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REAL OPTIONS AND PUBLIC SECTOR CAPITAL PROJECT DECISION-MAKING

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ABSTRACT. Capital budgeting decisions are among the most important decisions that a public financial manager makes. The traditional methodology for determining whether or not such an investment should be made is known as the discounted cash flow method. This method, unfortunately, does not capture efficiently the benefits of flexibility that often accompany capital budgeting decisions. This paper discusses the concept of real options and how the public sector managers can employ this relatively new technique to better value their capital budgeting opportunities. We argue, both through financial theory and through examples, that employing real option modeling in public sector capital decision-making will improve the efficacy of capital budgeting decisions.

INTRODUCTION

Real Options have become an important topic in the capital budgeting literature. This article attempts to show its importance, relevancy, and uniqueness within the public sector context. Real options differ from financial options in that they are options on real assets rather than on financial assets. Many types of real options have been identified such as the option to cease production, the option to defer production, and the option to expand. This paper will begin by discussing the importance to the public sector financial manager of including option theory decision-making in her or his capital project analysis. In the next section we will descriptively present examples of where in the public sector the theory would increase decision-making efficiency. Next we will discuss unique

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circumstances faced by the public sector and how those circumstances impinge on the use of real options. In the following section two simulation examples will be presented. The final section will include a summary of our findings, and their implications for public sector decision-making.

WHY INCLUDE REAL OPTIONS IN CAPITAL BUDGETING DECISION-MAKING

The typical methodology employed to analyze the efficacy of undertaking capital projects is the Discounted Cash Flow method (DCF). DCF assumes that managers can make a decision, implement it, but are subsequently incapable of altering that decision. The typical technique is to estimate the future net cash flows over the supposed life of the project and then discount those cash flows at the appropriate discount rate (typically thought of as the average cost of capital, perhaps, adjusted for the risk of the project in question). In truth, the DCF model is perfectly appropriate only when the future cash flows are known with certainty. In practice, it functions well in stable circumstances. It has become clear, however, that this method fails to capture the value of flexibility. The result is that beneficial projects may be inappropriately rejected, and less profitable projects may be chosen over potentially more profitable ones if the value of flexibility has been improperly assessed. Several researchers have demonstrated the benefits of employing real option theory in capital budgeting decisions [e.g. Brennan and Schwartz (1985), Kemna (1993), Kulatilaka (1993), Dixit and Pindyck (1995), Trigeorgis (1996)]. In addition, some researchers have suggested that the entire enterprise can be thought of as a portfolio of real options (Luehrman, 1998; Trigeorgis, 1996). This global view of real options has faced challenges from strategy researchers with a behavioral background who believe that too much flexibility may result in managerial problems (Barnett, 2003). This paper will concentrate on how the employment of real option thinking in capital budgeting can enhance traditional DCF analysis.

In 1973 Fisher Black and Myron Scholes published their study on pricing financial options. Financial options give the purchaser of the option the right but not the obligation to do something. Specifically, a Call option gives the purchaser the right to purchase an asset at a specified price over a specified period of time. The purchase price of the option is known as the premium. Financial option values are driven directly by five variables. These are the underlying asset price (say the share price of the stock), the exercise price, which is the price at which the asset can be purchased, the risk free rate of interest, the time the option will be in force, and the volatility of the underlying asset's returns. In the case of a Call option, higher is better in all the variables excluding the exercise price. The exercise price is generally fixed over the time period that the option is in force, but the level at which it is set is important, specifically, the lower the price at which the asset can be purchased the more valuable the option to purchase the asset is. The greater the underlying asset price, the more comfortable is the purchaser that the option will end up in the money (the underlying market asset price will be greater than the exercise price) and, therefore, the more valuable is the option. Options allow the purchaser to delay purchase and, therefore, the greater the rate of interest is, the greater the gain in waiting to make the purchase, since the money can be invested at a high rate of return until the time to purchase the asset arrives. The greater the amount of time until an option expires, the greater are the chances that the option will end up in the money and the longer the time before the expenditure needs to be made. This enhances the value of the option. Finally, high levels of volatility increase the chances that the value of the underlying asset will rise significantly above the exercise price, thus causing the value of the option to rise.

