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INVESTMENT RISK ANALYSIS: THEORETICAL ASPECTS

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Abstract

Strategic investment decisions are among the most important decisions made by business enterprises. During the investment decision making process investment alternatives are identified, evaluated and projects that are likely to have a big impact on a company's competitive advantage are selected. However, under conditions of global economy the steady increase in the variety and scale of uncertainties, competitive interactions and risks prevail, and the difficulty to make reasonable investment decisions is growing. To assist managers in the decision making process, researchers have developed various approaches dealing with uncertainty.

The main objective of this paper is to investigate the feasibility of different risk analysis techniques under conditions of environmental uncertainty.

Research method – systematic scientific literature analysis.

Keywords: investment decision making, investment decisions, risk analysis, uncertainty.

Introduction

Globalization of economy conditioned the situation that progressive companies operate in market sectors that were largely developed by the new economy. The new economy is the economy in which risk, uncertainty and constant changes become a rule but not exception. This is the economy of the global business where everybody has the same rights and possibilities of competing for success.

However, because of changing nature of global markets, in order to make correct investment choices and reach effective strategic capital investment decisions, there is a need for sound and reliable risk handling tools. A number of techniques have been developed that permit consideration of the uncertainty dimension as part of the process of investment analysis. These methods fall broadly into two major categories: simple risk adjustment and risk analysis (Ho & Pike (1991); Ho & Pike (1998)).

Many authors (Yao & Jaafari (2003); Sale & Atinc (2008); Schober & Gebauer (2011)) observed that, despite the apparent ease of use, simple risk adjustment methods contain assumptions that may not be clearly understood and could lead decision makers to accept decisions against their original intentions. In contrast, supporters of the risk analysis approach argue that the increased risk information improves management's understanding of the nature of the risks, helps identify the major threats to project profitability and reduces forecasting errors. These lead to better decision outcomes and enhanced corporate performance.

However, the feasibility of particular risk analysis framework depends on the level of uncertainty associated with an investment decision. The results of this study suggested that real options approach is the most appropriate for valuation of flexibility and investment opportunities, and is the primary enhanced decision making framework dealing with uncertainty.

The main aim of this paper is to investigate the feasibility of different risk analysis techniques under conditions of environmental uncertainty.

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Keywords: investment decision making, investment decisions, risk analysis, uncertainty.

Uncertainty: the new rules for risk analysis

Risk analysis (or probabilistic risk analysis) techniques emphasize a comprehensive awareness of the uncertainties associated with critical project variables, and usually involve evaluation of the associated expected values and variance of an investment project's outcomes before any risk-return trade-off decision is made.

Generally prescribed risk analysis techniques for strategic, large-scale projects include sensitivity analysis, Monte Carlo simulation, decision tree analysis and option pricing approaches, etc. These methods involve quantification of the uncertainties surrounding a project and are in contrast to the simple risk adjustment methods that are mainly based on deterministic estimation, intuitive adjustments to the discounted cash flows evaluation model (e.g. increasing the discount rate or reducing the payback criterion for higher-risk projects) and rely on a subjective rather than a quantitative assessment of uncertainty.

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Risk analysis also offers many qualitative benefits to managers and to the company as a whole. The use of risk analysis provides a systematic and logical approach to investment decision making, helps communication within the organization, and allows managerial judgment to be presented in a meaningful way. Ho & Pike (1991; 1998) also found that the risk-analysis approach provides useful insights into the project, improves decision quality and increases decision confidence.

The feasibility of particular risk analysis technique depends on the level of uncertainty associated with an investment decision.

Coyne & Subramanian (1996), Courtney *et al.* (1997), Courtney & Lovallo (2004) and other academicians distinguish four levels of uncertainty:

Clear enough future. At level one, the traditional microeconomic model, assuming that uncertainty is low enough for managers to make reasonably precise forecast of the future on which strategy can be based, still holds. So decisions can be made using traditional discounted-cash-flow methodologies and sensitivity analysis.

Alternate futures. At level two, the future will follow one of a few discrete scenarios, though analysis cannot predict which one. In this case, strategy could be built around two possible scenarios. At this level of uncertainty the number of scenarios is usually small, so strategy can be determined analytically, and decisions should be made using techniques as at level one plus Monte Carlo simulation, decision tree analysis, option pricing approaches.

A range of futures. At level three, continuous uncertainty prevails and a range of potential futures can be identified. There are only a few dimensions of uncertainty, though analysis can’t reduce the future to a limited number of discrete scenarios. At this level, decisions can be made using decision tree analysis and option pricing frameworks.

True ambiguity. At level four, there is true ambiguity and a number of dimensions of continuous uncertainty exist. It is impossible to identify a range of potential outcomes or scenarios within a range. Situation analysis at level four is highly qualitative. So decisions should be made by working backward to define what managers would have to believe to support particular strategy.

In the conditions of today’s globally competitive marketplace for most business situations uncertainty of two and three levels is incident and the value of flexibility to perform a particular action or not is growing.

