Potential Applications of Real Option Analysis in the Construction Industry in Developing Countries

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Abstract

This paper introduces the real options method of investment appraisal and its evolution. It discusses the advantages and disadvantages of real options with regard to other commonly used investment methods and with emphasis on the construction industry in developing countries. Investment analysis is not an entrenched practice in construction industries, and needs to be undertaken more often, which is discussed together with possible areas of application of real options for participants in the construction industry. The process of implementing real options and problems encountered in implementation are then considered. The paper concludes with reasons for the likely success of real options as an investment analysis method and notes the potential positive effects implementing the approach will have in the construction industry in developing countries.

Keywords: Real options, real options analysis, investment, investment analysis, developing countries.

INTRODUCTION

There has been a growing use of real options analysis as a tool for valuation and strategic decision-making in the recent past. This has potentially significant implications for the construction industry in developing countries. Faced with limited resources, clients and construction firms see the decision to invest or tender as fraught with danger. There is a great need for methods of analysing such investments that identify uncertainty, reduce risk and maximise value to the parties in the construction industry, be they contractors, the professionals or clients. Real option analysis is touted as containing the insight and flexibility needed in valuing opportunities and uncertain investments. It offers a novel way of valuing changes to ongoing projects and assessing the implications of changes to programme decisions.

Traditionally, the construction industry in a typical developing country has not delved deep into the fields of formal risk analysis and valuation. Participants operate primarily on intuition, historical data or cursory financial analysis and judging the value of and risk involved in any project is rarely the subject of an exhaustive scrutiny of the options involved. The advent of globalisation, the resulting need to operate at international standards, the increasing cost of construction and the many competing uses for scarce capital have made it imperative for construction industries in developing countries to adopt new strategies and tools.

This paper will look at the potential of real options in developing country construction industries. It will analyse the workings of the method, its strengths and weaknesses and make recommendations as to its implementation in the construction industry.
Real options – An introduction

In 1997, Robert Merton and Myron Scholes were awarded the Nobel Prize in Economic Sciences for their work in devising a new method to determine the value of derivatives. Derivatives are financial instruments such as futures and options; futures are trades where the price of a commodity is set against future delivery at a specific date, while options are the rights (but not the obligations) to sell or buy a commodity at a predetermined price on or before a predetermined date.

Along with Fisher Black, Merton and Scholes solved what had up to then been an intractable problem. While the first attempt at valuing options had been made by Louis Bachelier in 1900, until 1973 no one had solved the problem of valuing the risk element of derivatives. Investors are by nature risk-averse and demand a premium on top of the interest rates to cater for risk, and the determination of this premium was, and is, a subjective exercise. (Mason and Merton, 1985; Amram and Kulatilaka, 1999; The Royal Swedish Academy Of Sciences, 1997).

In 1973, Black and Scholes with input from Merton derived a formula which eliminated the need to determine the risk element by incorporating it into the option price. By recognising that any attempt to value an option must eliminate arbitrage (the existence at the same time of a different buying and selling price for a commodity), the three introduced a tracking portfolio of traded securities similar in nature to the option, which would in essence provide a hedge for it (Bernstein, 1992). Changes in the value of the option’s underlying asset would be matched by introducing changes in the hedging portfolio in a process referred to as dynamic tracking. The hedging position creates a situation of no uncertainty, which eliminates the effect of risk (in effect, a risk-free rate of return) and the value of the option would then be determined by the value of the portfolio. If they differed, as Smith (1999) describes, there would be a chance to earn a risk-free profit by buying the more expensive and selling the cheaper.

The development of the Black-Scholes formula was important because, as Altman and Subrahmanyam (1985) note, the development of a way to price options provided a framework for the valuation of traded options on stocks and related financial instruments. This could then be extended to a wide range of corporate assets and liabilities. The formula’s attractiveness derives from its reliance on observable variables, giving it practical appeal. Courtadon and Merrick (1986) observe that of the five variables required in the equation developed by Black and Scholes: the stock’s current value, the option’s exercise price, the option’s time to expiration, the prevailing interest rate and the volatility of the underlying stock, only the last is not directly observable.