What ultimately makes an option valuable is the fact that it helps the investor of both financial and real options to measure the significance of flexibility. Options allow flexibility to be valued appropriately. That is, option valuation allows the decision-maker to place value on the ability to change tactics while the issue is ongoing. For example, the ability to wait has beneficial applications, including the opportunity to earn returns on funds that can be expended later rather than sooner and the opportunity to learn more about the likelihood of success. The fact that a flexible investment allows for a more efficient response to changing circumstances than does an inflexible investment, adds value to a flexible investment in comparison to an inflexible investment. The standard discounted cash flow model does not adequately measure flexibility. While it is possible to create sensitivity analyses and Monte Carlo type simulations, these models allow the decision-maker to measure the outcome around different scenarios; however, they do not measure the importance of being able to adjust his or her actions while the investment is ongoing. Whereas option pricing models achieve this end.

Real options create value because they allow the manager to adjust decisions when either the facts change or when information is enhanced. The more uncertain the facts the more valuable the option is. Projects either allow for managerial flexibility or they do not. Therefore, the value of a real option is either positive or zero.

EXAMPLES OF HOW REAL OPTION MODELING CAN IMPROVE OUTCOMES

The public sector undertakes many projects where understanding the value of real options could alter and enhance the efficiency of decision-making. For example, consider a township interested in building a new school. One architect designs a one-building school while another develops a two-building plan. Assume that in both cases the academic facilities are of equal quality and that both facilities could house an equal number of students. Further, assume that the present value cost of School 1 is less than the present value cost of School 2. Standard DCF analysis would lead the township to choose School 1, but employing option theory might alter that decision. The use of two buildings creates an option to more easily "spin-off" part of the school should the school population drop or change geographically. For example, a senior citizens' center might be created in one of the buildings. Two buildings may also allow more flexibility in creating meeting space for civic groups.

Other design issues in public sector capital projects create similar "embedded" options. For example, it may be worth paying more for a flexibly designed office building that can be more easily (and more cheaply) converted to other uses than to build a cheaper but less flexible building. Similarly, it may make sense to purchase a state of the art computer system that is likely to be able to employ new software for several years into the future, rather than to purchase a cheaper computer system which can also run today's software but whose upgrade capacity is limited.

The option to wait is valuable when the benefit of waiting is likely to exceed the cost. The option to delay a decision on whether or not to build a convention center may be extremely valuable if delaying the decision allows the municipality to better evaluate the competition or the likelihood of landing the more important conventions.

The option to cease operations is also an important option. For example, assume a township believes (but is not sure) that it is more efficient to outsource its snowplowing operations. In order to mitigate the damages of an improper decision, it may find it beneficial to pay more per year for a short-term agreement than less per year for a long-term agreement.

THE PUBLIC SECTOR DIFFERS FROM THE PRIVATE SECTOR

The public sector undertakes a variety of projects and, due to the nature of its obligations and because of the democratic process faces decision-making forces not commonly found in the private sector. For example, it is not uncommon for the public sector to invest in capital projects where the values of the benefits are far more difficult to assess than are the costs. The decision to construct a new school building may reflect population growth, state mandates, or a desire to improve the educational process but will typically not reflect an attempt to be profitable. The result is a tendency to see the decision as a straightforward cost minimization problem. This phenomenon can lead to great error in decision-making. The choice of location and building style is typically fraught with important "embedded" options, which include:

Land. Should the municipality purchase a large tract of land, or, assuming the township owns the land, zone a large piece of land for the school district? This allows the school, in the future, to add buildings, athletic fields, parking lots etc., but it may also be costly to maintain and it limits private sector development.

Size and structure of the building. Should the building be constructed in such a way that expansion is easily accomplished? Should a variety of classroom types be constructed? Such construction might not only improve the educational process, but might also allow for classrooms to be rented to different organizations for meetings and lectures. Should the school have a pool and/or a large gymnasium that would also allow for revenue ventures?

