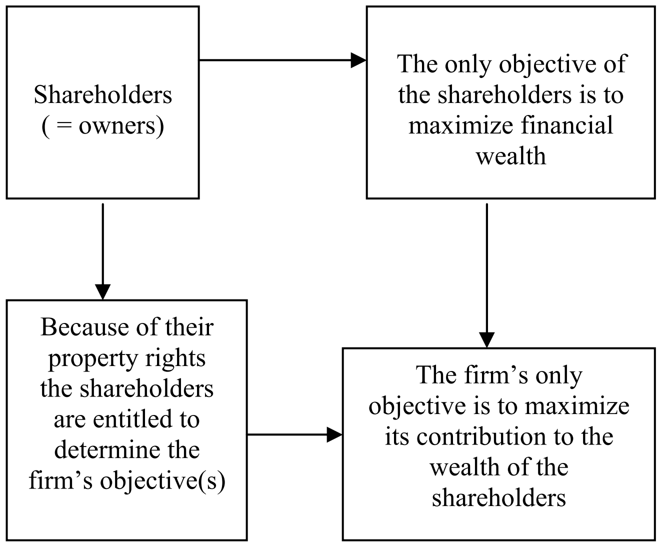

Figure 1 The neo-classical view on the objective of the corporate firm

It is important to note that this position is embedded in a much larger framework of stylized thinking in among others economics (general equilibrium framework) and law (property rights theory and limited liability of shareholders). Until today, this view is seen as an ideal by many; see for example Jensen [2001]. Presently, however, the societal impact of the firm and its governance structure is a growing topic of debate and discussion.

Here we will show that also in finance there are many roads leading to Rome, or rather to the quasi Roman numeral MCDM. Whether one belongs to the camp of Jensen or to the camp of those advocating socially responsible entrepreneurship, one has to deal with multiple criteria. The following section is devoted to the position of the firm, while the third section addresses the position of the financial investor. The fourth section discusses the issue of risk management that relates to both the firm and the investor. Section 5 concludes the paper.

2. Multiple Criteria Financial Decisions and the Firm

In this section we describe a series of situations in which the firm chooses (or has to take account of) a multiplicity of objectives and (policy) constraints. An overview of these situations is depicted in Figure 2. One issue is who decides on the objective(s) of the firm. If there is a multiplicity of parties who may decide what the firm is aiming for, one generally encounters a multitude of goals, constraints and considerations that - more often than not - will be at least partially conflictive. A clear example is the conflicting objectives arising from agency problems (Jensen & Meckling [1976]). This means that the decision problems that have to be solved are characterized by multiple criteria and multiple actors (viz. group decision making, negotiation theory, see Box 3 in Figure 2). Sometimes, all those who decide on what the firm should aim for agree upon exactly the same objective(s). In fact, this is what neo-classical financial theory assumes when adopting shareholder value maximization (Box 1 in Figure 2). In practice, there are many firms that explicitly strive for a multiplicity of goals which naturally leads to decision problems with multiple objectives (Box 2 in Figure 3).

However, although these firms do explicitly state to take account of multiple objectives, there are still very few of these firms that make use of tools provided by the MCDM literature. In most cases firms maximize one objective subject to (policy) constraints on the other objectives. As such there is nothing wrong with such a procedure as long as the location of these policy constraints is chosen correctly. In practice, however, one often observes that there is no discussion at all about the location of the policy constraints. Moreover, there is often no idea about the trade-offs between the location of the various constraints and the objective function which is maximized. In our opinion, multiple criteria decision methodologies may help decision makers to gain better insights in the trade-offs they are confronted with.

Now let us get back to the case in which the owner(s) / shareholders do have only one objective in mind: wealth maximization. Although this is by definition the most prominent candidate for single objective decision making, we will argue that even in this case there are many circumstances in which the formulation as a multiple criteria decision problem is opportune.