Amram and Kulatilaka (1999) further note the relevance of the formula when applied to “real” options (as opposed to stock market options). First coined by Stuart Myers, real options are simply the “extension of financial options theory to options on real (non-financial) assets”. For example, owning a power plant gives a utility the opportunity, but not the obligation, to produce electricity at a later date and having the development rights to an oil field gives a company the option, but not the obligation, to produce oil later. Production of electricity or drilling for the oil would then be a case of exercising the option.

Copeland and Keenan (1998) point out that it is difficult sometimes to identify real options in real life managerial settings. They give the example of insurance contracts in the 1960’s that gave holders the right to borrow against the policy at a fixed rate of interest when interest rates were low and that option, when exercised at a time of prevailing high interest rates, caused near insolvency in the insurance companies as they had to borrow at higher rates in order to honour their contracts; they had no idea of the value of the options they gave away.

The problems with standard methods of valuation

Capital budgeting is the process of determining whether the value of investment projects exceeds the cost of implementation. The discounted cash flow method is the most commonly used method for capital budgeting and involves the comparison of the cost of the project and the present value of future cash flows the project will generate. As Brennan and Schwartz (1986) point out, that this assumes that future cash
flows will be constant, certain and unaffected by future management decisions. It also assumes a known and constant discount rate. By ignoring the effect of future managerial decisions, for example the decision to expand, contract or close down operations, the discounted cash flow method ignores decisions that can significantly affect the value of a project.

The difficulty in assuming a known discount rate arises from two problems; one, the selected rate, in addition to being determinable, should account for the individual nature of project risk and two, that it remain constant over the life of the entire project. Both conditions are unlikely to be true for a project of any complexity and significant errors in valuation can result over the wrong choice of discount rate. Further to the previously mentioned problems, discounted cash flow analysis also suffers from the fact that there is no way of incorporating uncertainty or choosing between scenarios.

Other tools and methods for decision-making and the valuation of investments also exhibit limitations in their approach to valuing projects. Classic decision tree analysis builds a tree of possible situations and the decisions management can make in response to those situations. Cash flows are then determined based on their objective probability and then discounted at a chosen rate. Discount rates are adjusted to reflect risk, however, and the risk changes depending on the node in the tree. Thus, we would need to calculate a different discount rate for each node. Decision tree analysis gives us no indication of how to choose the rate or adjust it for risk. The rate usually used is the weighted average cost of capital, which when used can give false results of up to a factor of two. (Copeland and Keenan 1998)

Comparing real options and the decision analysis approach, Smith (1999) states that while both are about modelling decisions and uncertainties related to investments, real options analyses usually focus on the evolution of a few stochastic factors (factors that change over time in an uncertain manner) that determine the value of the investment over time. The cash flows are then defined as functions of these factors, and thus the models are said to “focus on dynamic complexity at the expense of detail complexity”.

Decision analysis models, on the other hand, tend to consider in detail cash flows and other uncertainties, emphasizing detail rather than dynamic decision-making or downstream decisions. Amram and Kulatilaka (1999) point out that decision analysis relies on the subjective assessment of discount rates and probabilities that are not considered in the real options method.

Traditional capital budgeting methods further have difficulty in valuing project abandonment, deferral or alteration in any way. This means that such methods cannot adequately recognise managerial operating flexibility and strategic interactions. The end result is an “inability to properly recognise the value of active management in adapting to changing market conditions” (Trigeorgis, 1997:9). Traditional techniques are also prone to managerial bias, especially in the selection of interest rates to be used.

