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REAL OPTIONS IN PROJECT MANAGEMENT

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JEL classyfication: H54, G32, O22

Introduction

Valuation and risk management are among the key issues in project evaluation. This is particularly true of complex, capital intensive, multi-stage projects. Such projects, especially in the context of a hyper competitive business environment, require new methods of evaluation and risk mitigation. One of them is real option method.

The value of flexibility in project management

One of the key concepts in the new competitive environment is the one of flexibility. Flexibility can be defined as "(…) the ability to change or react with little penalty in time, effort, cost or performance" (Upton, 1994).

Rapid changes in technology and ever increasing pace at which new products and processes are introduced require that firm remain flexible, both as regards strategy and organization. A comprehensive analysis of the importance of strategic flexibility is provided by Sanchez (1995). Strategic flexibility – further subdivided into resources flexibility and coordination flexibility – denotes firm's ability to respond to various demands from the dynamic competitive environment.

Considering the object of flexibility, Kaluza (1993) distinguishes between goal and means flexibility. Goal flexibility refers to the flexibility to eliminate existing goals or incorporate new goals into the corporation's goal system. Means flexibility denotes the flexibility in selecting the means to obtain the before mentioned goals. One can further distinguish between *built-in flexibility* and *action* flexibility. The first category of risk management is related to defensive risk management, which helps to mitigate the impact of the unfavourable changes in the business environment. The action flexibility refers to the company's offensive capacity of reaction to take advantage of chances.

Management of flexibility can be understood as *reactive* or *proactive*. In the first sense, flexibility management refers to the management of the company's ability to react in response to changes in the relevant environment. In the second sense, it denotes the company's capability to proactively use existing flexibility in order to strengthen its competitive position, e.g. by creating new products, employing new technologies or serving new customer groups.

The flexibility potential is of value. Its value is especially high in cases where all components of the investment project's variability (market payoff variability, schedule variability, performance variability, market requirement variability) are considerable and decisions have to be made well in advance. Flexibility should be managed at both project and corporate level.

Rapid changes of the competitive environment pose an important question as to how to evaluate major capital expenditure (e.g. new-technology development projects, new plants, new businesses) characterized by a very high degree of uncertainty. In such circumstances classic discount-based techniques become inadequate. One alternative that is gradually gaining in popularity is to treat investments with above mentioned characteristics as taking options on future cash flows generated as a consequence of current capital expenditure. Hence, conceptual framework as well valuation techniques transferred from finance, called *Real Option Analysis* (ROA), have attracted attention of a number academics as well as practitioners.

Financial versus real options

The three main characteristics of financial options are:
– flexibility
– uncertainty
– irreversibility

Flexibility refers to the key characteristic of this instrument, namely, that the option holder has the right but not the obligation to exercise the option. Options also contain an element of *uncertainty* because the economic attractiveness of the option primarily depends on the development of the underlying asset. The *irreversibility* is related to the fact that the option holder's right ceases to exist once the option is exercised.

Financial options limit the downside potential of the underlying asset while at the same time offering an upside potential. As a consequence financial options have an inherent value, the option premium. In general, the option value is influenced by six factors: price of the underlying asset, uncertainty of the underlying asset's price movement, time to expiry, exercise price, dividend payments, and risk-free rate.

The term „**real options**" was introduced by Stewart Myers (1977). It referred to the application of the option pricing theory to the valuation of non-financial or "real" investments with learning and flexibility. In finance theory, option pricing is a widely acknowledged instrument to assess uncertainty and flexibility. Since the mid-1990s there has been a growing interest in real options perceived as a potentially important tool for valuation of uncertain investment projects with embedded flexibility. There has been as well growing interest in using real options for business strategy formulation.

A real option is the right, but not the obligation, to acquire the present value of expected cash flows generated by the project by making an irreversible investment on or before the date the opportunity ceases to be available.