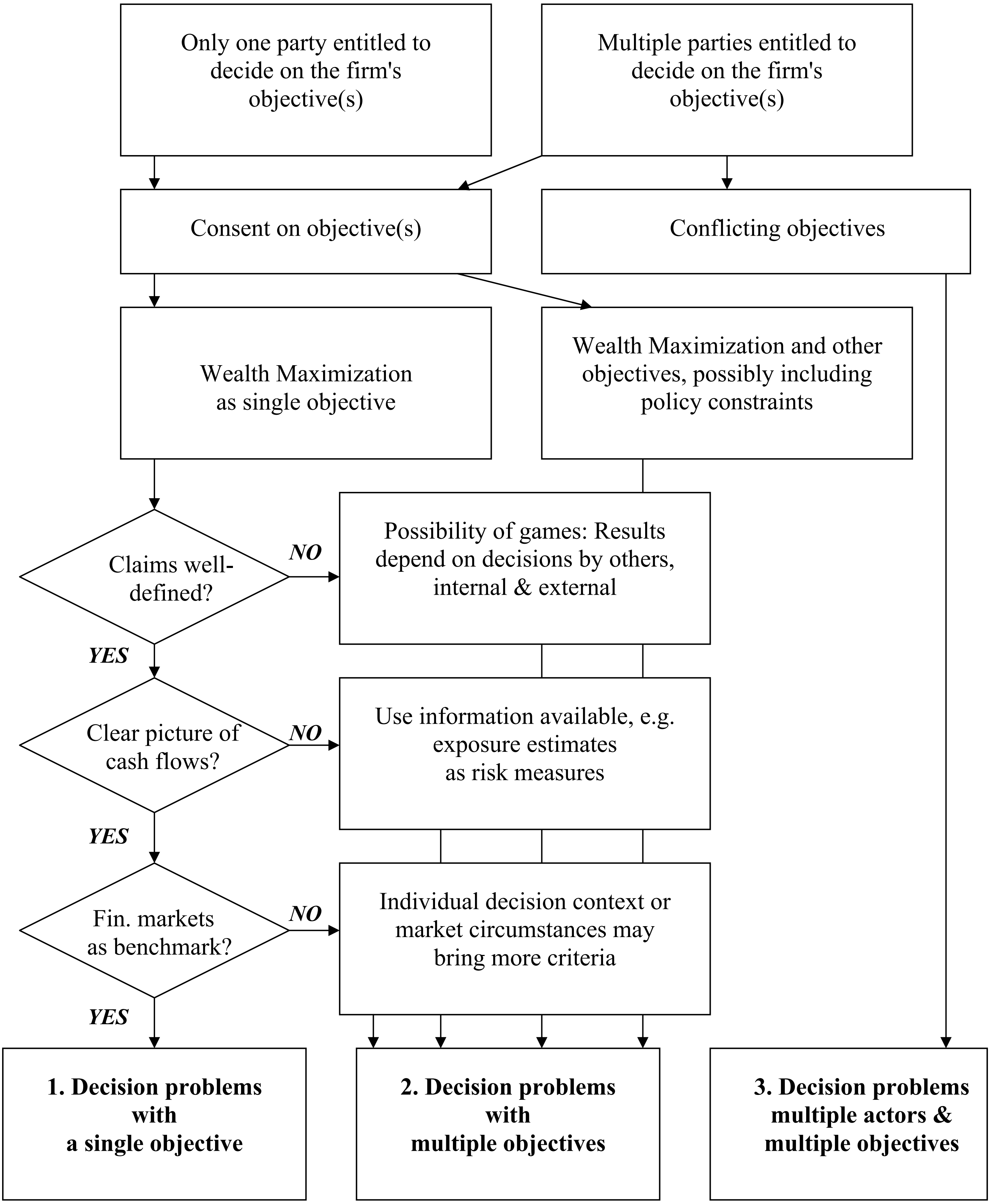

Figure 2 Situations leading to MCDM in the corporate firm

In order to contribute maximally to the wealth of its shareholders, an individual firm should maximize the value of its shares. The value of these shares is determined on the financial markets by the dynamic forces of demand and supply. Shares represent claims on the future residual cash flows of the firm (and also a usually very limited right on corporate control). In the view of the financial markets, the value of such a claim is determined relative to the claims of other firms that are traded on these markets. The financial markets' perception of the quality of these cash flow claims is crucial for the valuation of the shares. Translated to the management of the individual firm, the aim is not only to maximize the quality of the future residual cash flows of the firm but also to properly communicate all news about these cash flows to the financial markets. Only by disclosing this information to the financial markets potential information asymmetries can be resolved and the fair market value of a cash flow stream can be gauged. In evaluating the possible consequences of its decision alternatives, management should estimate the effects on the uncertain (future) cash flows followed by an estimation of the financial markets' valuation of these effects. Then (and only then) the decision rule of management is very simple: choose the decision alternative that generates the highest estimated market value.

The first problem that might arise while following the above prescription is that residual claims cannot always be defined because of 'gaming effects' (see Figure 2, Box 2). In other words, the future cash flows of the firm do not only depend on the present and future decisions of the firm's management, but also on the present and future decisions of other parties. An obvious example is the situation of oligopolistic markets in which the decisions of the competitors may strongly influence each other. Simular situations may arise with other external stakeholders such as powerful clients, powerful suppliers and powerful financiers. Games may also arise within the firm, for instance between management and certain key production factors. The problem with game situations is that the effect (on the firm's future cash flows) caused by the other parties involved cannot be treated as simple constraints or as cost factors in the cash flow calculation. MCDM may help to solve this problem by formulating multi-dimensional profiles of the consequences of the firm's decision alternatives. In these profiles also the effects on other parties than the firm itself is included. These multi-dimensional profiles are the keys to open the complete MCDM toolbox.