The reason for real options superiority in factoring in managerial flexibility is its consideration of more variables. It factors in the time to expiry, uncertainty of expected cash flows, risk free interest rate, value lost over duration of an option, present value of fixed costs and the present value of expected cash flows (note the slight difference with the five variables Black and Scholes consider for stock option valuation). Discounted cash flow methods factor in only two; the present value of fixed costs and the present value of expected cash flows. Real options can be seen as encompassing discounted cash flow plus a premium, so to speak, in the form of flexibility value, the change in discounted cash flow over a projects life. (Net present values for our purpose are a form of discounted cash flow valuation.)

The advantages of real options

Perhaps the greatest value of option pricing theory to the construction industry lies in implementing it more as a way of thinking than a method of valuation. Leslie and Michaels (1997) and Amram and Kulatilaka (1999) both stress this aspect, with the former stating that “while option-pricing models are indeed a superior valuation tool - the purpose to which the theory is generally put - we believe real options can provide a systematic framework that will also serve as a strategic tool, and that it is in this strategic
application that the real power of real options lies”. They recognise that proper use can provide the tools to help turn strategy concepts into strategic plans.

A significant advantage of option valuation over the other approaches lies in its treatment of uncertainty and flexibility.

**Uncertainty**

The historical use of discounted cash flow valuation emphasised the importance of selecting the right discount rate, which accentuated the negative aspects of uncertainty for managers. With the use of real options, however, uncertainty can be seen as an opportunity. Factoring in volatility in valuing options shows that the more volatile an asset, the more valuable the option on the asset. Coy (1999) gives the example of an option to buy a share at a set price by a certain date when the current price is lower. The lower the volatility, the lower the chance the shares will rise, so the option to buy them at the lower price is not very valuable. If the volatility is high, the chance the shares will rise increases, which makes the option to buy them at the lower price more valuable. Should the shares price fall the option can simply be allowed to expire.

In addition, the real options approach brings a new perspective on capital investment decision-making to managers and investors. Viewing investment opportunities as options on real assets provides valuable insights and may challenge popular beliefs, one of which is the perception that uncertainty is bad. As a hypothetical example, take a company with a licence to exploit a stone quarry. Traditional analysis may show that there is a marginal profit to be expected from exploitation of the mine, but the high risk caused by uncertainty over future prices in the construction industry makes the investment undesirable. A real options approach would recognise, however, that the company has the option to develop the quarry at any point in the future, including those times when prices are favourable. Also, should prices drop to unprofitable levels, the option exists to shut down temporarily. These two decisions would be missed by a traditional analysis. Financial market information about prices and trends in the construction industry is used to predict aggregate price volatility, avoiding subjectivity.

**Flexibility**

Mason and Merton (1985:32) define project flexibility as a “description of options made available to management as part of a project”. Flexibility arises through management’s ability to make contingent business decisions (i.e., those decisions made because an event has happened and if the event changes, the decision changes). The payoff to an option will be non-linear; it will change with the decision taken. In contrast, fixed or non-contingent decisions have linear payoffs; whatever happens the decision made is the same (Amram and Kulatilaka, 1999). Non-linear decision-making is actually the norm in business. Leslie and Michaels (1997) postulate two types of flexibilities as identified by option theory, proactive and reactive flexibility. Reactive flexibility refers to the flexibility exercised by an option holder in response to changes in the environment. Proactive flexibility is the maximization of the value of an option after acquiring it, making it worth more than its purchase price. The six levers they identified; i.e. the

- uncertainty of expected cash flows
- time to expiry
- present value of fixed costs
- present value of expected cash flows
- risk free interest rate
- value lost over duration of option

could be used to increase option value. For example, increasing the marketing budget and hence sales will by extension increase the present value of expected cash flows.
Utilisation of option valuation helps expand the identifiable menu of available resources and alternative markets for investment. It establishes the risk of strategic alternatives, asks questions to create value from uncertainty and aligns internal project valuations with financial markets. Used in conjunction with traditional, resource-based perspectives, it can identify new capabilities. Instead of focusing on increasing pricing power as suggested by competitive strategies, real options create value through the recognition and management of risk (Copeland and Keenan 1998).