Generally the decision to allow for these potential benefits includes additional costs. Nevertheless, the value of the option to do "things" is not likely to be immaterial. In short, the public sector should carefully analyze the potential revenue embedded in seemingly non-revenue-generating capital assets.

A second problem, typically having more impact on the public sector than the private sector, is that physical flexibility and political flexibility are not identical concepts. For example, in the private sector the option to sell part of a firm's property to another firm will generally not result in political interference. However, the decision to sell a poorly used branch library to a retailer or a section of the school grounds to a developer may well create a public reaction that forces the government to decide not to exercise the option they thought they had purchased. In assessing the value of a capital investment, the public sector needs to recognize how politics may impinge on the value of embedded options.

Capital budgets are time sensitive and competitive, creating difficulties in the use of real option valuation. The private sector executive is under tremendous pressure to efficiently utilize capital and to earn high returns on invested capital quickly. Overbuilding penalizes the manager's performance outcomes. Each project must be designed to add value to the firm and if waiting for better information does that, the manager is inclined to wait. Flexibility creates clear value to the private sector manager. Conversely, when public sector executives are fighting for scarce capital budgeting dollars they tend to have an appetite for "overbuilding" and for not waiting. In a use it or lose it environment, the value of flexibility can be strongly discounted. A public sector manager is likely to design a budget that overbuilds assets such as schools and water treatment facilities in order to serve future growth potential rather than to wait and see if such potential growth becomes more likely. In the scenario where the manager waits, and the potential growth occurs, the manager will need to go back and argue for more resources, when in the overbuilding scenario they need only argue for the financial resources once. While recognizing that a strongly driven profit motive may find more value in flexibility than in the non-profit environment, discounting the value of flexibility to the point of ignoring it is poor financial management practice. In the end, taxpayers, like shareholders, deserve an efficient employment of equity financing. Flexibility adds value to capital projects and option pricing models measure that value better than do the alternatives. While in the final analysis, we believe that real option valuation, in conjunction with discounted cash flow analysis, will add efficiency to public sector capital budget decision-making, the employment of real options cannot substitute for good management decisions.

OPTION VALUE MODELING AND REAL OPTION EXAMPLES

There are several option-pricing models available. We will employ the best known of these models, the Black-Scholes model (for a detailed explanation of the model see Appendix 1). For our purposes the key issue is the functional form of the model and the ability to realistically assess the option value of a public sector capital project. In option-pricing models, the key variables in assessing value are the underlying value of an asset, the value at which the option can be exercised, the amount of time in which the option is in force, the rate of interest, and the volatility of the returns on the underlying asset.

One of the key questions in valuing real options is how will the inputs for the option valuation be measured? Fortunately, most of the inputs are observable. Typically the exercise price and the current value of the asset are known. The risk free rate is calculated as the continuously compounded rate of return on a federal government security maturing at the time the option matures. That measurement, like the maturity measurement, assumes that the date by which the option needs to be exercised is known. When that is not the case, the decision-maker will need to make a best guess. The most troubling variable is the measurement of the underlying volatility of asset returns. Even financial options are problematic in this regard. Volatility is typically measured as the standard deviation of the continuously compounded return on the underlying asset. For revenue oriented ventures, the decision-maker needs to seek out information on the returns for comparable projects. Those returns are converted into continuous returns and the standard deviation is calculated. Two caveats here: first the cost of obtaining such data may be high thereby limiting the efficacy of the option valuation process; second, the past volatility of a comparable project may not effectively forecast the future volatility of the asset under analysis. In short, the mechanics of real option pricing are not likely to be much easier than the forecasting of net cash flows for discounted cash flow purposes. In the case of non-revenue ventures, the volatility of costs is measured. Again the notion that past volatility and future volatility are identical is somewhat heroic.