The second problem in dealing with the single objective wealth maximization problem is that the quality of information concerning the firm's future cash flows under different decision alternatives is far from complete (complete in terms of probability distributions and / or stochastic processes). In addition, the available information may be biased or flawed. One way to approach the incomplete information problem is suggested by Spronk & Hallerbach [1997]. In their multi-factorial approach, different sources of uncertainty should be identified after which the exposures of the cash flows to these risk sources are estimated. The estimated exposures can next be included in a multicriteria decision method. In the case that the available information is not conclusive, different 'views' on the future cash flows may developed. Next each of these views can be adopted as representing a different dimension of the decision problem. The resulting multi-dimensional decision problem can then be handled by using MCDM (see Figure 2, Box 2).

The third potential problem in wealth maximization is that the financial markets do not always provide the relevant pricing signals to evaluate the wealth effects of the firm's decisions, for example because of market inefficiencies. This means that the firm may want to include attributes other than the market's pricing signals alone in order to measure the riskiness and wealth effects of its decisions.

3. Multiple Criteria Financial Decisions and the Investor

Maximizing market value is the central paradigm in financial economic decision-making. There is one complication, however. Current market value originates from future cash flows. A common share of stock, for example, derives its value from the dividends that are expected to be received in the future (and from its subsequent selling price). Likewise, the value of a bond depends on the coupon payments and final repayment of the nominal face value. In a frictionless market (in which one can trade immediately at no transaction costs) one would indeed be indifferent between receiving $100 in cash, $ 100 in stocks or $ 100 in long term bonds. After all, the stocks or bonds can be sold immediately in the market resulting in a cash position of $ 100.

The choice situation is completely different when we rephrase the problem as *holding* a position of $ 100 in cash, stocks or bonds over a period of say one year.

Now we are confronted with the cash flows that will be generated by the position during this holding period of one year, and with the value that will be realized at the end of the period. The degree of uncertainty attached to the cash flows from a risk free position, a long term bond and a stock is fundamentally different. It is therefore not feasible to maximize 'the' return over the holding period, for the simple reason that the return is stochastic. Maximizing *expected* future return does not make sense either since this criterion ignores risk (strictly speaking, with probability one the realized return will deviate from expected return).