In addition to investments involving uncertainty and flexibility, non-cash generating investment opportunities like the following can be best valued using real options:

- Platform investment like research and development - In platform investments, the choice of an option will modify the possible future investment strategies.
- Contingent contracts, and non-linear payoffs - In contingent contracts, for example partnering or joint ventures, each milestone represent a series of options where the payoff is proceeding to the next stage. The judicious use of contractual options will change the risk profile faced by asset owners. (Amram and Kulatilaka, 1999).

Granted, these are rarely found in the realm of the construction industry, but the industry’s dynamism should see them as part of the landscape sooner rather than later. To value these investments, instead of asking what that investment is worth, real options ask; what does it take in the form of outcomes and payoffs from future investments to justify the present investment.

Real options allow a firm to identify operating alternatives and the flexibility to use an asset in all ways. For example, machinery can be valued with regard to the option to switch to different use or even to shut down. The value of a real option can thus include the value of optimal utilisation of all its operating options. The identifying of investment and disinvestment options - asset configuration, type and scale, timing of investment are some examples - is a further benefit of option analysis. Also, since modules can be treated as a portfolio of options with one contingent on the previous one, modular development - where one stage or module is completed and a decision on whether to proceed to the next stage taken - can now be valued at inception. An interesting application of this in the construction industry would be in the type of serial construction common on large-scale projects like housing estates. Completion of the first stage determines whether and in what form the project will advance to subsequent stages.

Construction in developing countries and the need for a method of investment analysis

The importance of the construction industry in developing countries can be seen from recent estimates putting the share of the industry in developing country economies at between 5 and 10 %. Wells (1986) indicates that about half of this may be in civil engineering projects, and these are usually large projects involving substantial amounts of capital. Construction also plays a major role in providing capital, accounting for over 50% of gross capital formation in the economy. The industry in developing countries has inherited the fragmented structure described by Ball (1988) as hierarchical, with professions heading the production team comprising of contractors and suppliers who have further links down the chain to subcontractors.

Construction industries in developing countries have similar characteristics to those in other parts of the world but have their own unique characteristics. Amongst the universal characteristics of the industry are:

- unique products
- long production process
- fragmented industry
- fluctuations in workload
- immobile end product.

(Hindle 1997, Ball 1988, Hillebrandt, 1984)
Specific characteristics of the construction industry in developing countries include:

- A dual structure of indigenous and exogenous contractors (Uwakweh, 1999).
- A large informal sector.
- Underdeveloped human resources capacity characterised by little training and manpower development.
- Reliance on external funding for major infrastructural developments.
- Fluctuating workloads in the industry.
- The predominance of the public sector as a client.

We can look at the application of real options valuations in developing countries from the perspectives of the three broad interest groups in construction identified by Chow (1990), developers, contractors and the industry professions. However, it is important to keep in mind that developing countries are a disparate lot in terms of their socio-economic development, resource endowment and the nature and problems of their construction industries (Ofori 1991).

Developers

The government as a construction client deals in public projects, which usually form the largest single infrastructural investments made in developing countries. Low gross domestic product and competing needs for scarce funds require that optimal use of these resources be ensured. One way of doing so is through the accurate valuation of development projects the real options approach can offer. Further, stricter conditions on the disbursement of development assistance by donors and multi-national bodies emphasizing transparency and accountability render accurate valuations essential for such large projects. These conditions also apply equally for private sector developers. Limited funds for investment and shareholder scrutiny, intensified by the present trend of increasing economic awareness, drive the need for accurate project valuation.

The growing use of non-traditional methods of procurement provides another potential avenue for the increased use of real option valuations. De Valence (1999) has noted the growing trend toward the private sector provision of infrastructure in developing countries through variations of build-own-operate, design and build and turnkey procurement methods. These have been fuelled by capital limitations for infrastructure development, increasing client awareness and dissatisfaction with traditional methods, globalisation and the effect of imported business practices, and greater project complexity.