Real options are similar to financial options (Miller and Park, 2002). They contain the same three elements that were used to characterize financial options. For most of investment projects there will be some form of flexibility (e.g. when to start the project, whether to stop it, to abandon, to change the scale, to switch inputs or outputs) Most real options have to be purchased by a company through the payment of an implicit option premium (e.g. conducting an investment).

Any financial or real option can be seen as an initial investment offering the exclusive opportunity to keep open a specified follow-on (dis)investment trajectory at limited predetermined costs.

The value of a real option is influenced by the following six factors (corresponding to factors influencing the value of financial options): present value of expected cash flows from the project, uncertainty of the expected cash flows, time period until investment opportunity disappears, present value of fixed costs of investment, value lost over duration of option, risk-free rate.

Table 1 presents comparison of input variables for a call option on a stock and a call option on an investment project.

Due to the stated analogies it appears legitimate to apply the principles and pricing models for financial options also to real options.

Table 1

Comparison of a call option on a stock and a call option on an investment project

	Call option on a stock	Call option on an investment project
Underlying	Current value of stock	Present value of expected cash flows
Exercise price	A fixed stock price	Present value of investment cost
Time to expiration	Fixed date	Time until opportunity disappears
Risk	Stock value uncertainty	Project value uncertainty
Dividend payments	Payments to the stock holder	Payments lost through waiting to invest
Interest rate	Riskless interest rate	Riskless interest rate

Source: L. Trigeorgis: *Real Options: Managerial Flexibility and Strategy in Resource Allocation*, Cambridge, MA, MIT Press 2007, p. 125.

The basic idea of the real option approach is to transfer the sophisticated option pricing models from finance to the valuation risky investment projects. The rationale behind this analogy is that if the option is exercised, projects – like financial options – may lead to substantial financial returns. If, however, the option is not exercised, because of detrimental changes in the business environment, the losses are avoided. Thus, the treatment of the project as an option creates a potential for future profits, while at the same time limiting downside risk.

The concept of real options acknowledges that downside risk is limited and upward potential is maximized if management can alter the sequence of actions and investment. However, real options generally require control over the underlying asset whereas financial options do not.

Projects with in-built flexibility give the decision maker opportunity to react to the new information, "arriving" in the future, in different ways. Depending on this information, a project may be delayed, continued, stopped or halted to wait for additional information. The scope of the project may be limited or enhanced. The categorization and rigid quantitative treatment of these different possibilities of reacting are central concerns to real option research. The real option approach is especially tailored to deal with **uncertainty** and **flexibility**.

Real options in transportation projects

During the last decade the real options method has grown in popularity in the analysis of transportation projects. Smit (2003) analyzes the decision to expand European airports combining the real options theory and games theory. Bow and Lee (2004) use real options valuation methodology to evaluate high-speed rail projects. Tibben-Lambke and Rogers (2006) propose a framework for enabling managers to extend the use of options to the future use of logistics resources. Tsai (2008) analyzes procurement for transportation services based on the real options theory. Sodal and Koekebakker (2008) derive a real options model of flexibility and apply it to shipping, valuing the option to switch between the dry bulk market and wet bulk market for a combination carrier, a ship type that is capable of operating in both markets. Evans and Zhang (2009) apply the real options analysis to evaluate an investment in flexible manufacturing system in the automotive industry; the investment project analyzed has two phases, with the expansion investment viewed as a real extension option. The use of real options in the automotive industry is also presented by Ford and Sobek (2005). The authors adapt real options concepts to product development management to partially explain the, so called, Toyota paradox, i.e. the fact that Toyota Motor Corporation achieves the fastest development times in its industry by intentionally delaying alternative selection, a strategy termed set-based development. Galera and Solińo (2010) use real options to value highway concessions. Hult *et al.* (2010) theorize how the options can be related to perceived value under conditions of high supply chain **risk uncertainty**. Overall, their investigation builds knowledge by extending real options theory to the supply chain context and by providing evidence suggesting that some options operate differently in supply chains than they do in firms. Supply chain coordination and performance management with real options is analyzed by Johnson (2010). Negotiated, bilateral, contingent performance commitments - effectively contracts with multiple embedded real options - are shown to be necessary to convey the information, incentives, and allocation of risk required to identify and execute appropriate strategies across the supply chain. Schafer and Sorensen (2010) provide a general valuation model for the optimal design of the product development process, exemplified by automobile development. Using a novel real options model the authors demonstrate that it is possible for the optimal number of design alternatives to develop in parallel. Under certain circumstances, developing multiple design alternatives in parallel is shown to generate significant value, fully accounting for the increase in costs of doing so. Chow and Regan (2011) present a model to address managerial flexibility in transportation planning. According to the authors, the model can be applied to any network design problem under uncertainty. Jain and Cox (2011) examine the uncertainty of acquiring the lowest possible airfare when contemplating the purchase of a ticket. A real option model is applied to value insurance contracts that could be offered to passengers to cope with price risk. Tsai *et al.* (2011) apply concepts from the theory of real options to hedge uncertainty in transportation capacity and cost using derivative contracts, called truckload options.