Imagine that Town Z is considering building a public golf course. Research indicates that the average public golf course is valued at 18 million dollars (employing standard discounted cash flow analysis). PG Golf Courses, a golf course design and building company, has informed the town that they can build the course for 18.5 million dollars. The offer is good for one year. The current risk free rate of interest (the yield on a U.S. Treasury security maturing in one year) is 5 percent and the standard deviation of the returns earned on investments in public golf courses tends to be about 30 percent per year. Standard DCF analysis would lead the town to reject the project. The reason is that the net present value of the investment is estimated to be negative (18,000,000 - 18,500,000 = -500,000). However, the ability to wait to make the decision may have material value. Perhaps the waiting period will allow the financial manager to learn more about the specific market that the golf course will serve. For example, the manager might find that there is a large amount of growth in the demand for public courses. It might be possible to sell special "memberships" to local businesses that allow them to play a certain number of rounds and to use the clubhouse for business and social gatherings. Such an outcome could improve the predicted results. The question for the decision-maker is does the option to wait and, therefore, obtain additional information have value? The answer is yes. The value of the option, as determined by the Black-Scholes model is $2,332,760 (see Appendix 2). This means that the value of the investment now stands at $20,332,760 not $18,000,000. That is, the project has an expected value (given our information) of $18,000,000 but because of our option to wait and consequently learn more about the profit potential of the course, an additional $2,332,760 of value exists. At this point, it is worth keeping the project idea alive because $20,332,760 is greater than $18,500,000.

One important aspect of options is that they suffer time decay. That is, they offer us an opportunity to improve our decision-making capacity over some time frame. The more time we have, the more valuable the option. For example, if the township had only six months to make the decision, then the option studied above would be worth only $1,504,464. Similarly, the underlying volatility of the market is also significant. The greater the volatility of possible outcomes the more valuable is the option. For example, if the standard deviation of returns on public golf courses were .40 rather than .30 the value of the option would be $3,030,250.

A more difficult task arises in our thinking about option values for ventures that typically are not associated with profitability. The simpler problem is around converting our thinking from cost only to cost and revenue venture thinking. A new school is typically thought of as a cost minimization problem with a quality constraint. However, school facilities are loaded with imbedded options. As discussed earlier, revenue options exist in the athletic facilities, dining facilities, group area facilities (such as the auditorium), and classroom facilities (e.g. having some classrooms with high-tech equipment and stadium seating). These types of assets can be rented to any number of organizations if of sufficient quality. Typically, improving our options includes increased costs. The management process should be to consider the value of these options and the potential to exercise them.

More difficulty exists when projects are more about cost containment than they are about potential revenue ventures. Imagine that a municipality is interested in minimizing the cost of salting, sanding, and snow removal. Currently it costs the municipality, on average, $600,000 per year to do the job. They decide to consider outsourcing the function. Two firms bid for the job. Firm 1 offers the municipality a rate of $500,000 per year for a six-year commitment and Firm 2 offers a rate of $550,000 per year for six years with a $100,000 buy-out clause. The clause allows the City, for $100,000, to buy-out the last three years of the contract. That is, if for any reason the municipality is unhappy with their decision to hire Firm 2, they can, after three years, choose to buy out the contract for $100,000. Is the first deal better? The first firm charges considerably less than does the second and the cost is well below our current cost. However, the second deal gives us the option to change our mind more quickly should we find that the outsourcing solution or the choice of contractor was not the proper decision. For example, the private contractor might perform unsatisfactorily or disputes may arise around the meaning of certain contract provisions (e.g. our contract may poorly define issues around the timing of snow removal or preventive measures such as salting or sanding icy roads). In addition, labor issues, such as private sector strikes or failure to meet the spirit of municipal contractor hiring goals, may surface, or new technologies that significantly reduce snow removal costs may arise. The contract with the buyout option might be more valuable. This problem is complicated. The present value cost of contracting with Firm 1 is $2,055,704 (see Appendix 3). The present value cost of contracting with firm 2 if we do not buy out the firm is 2,261,274. The difference is $205,570. If we find after three years that privatizing was a mistake, the present value cost continues to be $2,055,704 with firm 1 but is reduced to $1,392,175 for Firm 2. This difference is 2,055,704 less $1,392,175 or $663,529.