From real options identified by Trigeorgis (1997) we can find parallels for developers in the construction industry, such as:

- Flexibility options: the option to switch creates value out of uncertain events. It may make the construction of a building previously thought of as too expensive profitable. For example, if a building has only one use as a warehouse, valuation of the potential income to a developer may show its lack of viability. Recognizing that the use of the building can be changed to production in times of demand incorporates the dimension of flexibility, which creates added value.
- Learning options: where uncertainty can be resolved by a learning process, these processes can be broken down into stages, and the real options approach used to value the contingent decisions and structure each stage for a higher value. In the planning for a housing estate, the question may arise as to which architectural design or type of houses will be more marketable. If in the first phase of construction one type proves to be more in demand and attracts better prices, the subsequent make-up of the estate can be changed to reflect that discovery.
- Exit options: the exit option introduces the option to abandon a project. In the development of a new project, the size of the market may worry the company. Real options analysis can be used to value the option to walk away from the project should it not show promise. This is applicable both to contractors (as investors) and for developers.
• Evaluating market strategies: real options way of thinking expands the vision and alternatives used in creating strategies, and real options tools translate strategic thinking into an investment plan.
• Options to defer: for example, management may defer the investment while awaiting better market conditions.
• Options to default during staged construction: this refers to instances where a project is being implemented in stages. Each stage can be seen as an option on previous stages. The initial outlay creates the asset and the developer has the option to default should conditions prove negative.

**Contractors**

The primary focus of a real options approach to contractors would be in the evaluation of investment choices. The nature of construction is such that at the end of a project the contractor has a large liquidity position. Given the unpredictable nature of workloads in the industry and the predominance of the traditional procurement method in developing countries (which forces contractors to compete afresh for each new project thus adding uncertainty to individual contractor workloads), it becomes even more imperative to put available funds to the most efficient use possible. Should a contractor invest in treasury bills or property? Should they add to the firm’s resources by purchasing plant? If plant, which would be a better option, a crane or an excavator? The choice of where and what to invest in is a crucial part of a contractor’s strategy, and the use of a tool that helps master that strategy has positive implications for a construction firm.

Given the trend towards new procurement systems and increasing usage of private sector in infrastructure provision there may also be a need for contractors to adopt better ways of valuation of the choice of project to tender for or implement and anticipated returns to the firm. Some construction procurement methods involve outlays in capital and long payback periods that essentially transform the process into an investment. This is particularly so in the build-own-operate procurement method where the contractor undertakes the design, construction, financing, operation and maintenance of a facility of an agreed period.

Examples of real options in the construction industry for contractors are:

• Growth and expansion options: a sector of the construction industry is booming. Should a construction company invest in equipment and plant in order to take advantage of any upcoming projects? As Trigeorgis (1997) says, when a firm buys plant and equipment, land for development or sets up in a new location it takes out an option for future growth. Investment in plant and equipment is expensive but it could lead to increased capacity and the ability to undertake previously undoable projects. Conversely, the scaling down of operations creates the option to contract.
• Takeover and merger options: should a construction company desire to take over or merge with another, what would be an accurate valuation of the target company? The primary reason for the surge in attention paid to the real options approach has been in its role in valuation of Internet start-ups. Its recognition of the value of the technology companies as a function of their greater number of real options, exemplified by their ability to move easily into new markets, niches and segments, gave a method for the valuation of these companies that reflected their quoted values. Real options capture the value of managerial flexibility and so the consideration the value of management quality and intellectual capital in a firm is easier. Companies with little in the way of physical assets, like construction companies, can now be valued more realistically by weighing their options as compared to their liabilities.
• Competition and strategy: strategy development requires a long-term cause and effect mode of thinking that is best visualised by the application of real options. An investment can now be pursued on the basis of the options it opens up. The value of a diversification strategy (into, say, materials supply) can be incorporated into the present investment decision by a construction company to purchase a quarry.
Professions

The role of professions in the construction industry is to provide design advice and supporting services to the industry on both the producing and consuming sides. This role is rapidly and constantly evolving to encompass new fields, which results in the professions having to acquire new skills to keep up. These skills will span traditional industry boundaries, and will be subject to perpetual change (Hindle, 1998). The services that they provide will affect the viability and outcome of a project. As a result, for all categories of consultants’ knowledge of the options applications listed above may well prove useful as they consult for developers and contractors, in contracting, investment decision-making, acquisitions, research and development.