Real options in revenue risk management in public-private partnerships in infrastructure projects

Prior to the economic troubles begun in 2008 the interest in public-private partnerships (PPPs) for infrastructure, and particularly highways, was substantial (Garvin and Bosso, 2008). A driver for this interest was the potential of additional private financing to address public sector budgeting shortfalls.

The success of PPP projects largely depends on effectively management of a variety of risks (Li *et al.*, 2005); Ng and Loosemore, 2007). A common principle is that risks should be allocated to the party who is best able to manage them (Loosemore *et al.*, 2006). For example, the government uses its authority and jurisdiction to acquire rights of way, while the concessionaire takes the responsibility of completing the project on time and within budget. In the context of revenue risks allocated between government and concessionaire, a variety of approaches have been implemented. *Real toll projects* charge user fees to fund a project that concessionaires collect. *Shadow toll projects* allow travellers to use the facility free at the point of use, while a concessionaire is compensated by the government with a fixed fee per vehicle. In *availability payment* projects, the government reimburses a concessionaire with periodic payments subject to service quality. In all three types of projects, concessionaires bear some form of revenue risk, i.e. probability of not receiving payment.

In all three types of projects, concessionaires bear some form of revenue risk, i.e. probability of not receiving payment. In availability payment projects, this risk is essentially budgetary appropriation risk – whether or not the government will allocate the funds necessary for payment over the contract period. In shadow toll projects, the concessionaire assumes appropriation risk and doers not bear demand/traffic risk since its fees are tied to traffic volume. In real toll projects, concessionaire typically bears the full brunt of revenue risks. Within a real toll funding method, revenue risks are managed by specific concession agreement terms and financial guarantees. Every PPP real toll project has different characteristics. As a result, no single revenue risk technique applies universally.

Real toll projects with a fixed concession duration

One common approach to dealing with the revenue risk in a real toll fixed-duration project is that the concessionaire assumes the entire risk, and the government does not provide any subsidy when collected revenue is not sufficient to cover upfront construction costs as well as operating and maintenance expenses. Since the concessionaire takes the full responsibility for reimbursing its expenses from project revenues and carries great credit risks, lenders may require clauses that grant them step-in rights in case of default on payments. In addition, since toll rates and demand are the major determinants of operating revenue, the concessionaire may require a non-compete clause to safeguard its project revenues.

Another approach is that the government grants subsidies when the project is not expected to generate the needed level of revenue. Such subsidies are essential for certain projects to boost their financial viability. Some countries such as Chile, Korea and Spain, grant minimum revenue guarantees in exchange for sharing upside revenue. Some developed countries, for example Australia, the US, the UK use either such guarantees or direct operating revenue subsidies. Academics have made attempts to value revenue guarantees, however, up to now such a valuation is not the norm and, if conducted, is usually made in an unsophisticated manner.