Traditional approaches dealing with uncertainty

Traditional risk analysis techniques typically develop models based on the discounted cash flow (DCF) approach for project investment decision making. This approach is used widely to determine whether to undertake or not an investment project. However, it is rational to use DCF when the decision involves a relatively simple business structure, uncomplicated projects, and a stable environment that enables reliable forecasts. Under conditions of global economy projects or investment decisions violate the underlying assumptions of DCF, causing this analysis to be of limited value at best, or misleading at worst.

Three competing traditional risk analysis methodologies mostly are distinguished in academic literature: sensitivity analysis, traditional simulation and decision tree analysis.

Sensitivity analysis deals with the identification of variables that could cause significant impacts on expected outcome of the project (measured as project’s NPV, or possibly IRR in some cases) and determine the impact on the project’s expected outcome of a given variation in each significant variable at a time, with other variables held constant. This analysis frequently referred to as “what if?” analysis and it is useful in determining the key variables that could contribute the most to the magnitude of uncertainty associated with an investment project.

However, sensitivity analysis has some limitations (Yao & Jaafari (2003); Gilbert (2004); Wang & Hwang (2007)):

First, it considers the effect on NPV of only one error in a variable at a time, thus ignoring combinations of errors in many variables simultaneously.

Second, it treats variables as if they are independent and does not consider interrelationships that might exist between key variables. In situations when there are interdependencies among the variables, examining the effect of each variable in isolation is even less meaningful.

Third, it does not formally attempt to quantify risk. There is no assessment of the probability of changes in any of the variables occurring.

Fourth, it does not provide any clear-cut decision rule – managers do not know if their decisions should be altered as a result of the sensitivity of any variable.

Despite all these limitations, in practice sensitivity analysis is a very popular risk analysis technique (Ryan & Ryan (2002); Kester & Robbins (2010); Weaver (2011)).

Traditional simulation techniques use repeated random sampling from the probability distributions assigned to each of the crucial primary variables underlying the cash flow of a project to arrive at output probability distribution or risk profiles of the cash flows or of NPV for a given management strategy. The process of simulation analysis uses a mathematical model to capture the important functional characteristics of the project as it evolves through time and encounters random events which have an equal probability of occurrence.

Monte Carlo simulation for risk analysis is a form of traditional simulation and is explored in literature on investment appraisal (Tarnoczi *et al*. (2011); Carmichael (2011)). It is able to handle complex, multivariate investment decision problems under uncertainty with a large number of input variables, which even may interact with one another or across time.

Monte Carlo simulation provides a number of advantages over sensitivity analysis. With just a few cases, deterministic analysis makes it difficult to see which variables impact the outcome the most. In Monte Carlo simulation, it's easy to see which inputs had the biggest effect on bottom-line results. Therefore this technique is much more useful than a traditional "what if?" approach.

Monte Carlo simulation process is based on predetermined operating strategy and it may be an appropriate model for history-dependent investment proposals. However, the model requires accurate probability assessments of the significant variables, yet these are subjective and difficult to estimate in practice. In addition, this approach is not well suited to accommodate the asymmetries in the distributions introduced by management's flexibility to review its pre-established operating strategy when it turns out that, as uncertainty gets resolved over time, the realization of cash flows differs substantially from initial expectations.

Decision tree analysis has its roots in normative decision theory, is a well established methodology for decision analysis and is used in situations in which decision makers face a sequence of decisions, and between each two successive decisions, an outcome of the previous decision intervenes. This analysis involves the structuring of the problem by enumerating all possible intervening and final consequential outcomes and applies the principle of maximum expected utility to determine the best project alternative. So decision trees force management to bring to the surface its implied operating strategy and to recognize explicitly the interdependencies between the initial decision and subsequent decisions (Trigeorgis (2000); Wang & Halal (2010)).

The main advantage of applying decision tree analysis is that is possible to represent and analyze a series of complex sequential investment decisions to be made over time.

However, the construction of the decision tree is not only time consuming but can also be extremely messy when the problem is large and complex. Decision trees can become difficult to understand and solve because they are inherently combinatorially explosive, can become intractably large and complex quickly, and require knowledge of the joint probability distribution. In addition, pre-processing of probabilities in a relatively complex problem may become intractable. Lastly, as the number of options modelled in a tree increases, the number of scenarios increases exponentially, but often without adding much value (Lander & Pinches (1998); Wang & Halal (2010)).

Another problem that remains is how to determine an appropriate discount rate for the tree (Yao & Jaafary (2003)). Using constant discount rate presumes that the risk borne per period is constant and the uncertainty is resolved continuously at a constant rate over time, not in discrete lumps; if discrete chance events were appropriate, then different discount rates should be used in different periods

Real options approach

The quantitative origins of real options or options on real assets derive from the seminal work of Black & Scholes (1973) and Merton (1973) in pricing financial options. Black-Scholes equation requires five parameters for calculating the option value. For real options, these parameters include the present value of future cash flows, the investment cost, the interest rate, the time horizon, and the project volatility. The first four variables are exactly the same as those required to determine the net present value. Volatility is the only added variable, although it is the most difficult to determine and the most complex of the input parameters (Eschenbach *et al*. (2007)).