The process of implementing real options

Once a real options approach has been decided upon, the next important step is framing the application. This involves identifying the decisions to be made, the risks and uncertainties, and stating them in a logical expression. For example, continuing with the quarry example, deciding whether to exploit it or purchase aggregate for a major roads project can be summarised by:

Exploit it when the value of the extracted product is greater than the value of purchased product plus costs of extraction.

Real options analysis is about expanding the investment horizon, so all options should be considered with the emphasis on broad thinking. As a general rule, financial options are usually easier to configure than physical options.

The next step is to identify the inputs, which are: (1) present value of expected cash flows; (2) leakages in the value of the option over time due to, for example, dividends, convenience yields, rental payments; (3) the time to expiry or the life of the option; (4) the uncertainty of expected cash flows (sometimes referred to the volatility of the underlying asset which is estimated form similar assets or historical data; (5) the present value of fixed costs and (6) the risk free interest rate, which can be ascertained from short-term treasury bills’ yield.

Not needed are probability estimates of future asset prices, the expected rate of return of the option and an adjustment to the discount rate for risk. Future asset prices are captured by the current value of the underlying estimate and the volatility estimate, while the value of the asset and the tracking portfolio capture its risk-return trade-off eliminating the need for the expected rate of return.

There are a number of “option calculators”, or mathematical expressions, available that the inputs can be slotted into to produce an accurate value. The choice of these calculators will depend on the inputs, the particular application and the user’s preference, though properly applied all will give the same answer. The types of calculator are:

- Partial differential equations, an example of which is the Black-Scholes equation, express the option value through the equation and boundary conditions. While providing an easily available solution for the valuation, they cannot deal with more than two variables. Software solutions are available for partial differential equations, which enhances their usability.
- Dynamic programming methods like the binomial model, which chart out possible paths for the option, determine the ideal one and then track it back to the present, handle complex decisions, leakage conditions and asset-option relationships well.
- Simulation models, which roll out possible future scenarios, average the payoffs and then discount to the present. The commonest example of a simulation model is the Monte Carlo simulation.

The need is to establish a mathematical representation or frame for the stochastic processes, the payoff function and the decision rules in mathematical terms. Select a solution method between partial differential
equations, dynamic programming or simulation models and the specific option calculator: e.g. Black-Scholes equation, binomial model, and Monte Carlo simulation. The general rule is use an analytical solution if one is available as analytical solutions and the binomial model are easier to use and can be even be used on spreadsheets. Also, choose an option calculator based on ease of use, transparency and ability to re-use code. Simulations are best for path-dependent options (where the current value of an option depends on its past) use. Whatever the case, the focus should be on the application frame and not the calculator details (Amram and Kulatilaka, 1999).

Reviewing the results of the calculation is important as it determines the outcome of the proposed investment and possible company strategies. Deducting the value of assets under discounted cash flow from value of assets under real options will give the value of embedded options. Another way of looking at it is that if all volatility inputs were eliminated, the value of the asset should be equal to the discounted cash flow outcome. This is because without uncertainty there are no contingent decisions so discounted cash flow gives the right answer.

If necessary, a redesign of the investment can be undertaken. The proactive approach to flexibility options advocated by Leslie (1997) can be used in this regard.