Real toll projects with a variable concession duration

In a variable concession duration, the contract ends when a certain financial targets are met. The least present value of revenue (LPVR) grants the concessionaire the right to collect tolls until the present value of the total revenue reaches an agreed level (Engel *et al.*, 2001). Alternatively, the least present value of net revenue (LPVNR) takes the duration-dependent operation and maintenance costs as the threshold parameter instead (Nombela and de Rus, 2003). In both models, however, the uncertain duration complicates financial planning and discount rate selection.

Options as a new revenue guarantee technique

Revenue guarantee put option

A *revenue guarantee put option* is principally another risk management technique. Revenue guarantee options have been studied as a way to enhance a project's financial viability (e.g. Ho and Liu, 2002; Garvin, 2005); Huang, Chou, 2006; Chiara *et al.*, 2007; Brandao and Saravia, 2008).

If implemented within a project, a revenue guarantee put option would grant a concessionaire a right, but not an obligation, to claim a revenue subsidy form an option writer. The concessionaire and the underwriter choose the underlying asset, such as traffic volume or toll revenue, and negotiate the guaranteed value of the underlying asset (strike price), for example at level 2–2' in Figure 1. In the event that the actual value of the underlying asset falls below 2–2', the concessionaire has the right to exercise the option and claim the subsidy for the loss paid by the underwriter. If the actual value exceeds the guaranteed value, the option is out-of-the-money and expires without being exercised. Line 1–2'–3' represents the collected toll revenue, while line 1'–2'–3' represents the concessionaire's actual payoff.

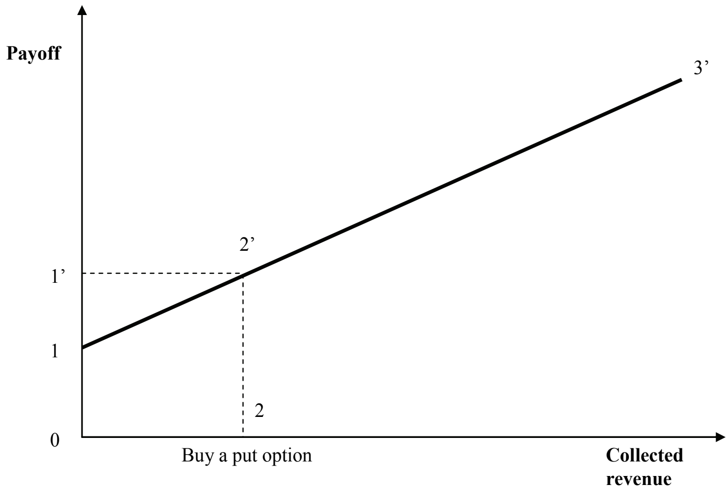

Figure 1. Concessionaire's payoff with a put option

Source: L. Shan, M. Garvin, R. Kumar: *Collar options to manage revenue risks in real toll public-private partnerships transportation projects*, "Construction Management and Economics", 2010, Vol. 28, Issue 10, p. 1059.

Revenue collar: a new type of revenue guarantee option

The major constraint of the revenue guarantee options is that if it were to be priced and sold, then the concessionaire would need to pay a substantial premium to the underwriter. A concessionaire is typically unwilling to make additional payments, so the option purchase becomes an extra burden. The revenue collar option demands less or no upfront payments and, hence, becomes a potentially attractive alternative to revenue guarantee option (Shang *et al.*, 2010).

A **collar,** another type of guarantee option, is a more complex arrangement than a put option. A collar is a combination of a call and a put option. In a revenue collar, a concessionaire buys a floor (a put option) form the underwriter to receive the protection against revenue below the floor, and simultaneously sells a cap (a call option) to the underwriter to defray the cost of the floor. In Figure 2 line 1–2'–3' still represents the collected revenue, but part of the concessionaire's payoff line 1'–2'–3'–4' differs from the case in Figure 1. The put option the concessionaire 'buys' secures its minimum revenue at level 2–2'. The call option it 'sells' forfeits its right to retain the excess revenue beyond level 3–3'; this excess revenue is then captured by the underwriter.

