THE DECISION-MAKING PROCESS FOR INFRASTRUCTURAL INVESTMENT CHOICES

edited by
Elisabetta Venezia

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This book is dedicated to Alessandro Leogrande, one of the most brilliant people in the Italian cultural field, well known and appreciated also abroad. Witness of uncomfortable, harsh realities, he was been able to bring them back to the public with wisdom, rigour and elegance.

All papers have been submitted to double review before being accepted.

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INTRODUCTION

Book covers several aspects related to the main topic of infrastructural investment choices, particularly linked to the decision-making process through which investments are selected.

The volume illustrates and critically analyses methodological issues, from the most traditional to the most recent ones, in order to emphasise the pros and cons connected with investment decisions with several references to economic activities, particularly to the transport sector. It poses a range of problems related to institutional structures, decision making processes, available tools and methodologies used for supporting investment choices.

Authors analyse several case studies to show how it is possible to utilise theoretical suggestions in practical applications, thus identifying current difficulties and detecting possible tools to overcome them.

Contributions are grouped by topics, namely: financial and economic aspects of public infrastructure investments, allocation criteria, decision-making models, mega-projects, dynamic analysis of transport infrastructure productivity, sustainable investments, financing and funding investments.

This book is therefore an updated volume which is addressed to researchers, decision-makers and advanced students who need to acquire a clear and new framework, as well as a tool box, in the field of infrastructural investment decision-making processes.

The need to publish this book stems from the absence of updated information, in the form of a book collection, of methodologies and case studies. This volume provides novelties in terms of new models applied to the transport sector, as well as to other fields where infrastructures have to be evaluated and decisions among different solutions have to be made.

1st PART

FINANCIAL AND ECONOMIC ASPECTS OF PUBLIC INFRASTRUCTURE INVESTMENTS

ANALYSING PUBLIC INFRASTRUCTURE INVESTMENT USING A REAL OPTION APPROACH

by *Fabio Pizzutilo*[*]

JEL codes: G31, G38, H54.

Keywords: real options, public-private partnership, PPP, public infrastructure investments.

1. Introduction

A real option is the possibility that the management has to modify an investment during the course of its life. Differing from a financial option, it has no legal existence but relates directly to the real assets of the investment. The financial literature recognizes four main types of real options. The best known consists of the possibility to make a follow-on investment (growth option). Instead, the option to delay refers to flexibility regarding the timing of the investment. It involves the ability to wait and see the development of the business. The third category of real options includes flexibilities enabling managers to make substantial changes to ongoing investments (option to switch operations), while the last category consists of all the possibilities to abandon (totally, partially or temporarily) an investment that has already been made (option to abandon).

Real options assure flexibility in an investment project. The greater is the flexibility, the higher is the value of the real option and consequently, all other things being equal, of the investment. However, the value of such flexibility is not adequately captured by the classical financial analysis of

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investment projects based on the net present value (NPV). The NPV tends to consider the investment in a static way and does not price correctly the value of the real options embedded in the project, ignoring a potentially important source of value. Thus, to estimate the value of an investment correctly, the value of the embedded real options, if any exist, has to be added to the NPV of the base project. In practice, real options are difficult to recognize and to price properly.

Largely studied in the corporate finance literature and taken into proper account by analysts of the private sector, real options seem not yet to have received the attention that they deserve in the decision process of public infrastructure investment projects.

This chapter deals with the issue of real options in public infrastructure investments. First of all, the conceptual framework of real options is provided (section two) and, in section three, their valuation problems and techniques are discussed. Then, in section four, the attention is focussed on real options in public investment projects, while section five deals with some problems related to real options embedded in public–private partnership investment projects. Section six presents a case study that shows how a real option approach can help the public investment decision maker in making the best investment choice, in dealing with the ongoing development of the project and in correctly valuing the investment. The last section concludes.

2. Real Options

Traditional discounted cash flow (DCF) analysis values an investment project with reference to the cash flows that the project is anticipated to produce in the expected scenario. It implicitly assumes that managers are passive in the ongoing operations and in the riskiness of the investment once it has been implemented and that they will adhere strictly to the planned strategy, without any possibility to adjust it if needed or valuable. Thus, DCF analysis fails to capture the value of the flexibility, if any, that the management has to adapt or modify the project during its life in response to unexpected internal and external developments, resulting in an undervaluation of the investment.

This can be achieved by real option analysis (ROA). ROA is thus a complementary analysis to the classical DCF. The actual value of a project is the classical NPV plus the value of such flexibilities. Consider two investments A and B that have the same positive NPV and are identical in all but one respect: at any moment during its life, project B can be abandoned at a recovery price P whilst project A cannot. Any rational investor will prefer project B to project A. Thus, project B is worth more than project A. The difference in values is the value of the flexibility that project B has to abandon the operations at any time if they break down.