The question that arises is whether or not the value of the option to save $663,529, should we be disappointed in our decision to privatize the snow removal function or disappointed with this specific contractor, is greater than the present value cost savings of $205,570? Assume that the standard deviation of snow removal costs is 40 percent and that the risk free rate is 5.00 percent. Then the value of this option is $577,529. Therefore, the option to terminate exceeds the present value difference of $205,570 and implies that policy two is preferable. It is important to be clear that the choice to abandon outsourcing has monetary costs beyond the simple exercise of the exit strategy. The municipality will still need to accomplish the snow removal task. In determining that outsourcing is not working, the additional cost of going back to doing the job itself must be considered.

In general, we need to understand what real options tell us and what they do not tell us. When our decision is altered by the existence of a real option, it means that additional flexibility is important and has value. That value should be taken into account. It does not mean that we will end up better off because we chose the path we did. For example in our first case, it may turn out after further investigation that we will not be able to profitably build a public golf course, or even if additional information creates the expectation of a positive net present value investment, it may not turn out that way. In our second case, we may find out that outsourcing works out well and that we might as well have taken the cheaper bid. In short, like all investments, outcomes may or may not turn out as expected. However, that does not change the fact that when viewing the project, ex ante flexibility has value, and options allow us to place a monetary figure on that value.

SUMMARY

Employing real options in public sector project decision-making is an important addition to improving the efficiency of the project evaluation process. Real options allow the decision-maker to formally add the benefit of flexibility to the capital allocation process. As shown above, real options are likely to have material value even when the project is solely about cost minimization. Alternatively, while the use of real option techniques will improve ex ante decision-making, they do not guarantee a successful outcome. The success of long-term projects will continue to be dependent on a portfolio of impacts including the use of good ex ante analysis and positive unexpected impacts after the project is in force.

REFERENCES

Barnett, M. L. (2003, June). "Falling off the Fence? A Realistic Appraisal of a Real Options Approach to Corporate Strategy." *Journal of Management Inquiry, 12* (2): 185-196.

Black, F., & Scholes, M. (1973). "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy, 81*: 637-659.

Brennan, M. J., & Schwartz, E. S. (1985). "A New Approach to Evaluating Natural Resource Investments." *Midland Corporate Finance Journal, 3*: 1985: 37-47.

Dixit, A. K., & Pindyck, R. C. (1995, May-June). "The Options Approach to Capital Investment." *Harvard Business Review, 73*: 105-115.

Kemna, A. G. Z. (1993, Autumn). "Case Studies on Real Options." *Financial Management*: 259-270.

Kulitilaka, N. (1993, Autumn). "The Value of Flexibility: The Case of a Dual Fuel Industrial Boiler." *Financial Management*: 271-280.

Luehrman, T. (1998). "Strategy as a Portfolio of Real Options." *Harvard Business Review, 76*: 89-99.

Trigeorgis, L. (1996). *Options in Capital Budgeting: Managerial Flexibility and Strategy in Resource Allocation.* Cambridge, MA: MIT Press.

APPENDIX 1

In 1973 Fisher Black and Myron Scholes published an article, "The Pricing of Options and Corporate Liabilities" in the *Journal of Political Economy*. In that article they presented the model for pricing options that became the centerpiece for all the option pricing work that followed. The model prices a Call option and takes the form:

$$C = S_{(0)}N(d_1) - Ee^{-rt}N(d_2)$$

Where:

$d_1 = [\ln(S_0/X) + (r + \sigma^2/2)T]/[\sigma(\sqrt{T})]$

$d_2 = d_1 - \sigma(\sqrt{T})$

C = The value of the call option.

$S_{(0)}$ = The current stock price.

E = The exercise price (the price at which the option can be executed).

$N(d_1)$, $N(d_2)$ = Cumulative normal probabilities.