How does financial theory solve this problem? In the neo-classical approach to finance it is assumed that an expected utility function, defined in terms of future wealth or holding period return, is maximized. The optimal decision rule is derived from confronting the preferences of the investor with the probability distribution of future investment returns. This allowed the Nobel laureate Markowitz [1952, 1959] to formalize the formerly undefined notion of risk by equating risk with the variability of returns in a portfolio context, and to operationalize this risk concept by means of the (co-) variance or standard deviation. From this emerges the concept of a mean-variance efficient portfolio: given its level of risk its maximizes expected return, and given its level of expected return it minimizes risk. The trade-off between expected return and standard deviation embedded in his preference structure allows an investor to choose a suitable portfolio from the mean-variance efficient (i.e. non-dominated) set. In this way the mean-variance decision criterion is a two-parameter substitutive criterion (see Sinn [1983], e.g.).

Note that the adopted preference functional is defined on single dimensional wealth or return. This relates to the left hand side of Figure 2, where there is only a single objective. But what about the two dimensions: expected return and risk? Well, because of the assumed substitutability between risk and expected return these two dimensions can be collapsed into a single preference dimension. This is even more apparent when one is willing to assume that risk free investment opportunities exist. In that case the optimal portfolio is simply the portfolio that maximizes the uni-dimensional Sharpe [1966, 1994] ratio.

Obviously, the simplicity of the mean-variance decision rule goes at a cost. In order to derive the decision rule, quite restrictive assumptions have to be made either with respect to the preferences of the decision maker (quadratic utility) or with respect to the representation of choice alternatives (joint ellipticity, cf. Owen & Rabinovitch [1983]). This is important since the mean-variance decision rule is truly "conditional normative" in the spirit of Keynes [1891]. The decision rule is normative and guides to optimal decisions, conditional on satisfying the underlying assumptions.

Now we turn to investment practice. How likely will the assumptions underlying the mean-variance approach be satisfied? Even within the context of a preference functional defined in terms of single dimensional wealth, variance may be an inadequate risk measure. After all, there is an important difference between variability *per se* and risk, especially when return distributions are asymmetric. For example, downside variability is perceived as risk, and this may explain the obvious success with which the financial community has embraced the downside risk metric "Value-at-Risk" (Jorion [2000]). Upside variability, in contrast, is evaluated positively as "potential".

In addition, a single dimensional risk measure may not prove sufficient to adequately discriminate between investment alternatives. In financial practice it is recognized that the potential variability in the returns can be attributed to the variability in several underlying state variables or economic factors. Some examples are interest rates, inflation, economic growth, and even market sentiments. Each of these factors represents a dimension of the economic environment in which the security returns are generated. We can thus view the returns as being *generated* by the factors. Conversely, the stochastic outcomes are *conditioned* on these factors. This notion can be formalized by a factor model.[2] The relationship between a security's return and changes in these factors is described by a response coefficient or factor sensitivity. By means of these sensitivities, the joint distribution of security returns is linked to (i.e. conditioned on) the joint distribution of factor changes. In this interpretation, the sensitivity coefficients can serve as risk measures; together they constitute the multi-dimensional risk profile of a decision alternative. As the variability of returns is linked to the variability in various identifiable economic variables, investment risk becomes an intuitively appealing, multi-dimensional concept.

The use of factor models permits replacing return variance as a uni-dimensional risk measure by multi-dimensional risk measures. These measures

[2] See for example Sharpe, Alexander & Bailey [1999].

provide more insight in the nature of risk perceived by investors than a uni-dimensional, 'aggregate' risk measure. In order to shape the risk profile of an investment portfolio not only the trade-offs among the exposures to the various factors must be evaluated, but also the trade-off between expected return on the one hand and different factor risks on the other. It may be clear that forcing this decision problem into the straitjacket of a single dimensional objective function with policy constraints will result in a very poor description of the actual decision context. Obviously this provides a fruitful area for MCDM applications.