The flexibilities that investment projects have are called real options. They are options because they give the possibility to exercise flexibility if it is useful (the management is not obliged to modify the project if it is not believed to be worthwhile). They are real because they are written on real assets and not on financial assets as common financial options are[1].

Consider again projects A and B mentioned above. If the uncertainty about the future prospects of the projects is null, there will certainly not be a need to abandon project B. Thus, the value of its flexibility is null. The greater the uncertainty about the future prospects of the projects, the greater the possibility that the management will exercise the exit plan of project B. Real options are worth more the more uncertain the expected scenario is. ROA is thus needed more when the level of uncertainty is high, as it is in many industries and in modern times.

However, real options are not an exclusive brand of private corporate investments. They are embedded in public investment projects too. In addition, similarly to “corporate” real options, “public investment” real options are worth more the more uncertain the expected scenario is.

2.1. Growth options

These are any options that an investment has to expand its operations.

They can be viewed as call options on the expansion project, in which the higher costs to achieve such flexibility are the premium of the option, the cost to expand is the exercise price and the maturity is the time in which it is possible to expand[2].

With reference to public infrastructure projects, for example, consider the case of the construction of a new motorway link road to decongest city centre traffic. If there is a high degree of uncertainty about the actual use of the new road, it can be wise to analyse the possibility to build rather than, for instance, a four-lane road, a two-lane one that is already arranged with the intention to become a four-lane one in the future, once, given the actual use of the two-

[1] For a comprehensive analysis of real option theory and practice, see among others Amram and Kulatilaka (1998), Copeland and Antikarov (2001), Brach (2003), Guthrie (2009).
[2] It is assumed that the reader is familiar with basic option terminology. Among the countless books on the subject, anyone who is not used to option theory can refer to Hull (2014).

lane road, the demand for the motorway link can be assessed more exactly. The cost for the rearrangement of the two-lane road into a four-lane one (consider, among others, the higher design expenses, the cost of building larger bridges or tunnels to be used for a four-lane road, the higher cost of building the road where there is enough space for a four-lane one, etc.) is the premium that the collectivity has to pay in order not to incur immediately the higher expenses (and risks) of a four-lane motorway but to have the flexibility to expand the road more easily and cheaply3 if actually needed. It should be obvious that the value of the real option embedded in the two-lane road is higher the greater is the uncertainty regarding the actual demand for the motorway link and its benefits for the community. In such a simplified valuation, a four-lane, a two-lane or a two-lane arranged motorway will be chosen if respectively NPV_4, NPV_2 or $NPV_2+RO_2–C$ is the higher, where:

- NPV_4 is the net present value of the four-lane motorway,
- NPV_2 is the net present value of the two-lane motorway,
- RO_2 is the value of the real option described above and
- C the adjunctive costs to achieve such flexibility[4].

2.2. Option to delay

This is any flexibility regarding the timing of the investment to be started.

The possibility of deferring an investment provides two main advantages. First of all, the extended time can be usefully employed for in-depth technical, operative, marketing and financial analysis, and so on, aimed at optimizing the planning of the investment and reducing the uncertainty about its costs, revenues and other benefits. Moreover, it gives the chance to choose the best moment to invest (that is the investment can be postponed to when its value is maximized). On the other hand, if an investment is deferred, there

[3] Notice that if the two-lane road is not arranged to become a four-lane one, the eventual future choice to expand the two-lane road will involve higher costs and a longer time or, in the worst case, will no longer be possible.

[4] A careful reader will soon see that there are many other possibilities from which to choose. For instance, the two-lane motorway that is not arranged to become a four-lane one can always keep the possibility of being expanded but will incur higher expansion costs. The value of such a real option should be lower than RO_2, but there is no need to pay for C today. On the other hand, it could be possible to limit the arrangement costs C, resulting in different values of RO_2. The optimal investment choice is the one with the highest combined NPV + net RO value. The greatest contribution of the real option approach is to train the decision makers in creating and recognizing project flexibilities to make the best investment choice.

is the possibility that other operators will enter the business, spoiling the expected source of value.

Given these considerations, real options to delay are particularly valuable for very-long-horizon investments that cannot (or can only with difficulty) be spoilt by the concurrence (in the private sector think of the exploitation of a mine or an oilfield for which the rights have already been achieved, to build on an area that has already been bought, to start the commerce of a new drug that has already been patented, etc.). For these reasons, they are particularly valuable and attractive in public infrastructure investments too, which by definition are very-long-term investments that do not face relevant concurrence problems (consider the possibility of deferring the wi-fi free coverage of an urban area to the moment when the fourth generation of mobile telecommunications technology (4G) is fully available and tested or postponing the building of a bridge between two islands to a time when the surrounding rail and motorway infrastructure is complete, for instance).