If the collar is structured in a way that the premium received from the sale of the call option, V_{call}, completely offsets the purchase price of the put option, V_{put}, the collar has zero value, and the concessionaire pays no upfront cost. This type of collar is called *a zero-cost collar.*

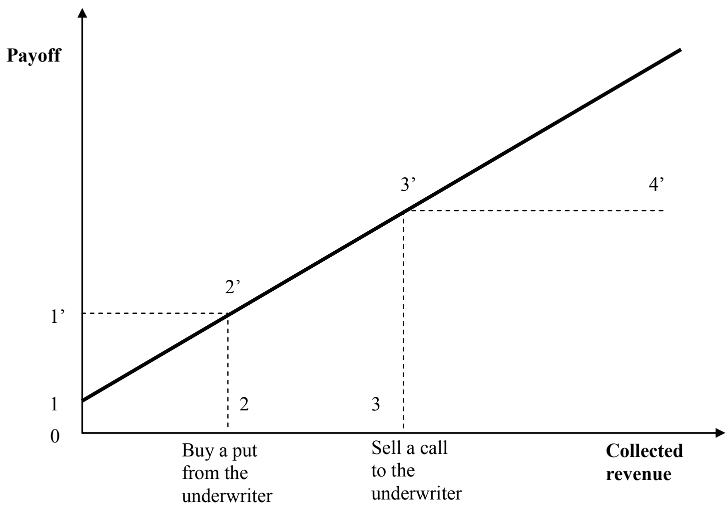

Figure 2. Concessionaire's payoff with a zero-cost collar

Source: L. Shan, M. Garvin, R. Kumar: *op.cit.*, p. 1060.

An *income-producing collar*, on the other hand, sets a narrower band: the call strike price is closer to the put strike price (Figure 3). The lower strike price increases the value of the call option in excess of that required to defray the put option's cost, thus generating cash equal to $V_{call} – V_{put}$. Compared to the zero-cost collar, the income-producing collar is a more conservative approach to managing the risk. Although the concessionaire gives away more potential for larger profit, it is able to harvest immediate cash rather than less predictable gains in the future. If the concessionaire is confident in the project's future profitability, the zero-cost collar is a better strategy.

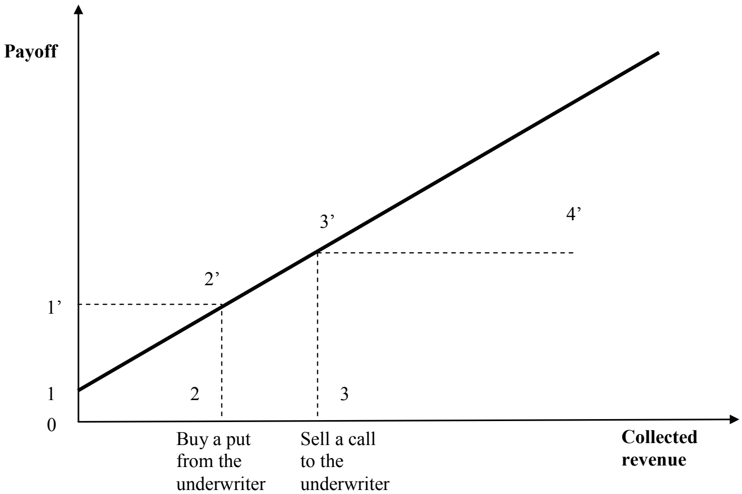

Figure 3. Concessionaire's payoff with an income-producing collar

Source: L. Shan, M. Garvin, R. Kumar: *op.cit.*, p. 1060

A concessionaire and an underwriter maintain their interests through arranging collar option terms in a flexible manner. Therefore, the two parties need to exercise due diligence to examine project conditions and external factors to decide whether or not to enter into the deal and subsequently determine mutually acceptable collar option terms. Factors worth consideration include: traffic projection, toll rate structure, capital expenditure plan, road capacity, demographic conditions, and transportation network.