Companies establish options by making an initial investment, for example by performing a market test, creating a joint venture, developing a prototype, or purchasing an operating license. If the economic prospects of the project turn out to be favorable, a company may decide to exercise the option later. Contrarily, if economic circumstances are unfavorable, it won't make any subsequent investment and abandon the option.

Real options are commonly classified into three main groups (Trigeorgis (1993, 2000); Copeland & Keenan (1998); Lander & Pinches (1998); Damodaran (1998); Madhani (2008); Zeng & Zhang (2011)): invest/grow options (scaling up, switching up, or scoping up a project), defer/learn options, and disinvest/shrink/abandon options (scaling down, switching down, or scoping down a project).

Option to invest/grow – this is an American call option. In particular circumstances, firms can implement projects because doing so allows them either to take on other subsequent projects or to enter other markets in the future. In such cases, the initial projects are options allowing the firm to take other projects and the firm should therefore be willing to pay a price for such options. A company may accept a negative net present value on the initial project because of the possibility of high positive net present values on future investments.

Scale up option – this is where initial investments scale up later through cost-effective sequential investments as market grows. *Switch up* – a flexibility option to switch products, process on plants given a shift in underlying price or demand of inputs or outputs. *Scope up* – this option values the opportunity to leverage an investment made in one industry into another, related industry cost-effectively.

Option to defer – holding this option derives its value from reducing uncertainty by delaying an investment decision until more information or skill is acquired. This option is an American call option and is especially valuable in an environment in which a project can be taken by only one firm (because of legal restrictions or other barriers to entry to competitors).

Option to disinvest/shrink/abandon – this is an American put option and it gives option's holder the right to dispose a project and recover its salvage value when under particular market conditions its cash flows do not measure up to expectations.

Scale down – an option to shrink or shut down a project part way through if new information changes the expected payoffs. *Switch down* – this option values a company's ability to switch to more cost-effective and flexible assets as new information is obtained. *Scope down* is valuable if operations in related industry can be limited or abandoned when there is no further potential in a business opportunity.

Real options approach is most significant in the following situations (Amram & Kulatilaka (1999); Madhani (2008)):

First, Uncertainty. There must be high uncertainty. This is in contrast to most traditional thinking, instead of fearing the uncertainty, option thinking is actively taking advantage of uncertainty.

Second, New information. It must be very likely that new information is received (decreasing uncertainty) overtime.

Third, Managerial Flexibility. If there is high uncertainty and new information decreases this uncertainty, there is no option value unless management is able to respond appropriately to this new information.

When option pricing techniques are used, the resulting option-based model has the following specific advantages: is based on theory, is flexible, and can be a simple yet powerful decision making framework; can, at least conceptually, be used to model and value many types of business decisions and, in some cases, easily model and value reasonably complex investment opportunities; is specifically designed to model flexibility and can account for, and value, active project management, time dependencies, project interactions and interdependencies, and option interactions; avoids the issues of risk preferences and risky discount rates by using the risk-free rate and risk-neutral probabilities; introduces asymmetry into the distribution of investment opportunity value and models risk directly versus indirectly (risky discount rate); provides specific intuition into project valuation by explicitly representing the factors which affect valuation, and produces consistent valuations.

Some academicians (Kemna (1993); Lander & Pinches (1998); Wang & Halal (2010)) argue that decision trees may be an alternative way to value flexibility, yet this investment decision making framework requires some inputs which are difficult to estimate (for example, the subjective probabilities, appropriate discount rate for the tree, etc.). When applying real options approach the impact of misleading assumptions is eliminated: subjective probabilities are not needed (expected values are determined using risk-neutral probabilities) and discounting at the risk-free rate is performed.

Table 1 compares decision trees and real options methodologies using key criteria for decision making tools.

Table 1. Decision trees and Real options: comparison

	Cash flow based	Risk adjusted	Multi-period	Captures flexibility
Real options	+	+	+	+
Decision trees	+	–	+	+

So in comparison with decision trees, real options analysis is a superior framework for valuation of flexibility and investment opportunities in volatile environments – situations when uncertainty of two and three levels is incident.

Conclusions

The nature of global economy is one of dynamic change and uncertainty. Under such circumstances the importance of handling risk properly and managerial flexibility to alter a predetermined course of actions is growing. In academic literature a number of techniques, such as sensitivity analysis, Monte Carlo simulation, decision tree analysis and real options approach that permit consideration of the uncertainty dimension have been developed. However, the feasibility of particular risk analysis framework depends on the level of uncertainty associated with an investment decision.

Real options is the extension of financial option theory to options on real (non financial) assets. Real options valuation is important in situations of high uncertainty where managers can respond flexibly to new information. This risk analysis technique improves managerial decision making by systematically organizing the analysis; reformulating the problem to provide additional insight into, and understanding of, the investment opportunity and to reveal more features of the investment opportunity; distinguishing between alternative investment opportunities and options which are embedded in a single investment opportunity; improving communication among and between decision-makers, and providing an improved interface between capital investment decision making, strategic management, and long-range planning. So real options approach is the most appropriate for valuation of flexibility and investment opportunities, and is the primary enhanced decision making framework dealing with uncertainty.

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