σ = Annualized volatility (as measured by the standard deviation of the continuously compounded return on the stock).

r = Continuously compounded risk free rate. Typically the rate of the Treasury security maturing closest to the date of the option's maturity is employed.

T = The term to the maturity of the option. T is measured as a proportion of the year.

For out purposes the most important issue is the functional form of the model. Specifically, the real options value is determined by the current value of the underlying asset, the price at which the option can be exercised, the risk free rate, the volatility of the returns on the underlying asset, and the time in which the option is in force.

The greater the value of the underlying asset compared to the value at which the option can be exercised, the more valuable the option will be. That is, if we have an option that allows us to purchase an asset for $18,500,000, the value of that option will be greater if the asset is currently worth $20,000,000 than if it is worth $18,000,000.

The value of an option rises as interest rates rise, but not by much. In other words, the price is quite insensitive to rate movements. Typically, the rational for the relationship between high Call option values and high interest rates is that the option allows the investor to defer expenditures. When interest rates are high, deferring expenditures becomes more attractive since that money can be invested elsewhere at a high rate of return.

The Call price is quite sensitive to volatility. It is assumed that volatility can be measured by the standard deviation of returns on the underlying asset. The more volatile those returns, the more uncertain they are. The greater the volatility, the greater will be the possibility that exercising the option will yield large gains. Therefore, the more volatile the underlying asset returns are the more valuable the Call option will be. Note that high volatility also implies that returns could be exceptionally low. However, an option always allows the holder not to exercise. Therefore, downside volatility does not harm the option holder.

The Call price will also rise with the term to maturity of the option. The longer the decision-maker can wait until the option needs to be exercised, the more information that can be gleaned and, therefore, the more valuable the option is.

APPENDIX 2

In order to calculate the value of the option, for the golf course case, employing the Black-Scholes option-pricing model we need the following inputs:

The underlying value of the asset: $18,000,000.
The exercise price: $18,500,000.
The risk free rate: 5 percent.
The term the option is in force: 1 year.
The underlying volatility on returns to the asset: 30 percent.
With these inputs the model delivers an option value of $2,332,760.

In general, volatility is the most important of the variables and, unfortunately, the most difficult to assess. For example, if we kept the base numbers the same, but increased the risk free rate by 10 percent (to 5.5 percent); the value of the Call would rise to $2,374,271. That is an increase of less than 2 percent. If we increase the term by 10 percent (from 1 year to 1.1 years), while holding all the other variables constant, the value of the option rises to $2,476,337. Time clearly has a bigger impact than does the interest rate. Finally, if we held all the other variables constant but raised the volatility by 10 percent (from .30 to .33) the value of the Call would rise to $2,542,556. Volatility has the most impact on the Call's value.

APPENDIX 3

In this case we are looking at two outsourcing opportunities. In the first case the township can sign a six-year contract for $500,000 per year. In the second case a six-year contract is available for $550,000 per year but the township has the option to terminate the contract in three years for a payment of $100,000.

We are assuming a 12 percent rate of discount, a 5 percent risk free rate of interest and a standard deviation on snow removal contracts of 40 percent. The present value cost of Contract 1 is $2,055,704. The present value cost of contact 2 is $2,261,274. The difference is $205,570. Clearly, Contract 1 is cheaper. However, contract two offers flexibility. That flexibility has value. Should we find out that outsourcing was a poor idea or that the firm we are dealing with is a poor performer, the option to abandon the contract can be exercised at the end of year 3. If we choose Contract 1 and things end up not working out, the present value cost remains at $2,055,704, however, under Contract 2 we will exercise the option to abandon the contract. The present value cost should we abandon would be $1,392,175. $1,392,175 dollars are $663,529 dollars cheaper than $2,055,704.

The question is whether the option to save $663,529 if things are not going well is worth more than the $205,570 difference in present value cost. The inputs are underlying value, $663,529; exercise price, $100,000; time, three years risk free rate of interest, 5 percent; and volatility, 40 percent. The value of the option given by the Black-Scholes model is $577,529. Since that amount exceeds $205,570 it is a good idea to choose Contract 2.