Studying these factors is necessary for assessing a collar contract's value from the concessionaire's perspective and demonstrating profits from the underwriter's perspective. The two strike prices in a collar allow a significant flexibility. By changing the values associated with the strike price band, the concessionaire can adjust the future and current cash flow to accommodate its financial needs. The different levels of the strike prices can also serve the concessionaire's risk appetite.

A major constraint of revenue guarantee put option as a means of managing revenue risks in real toll PPP transportation projects is that it requires the concessionaire to pay the risk premium. A revenue collar can overcome this barrier. The opposite position in a put and a call option produces a collar with zero value. In addition to the removal of upfront payment, the collar is worthy of consideration for other reasons such as embedded incentives, easy early termination, flexibility, and favourable tax treatment.

Real options – promises and drawbacks

Real option valuation is based upon transferring models developed for financial markets to actual investment decisions. Assessment of the value embedded in real options requires a detailed analysis of the inputs. However, the inputs required for applying option pricing techniques quite often are difficult to get or even estimate.

One of the distinguishable features of the option pricing techniques is that future values of the underlying asset are not predicted. Future values are assumed to follow a certain defined process and numerical techniques try to approximate this process. A key assumption is perfect knowledge of the asset price that determines exercise policy and option value. In capital budgeting projects it is sometimes very difficult, if not impossible to identify the correct stochastic process that the underlying asset follows. However, if there are difficulties in determining the initial value of the underlying asset or difficulties in determining the parameters for the assumed diffusion process governing the behaviour of the underlying asset, than the use of option-based models is limited.

The concept of real options has grown in popularity in recent years. Despite numerous theoretical publications the number of business applications of real options concept is not impressive. The reasons for the slow adoption of real option can be summed up as follows:

(i) the types of valuation models currently used are not well known or understood by corporate managers and practitioners,

(ii) many of the required modelling assumptions are often and consistently violated in practical real option application,

(iii) the necessary additional assumptions required for mathematical tractability limit the scope of the applicability.

Another shortcomings of most of real option models is that they do not take into account the effects of competition.

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Summary

Real options have become an increasingly popular tool of valuation and risk management in investment projects analysis. They allow valuation of managerial flexibility and help in project risk mitigation either through highlighting the desired sequencing of the project or through generation of compensating cash flows. Real options are considered an alternative or a supplement to traditional methods of project evaluation based on discounting expected cash lows.

Numerous publications recommend the application of real options in transportation projects. This includes PPP highway projects where option-based tools are used to hedge against the risk of low revenue. The collar option appears to be an attractive alternative to earlier recommended revenue guarantee put option.

Despite numerous theoretical works, the actual use of real options in business practice is still limited. This is due to some factors, like mathematical complexity of real options models and problems with precise determination of variables which serve as valuation model inputs.

OPCJE REALNE W ZARZĄDZANIU PROJEKTAMI

Streszczenie

Opcje realne stopniowo zyskują na popularności, jako narzędzie wyceny i narzędzie redukcji ryzyka projektów inwestycyjnych. Pozwalają na wycenę elastyczności menedżerskiej oraz wycenę ryzyka uwzględniającą sekwencyjność dużych przedsięwzięć. Metoda opcji rzeczowych traktowana jest jako alternatywa dla, lub uzupełnienie, metod oceny efektywności opartych na dyskontowaniu oczekiwanych przepływów pieniężnych.

Rośnie liczba publikacji poświęconych możliwości aplikacji opcji realnych w inwestycjach w branży transportu i komunikacji. Jedną z dobrze udokumentowanych aplikacji jest zastosowanie opcji gwarancji dochodu w projektach budowy autostrad w ramach partnerstwa publiczno-prywatnego.

Rozwój teorii opcji realnych nie idzie w parze ze wzrostem aplikacji tej koncepcji praktyce. Wśród przyczyn takiego rzeczy wymienia się m.in. złożoność modeli matematycznych wykorzystywanych do wyceny opcji oraz brak pełnej kompatybilności między zmiennymi wykorzystywanymi w modelach wyceny opcji finansowych a ich odpowiednikami w modelach wyceny opcji realnych.