In our opinion the multifarious nature of perceived risk is only the first argument for applying MCDM. Experiences from practice show that explicit return and risk attributes do not seem to capture all relevant information (cf. the early research by Baker & Haslem [1974], for example). To fill this gap, additional attributes may be incorporated at the investor's discretion. These indirectly return related attributes may be considered of general relevance in practice, but may also be relevant because of idiosyncrasies in the investor's personal decision context. In the latter case, the incorporation of additional attributes can be motivated from either the specific tastes and desires (goals) of the investor, from specific investment constraints he faces, or from distinctive characteristics of the investment alternatives. For example, because of the investor's tax situation, the taxability of the portfolio components may be a relevant attribute. In terms of 'liquidity' or the flexibility to revise the portfolio's composition, the marketability of the component securities may be relevant. Especially the *Long Term Capital Management* debacle in September 1998 revealed the crucial importance of market liquidity. Because of some method of performance measurement, the position with respect to some benchmark portfolio may be relevant, and so on. In addition, the investor may adher to the notion that not all future events can be reduced to probability distributions, not even when the latter are of a subjective nature. This also implies that attributes may be considered in addition to explicit elements of return and explicit components of risk. We must seriously consider the possibility that some of these 'other' attributes act in fact as proxies for (components of) expected return and risk.

Many attributes are considered important, not only from a practical point of view, but also from an academic point of view because they represent 'anomalies'.[3] For common stocks, 'firm size' is a long-time notorious variable. Other examples are price ratios as indicators for fundamental firm value, like earnings/price, book/price (book value of common equity per share divided by market price per share), cash flow/price, sales/price and dividend/price. In the context of 'value investing' there is great renewed interest in these long time familiar attributes.[4]

In the view of (positive) financial theory, an attribute's ability to contribute to the explanation of cross-sectional return differences appears to be a convincing criterion for the selection of relevant attributes. However, an attribute will only carry a significant premium when it is 'priced' in the market. But a non-average investor can face a set of investment opportunities that is different from the market (i.e. the average investor). For example, his opportunity set can be restrained by investment restrictions or by prohibitive transactions costs. Hence this investor is only interested in the relevance of this attribute in his opportunity set. Furthermore, partly connected to the former argument, the reward that an investor attaches to the exposure to an attribute (a 'subjective' premium) may well be different from the premium that the market as a whole attaches to that attribute (the 'objective' premium). The difference between objective and subjective premia just reflects the differences in the preference structure of the investor *vis à vis* the market as a whole. This leads us back to the starting point that the selection of attributes depends on the personal circumstances of the investor, as summarized in his profile. In brief, there exist many security attributes that are relevant in practice, despite the stylized neo-classical view of financial theory.

How can the decision making process be shaped in this general multi-attribute context? Suppose that an investor can demarcate a set of security attributes that he considers relevant. On the basis of these attributes he can discriminate between the attractiveness of various securities.[5] For the investor, a financial security then

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[3] An attribute is an anomaly with respect to an asset pricing theory when that attribute possesses power to explain cross-sectional variation in expected returns in addition to the risk measures as specified by the pricing model at hand. An attribute is an anomaly with respect to the efficient market hypothesis when it can be used to forecast future returns. For an overview we refer to Sharpe, Alexander & Bailey [1999].

[4] See for example Fama & French [1992, 1993].

[5] This view is borrowed from consumer choice theory; cf. Lancaster [1966].

represents a basket of, say, *k* attributes and can be fully characterized by a *k*-tuple of attribute values. In an investor's view, when buying a security, he is actually buying an exposure to various attributes. Hence, we can specify a mapping of the securities in the space spanned by the attributes:

$$\text{security i} \rightarrow \{ a_{i1}, a_{i2}, \ldots, a_{ij}, \ldots, a_{ik} \} \qquad , i \in N \tag{1}$$