**Anticipated problems in using real options**

The difficulty in getting contractors in developing countries to accurately develop mathematical models and frame inputs will undoubtedly prove the biggest obstacle in the use of real options valuations. Apart from the size of the projects having to be substantial to warrant the time and trouble involved, there is the trepidation brought about by the arcane mathematical skills needed, and the corresponding further difficulties of actually getting people with the necessary skills to follow through these methods. As Ofori (1991) has stated, construction companies in developing countries tend to be transient and are unable and unwilling to employ qualified personnel. This will be even truer for a field that traditionally does not form part of the mainstream construction disciplines. It is also difficult to determine exactly what portion of success of the valuation would be attributable to the model, so serendipity may cause rejoicing at the selection of an inappropriate method or, conversely, the rejection of a valuable tool due to formulation errors.

Undeveloped financial markets in the developing countries may also result in a lack of tracking portfolios and little grounds for establishing risk-free rates. This is doubtful, however, as the vast majority of developing countries either have or are setting up securities trading mechanisms. A more serious problem is that few of the problems requiring valuation allow the direct application of no-arbitrage arguments. For example, technical risks and market shares for research and development cannot be perfectly hedged by trading existing securities. Though perfect hedges are not necessary to determine option values – using the tracking portfolio- finding similar assets is still a (conceptual) difficulty. The idea is to consider those hedging opportunities that do exist and recognise them and use market information to risk-adjust the probabilities associated with these risks. The possibility exists that the above will cause real options to be viewed as a “foreign” tool inappropriate to developing country settings.

Perhaps an even greater obstacle towards the use of real options in developing country construction industries is the fact that it is not at present being used in the developed world in the same capacity. Real options find applications in diverse industries like energy, electronics, mining and exploration and airlines, but have yet to make an impact in construction. The industry in developing countries is often modelled along the lines of the former colonial powers (Wells, 1986) and looks to them for new developments given that work on the theory of the construction firm is confined to the industrialised countries (Ofori, 1991). If a method or approach has not been tried and tested in industrialised countries there is little chance that the third world will pioneer it.
Reasons why real options are likely to make a big impact in developing countries construction industry

In conclusion, real options analysis shows enough promise to spur investigation into its viability in the construction industry. There is pressure on the construction industry professions to expand the quality and range of services offered. Potential developers face the pressure from shareholders, stakeholders or simply tighter budgets to be more accountable and to use resources in the most efficient manner. Construction companies desire a better way to allocate limited financial resources and invest under uncertainty. In all these cases there is incentive to study and, if applicable, implement as a system of valuation the touted method.

Just as new production methods such as supply chain management, total quality management and knowledge management have found their way into the construction industry, the adoption of real options as a valuation method by other industries and sectors may well result in its adoption. Furthermore, the use of tools such as computers and pre-programmed calculators will also aid in the usage and development of real options models.

SUMMARY AND RECOMMENDATIONS

This paper has tried to investigate the applicability of real options theory to developing country construction industries. While still in its infancy, the approach holds much promise once its esoteric aura has been stripped away. It encourages thinking far (into the future) and wide (across the firm). As long as financial markets exist to give a measure of relevant information, and the demands of accuracy and precision consider the rapidly changing environment of the construction industry, the results should be satisfactory. The framework and approach is more important than the details of numerical methods. For options to be optimally identified and exercised the organization must have good information management and the organization must be capable of acting on rational information, i.e. it must be a functional rather than dysfunctional organisation. Management should be prepared to act immediately the conditions favouring exercising the options come into play, and the real options team which includes the introducer, the measurers and the manager with an eye on the overall picture should be put in place. Academics are vital in the adoption of new strategies and theories in construction. They should scrutinize this approach for its merits and if found with value, urge for its inclusion in syllabi and courses.

More research on this topic, and indeed of valuation in construction, as it applies to developing countries is necessary, with special regard to efficacy of results and cost effectiveness. Finally, the construction industry in those countries needs to be sensitised on the evolution of the method as it applies to the industry.

As a planning tool real options is still in its infancy, but the new approach it brings to decision-making in developing countries may well prove valuable.

REFERENCES