where a_{ij} is the value that attribute *j* takes for security *i.* The opportunity set an investor faces can then be described in terms of a multi-attribute representation of the *N* available securities. For a given portfolio, its score on a certain attribute is a function of the attribute scores of the individual securities contained in this portfolio. The fractions invested in each of these securities can thus be treated as instrumental variables and the attribute exposures can be seen as goal variables. The investment problem now becomes a multi-attribute portfolio selection problem where the investor strives to balance the attributes of the individual securities on the portfolio level. Given the security attributes and the specific decision context, the investor strives to fashion the attributes of his portfolio in a way that suits his particular circumstances and preferences best. Often, the investor will try to either minimize or maximize each of these goal variables. Alternatively, the investor may strive to attain a target level or desired score on some attribute(s). Depending on the investor's insights and preferences, the relative importance of each of these goals may vary. Generally, no portfolio can be found for which each of the goal variables reaches its optimal value or for which all criteria are met. As a consequence, the investor has to evaluate the trade-offs between the various goal variables. This calls for multi-criteria decision methods. In this context, a single objective decision framework would become a *Procrustes bed*, chopping off any other characteristics of the investment alternatives that the investor may consider important.

The notion that the portfolio investment decision for individual investors calls for a multi-attribute approach dates back to Smith [1974, p.53]; Spronk & Hallerbach [1997] present a general framework for moulding the financial investment decision process, labelled 'multi-attribute approach to portfolio selection'. Of course, there are many more examples of moulding the portfolio selection problem in terms of multi-criteria decision making. However, one can observe that most (if not all) of these approaches are at best only partial. Either they fail to give room for the inherent complexity of the decision procedure, or they concentrate on the beauties of a particular multiple criteria decision method taking insufficient account of the decision context and of the results and principles of financial economic theory.

In our opinion, portfolio problems signify a fertile ground for applying MCDM methods. However, the potential rewards will only be reaped when the stage of applying MCDM methods to a given financial decision problem is surpassed and MCDM and financial knowledge is integrated. An important additional desirable feature of the applied MCDM technology is the possibility to explore the decision context. Instead of hiding the solution process and presenting the final solution in one step to the decision maker, one should allow the decision maker to learn about his preferences and about the characteristics of the investment opportunities. For example, the selection of relevant attributes is no 'once and for all' activity. The investor's decision context and the securities' economic environment may change over time and may become better understood because of learning effects. In addition the investor can evaluate the trade-offs offered by the investment alternatives and compare them with the desired trade-offs.

4. Risk management

Financial markets are forward-looking: current market value incorporates the market's expectations regarding the future. Changes in these expectations will induce changes in value. This implies that it is not only important to consider current market value as an important (but not the single) aspect of financial decisions, but also to incorporate the notion of potential future changes in this value. This calls for a risk analysis of the decision alternatives, in which the sources of risk and the corresponding exposures are identified – and possibly quantified. Moreover, when time passes by the current value must be guarded and protected against unwanted influences that may corrode this value. This in turn implies the need for risk management: the process of adjusting risk exposures in such a way that the desired risk profile is attained.

From the previous discussion, the role of risk analysis and risk management for financial investment decisions may be clear. Indeed, considering the level of volatility on financial markets the claim that financial investment is mainly risk management is not exaggerated. Especially in an asset-liability context (for banks, pension funds and insurance companies) investment decisions are driven by the desire to match the risk profiles of the liability portfolio on the one hand and the investment portfolio on the other. There are multiple risk sources (interest rates, economic growth, inflation, e.g.) and choosing the desired risk profile entails evaluating the trade-offs among the different risk exposures and between the risks on one side and expected return on the other. This calls for multicriteria decision methods.

Even in the simple case where an investment portfolio seems to be only sensitive to interest rate risk (a fixed income portfolio) a multicriteria approach can add value. Since long, a bond's interest rate exposure is measured by duration, defined as the (negative of the) bond's interest rate elasticity (see Fabozzi [1997]). However, the concept of duration assumes that the term structure of interest rates will only move in a parallel way. A richer description of interest rate risk can be obtained by allowing any shift in the term structure of interest rates. Instead of one single duration measure one could use a set of partial durations, each measuring the sensitivity of the bond price to changes in some specified rate. This is analogous to the multi-factor model discussed before. Reitano [1990, 1996] and Ho [1992] specify a set of key spot interest rates and consider the bond price sensitivities for changes in these key rates. Key rate durations may be used to account for the three major interest rate risk factors as identified by Litterman & Scheinkman [1991]: changes in the level, slope and curvature of the spot rate curve. Positioning a fixed income portfolio in an uncertain interest rate environment involves gauging the exposures to different sources of interest rate risk and evaluating the trade-off among different exposures as well as between risks and returns. Especially when the trade-offs are non-linear, the multicriteria specification of the decision problem cannot simply be collapsed into a two-parameter risk-return substitutive criterion. When translating additional criteria into restrictions, sight on these trade-offs is lost.

Risk analysis and risk management also play a paramount role in capital investment decisions. In the capital budgeting process the risk profile of the future cash flows generated by investment projects must be clearly understood. With the increasing globalization of markets, increased competition and fast changing consumer preferences, the economic environment in which these cash flows are generated can change drastically in many dimensions. The firm then faces the difficult task to evaluate a project's risk profile and – if necessary – to change this profile by means of operational or financial hedging techniques (cf. Smithson [1998], Stulz [2002]). Crucial determinant of the decision to hedge is the degree of comparative advantage that the firm has in the area of a specific risk source. When the comparative advantage is high (as will be the case for the firm's core activities) the firm can add value for its shareholders (and other stakeholders) by maintaining an exposure to the corresponding source of risk. Conversely, in the firm may decide to hedge risk exposures that are not (or only remotely) related to its core activities. In any case, the decision to hedge involves evaluating the trade-offs between the costs and benefits attached to exchanging one exposure for another. The interdependency between risk sources makes it difficult to evaluate these trade-offs. This is where multicriteria methods may help to support the firm in its hedge decisions.

Consider for example the airline KLM. KLM experiences the influences of different risk sources: it has exposures to foreign currencies (especially the US dollar with respect to the euro), interest rates (mainly because of its financing structure) and jet fuel prices. The hedging decision involves evaluating the risks and potential returns from these various risk sources. However, this risk analysis cannot be performed only for KLM in isolation. Also the potential effects of competitors' hedging strategies on KLM's position have to be taken into account (see Figure 2). Suppose, for example, that competitors hedge but KLM does not. When jet fuel (or oil) prices increase, KLM experiences a disadvantage relative to its competitors and this may hurt its profitability. When KLM would increase fare prices to compensate for the increased cost, its relative competitive position may deteriorate, resulting in loss of market share. Of course, KLM would experience a relative advantage when jet fuel prices decrease but the effect is not symmetrical. After all, it is much more difficult to conquer market share than to lose it.

5. Conclusion

From the neo-classical perspective of perfect markets, financial decision problems can be moulded in terms of a single objective. However, imperfections such as information asymmetries, conflicting interests and transactions costs (which restrict choice opportunities) require a much richer description of the decision context. Focusing on the three main areas of finance – corporate finance, financial investment and risk management – we argue that many decision problems involve multiple objectives, and sometimes even multiple actors. The fundamental concept of risk, for example, is by nature multi-dimensional. Competitive forces to the corporate firm are partly driven by decisions of third parties. Consequently, a single objective approach to financial decision making becomes a straitjacket. When attempting to cope with additional objectives by rephrasing them as policy constraints, the single objective feature is preserved. However, this goes at the high cost of losing the information about the relevant trade-offs.

The multi-dimensional nature of many financial-economic decision problems lends itself for the application of MCDM technology. However, to ensure a suitable description of the particular decision context at hand and to chose a suitable MCDM method to solve the destilled decision problem, financial theory and MCDM should be brought closer together. Problem description and problem solving are not two separate stages towards making better decisions. Instead, the whole trajectory from analyzing the decision context and gathering (imperfect and incomplete) information to chosing and implementing a suitable MCDM technology should be spanned. Indeed, the complexity of financial choice problems calls for an integration of financial and MCDM knowledge. Not only to improve final decisions, but above all to improve the quality of the choice *process*. The latter is necessary in order to cope with the frequent changes in the decision context. It allows benefiting from learning effects and it may at the same time facilitate the wider acceptance of MCDM techniques in practical decision making.

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