From a financial perspective, real options to delay can be read as call options (in general of the American style) on a project (the underlying asset). The strike price is the amount to be spent to realize the investment (note that there could be uncertainty concerning this value too – think about technological development that could reduce some fixed costs – which adds more value to the option). The premium is the amount that is possibly paid to have the option to wait and see (consider patent rights, concession rights or, to stay in the public infrastructure field, the cost of land expropriation or zoning an urban area to be easily employed for the construction of an airport, an underground station, a park, etc. when it is actually beneficial). On the other hand, deferring the project means losing the net benefits that would have been derived from undertaking it immediately. Thus, the option to delay has to be exercised (that is, the investment has to be made) when its value is lower than the net benefits that would otherwise have been achieved[5].

Notice that in the classical DCF framework the investment can be made either now or never. The postponed investment has to be treated as an alternative investment. More efficaciously, ROA analysis advises postponing the investment if the value of the option to delay is higher than the NPV of the project realized immediately, even if the latter is highly positive. Moreover, ROA assumes that an investment cannot always be unattractive. Circumstances can change, so an investment that has a negative NPV if realized today can be attractive in the future.

[5] Those who are accustomed to financial option valuation will immediately note the similarity to an American call option on a stock that pays dividends.

2.3. Switch option

This refers to any flexibility that the project has to make substantial changes to its inputs and/or outputs.

To stay in the public infrastructure industry, think of the building of a new primary school. Instead of building a single edifice, it could be better to erect two smaller buildings to achieve the flexibility necessary to convert one of the two into a library, a senior centre, or a nursery school, for example, if the demand for primary instruction falls in the future. Another common example is to build a new hospital or a public building with no permanent internal walls, so the internal spaces can be redistributed easily and flexibly according to changes in future operations, demand, needs and so on, without suffering the high costs that such modifications imply if internal spaces are separated by permanent walls.

The major costs for the two building projects are the premium that the collectivity has to pay to achieve such flexibility, which can be immensely useful in countries where the population growth rate is small or negative. The major costs for the non-permanent walls are the premium that the collectivity pays to acquire the flexibility to redistribute the internal spaces of the public building easily, quickly and economically, if needed.

The financial replication of this kind of real option largely depends on the actual type of switching flexibility that the project has.

2.4. Option to abandon

This is any flexibility that the project has to cease totally and/or partially and/or temporarily during the course of its life. Given their similarity and the scope of this chapter, to save space and avoid redundancies, in this category are included what should properly be named respectively as the real option to cease (total abandonment), the real option to contract activity (partial abandonment) and the real option to suspend (temporary abandonment)[6].

Almost every investment project has the possibility of being halted, contracted or suspended at any moment in time if the business fails. The numerous public infrastructures that have been abandoned or significantly downsized throughout the world bear witness that this kind of option is largely exercised by public agencies too.

[6] For an in-depth analysis, see Trigeorgis (1996).

If it is relatively easy to abandon an investment, and thus not suffer the subsequent losses, the value of such a real option largely depends on the value that can be recovered by the eventual total or partial abandonment and from the costs that (possibly) the company has to suffer to cease the activity totally or partially or to suspend it temporarily and eventually reactivate it.7 Hence, it could be of great importance in the planning phase of the investment to try to maximize the value of the abandonment real options embedded in the project and not to treat them as a passive event that is unlikely to affect the business.

Remaining in the public infrastructure industry, consider the construction of a new public swimming pool. If it is incorporated into another public building (e.g. a gymnasium, a basketball arena, etc.) it could be difficult to sell it to private entities and thus collect a fair recovery price if the demand is not as high as expected and the municipality opts to shut down the service (or, as frequently occurs in these times, the municipality does not have the financial resources to maintain the swimming pool). Moreover, suspending (e.g. at the beginning of the summer) and resuming (e.g. in the autumn) the swimming pool activities can be a rational solution to deal with the seasonality of the demand. However, the temporary abandonment implies certain fixed costs, both for the suspension and for the recovery. Arranging the project to minimize these kinds of costs increases the value of the suspension real option. The higher cost that the municipality has to pay to build the swimming pool with a separate entrance or to minimize the suspension and the reactivation costs are the premiums that it pays to achieve greater flexibility to abandon the service totally or temporarily.

In their easiest forms, real options to abandon can be viewed as put options on the investment. For the ceasing and contracting real options the strike price is the net recovery price. The value of the suspended operations less the suspension costs is the strike price in the case of temporary abandonment. Abandonment real options should be exercised if the value of continuing the business is lower than the strike price.

3. Valuing real options

Real options are often difficult to identify. Their valuation is more complicated than financial options given that, above others, their underlying is

[7] Some businesses (nuclear power stations, asbestos production and manufacturing, pipelines, etc.) can involve significant ceasing costs.

not traded, they can be exercised at different times and the volatility of their returns is a great exercise of estimation. Furthermore, complex investment projects can embed several real options that cannot be valued separately if, as is often the case, they are interdependent and/or conditional (think of a project that has the flexibility both to be halted and to be contracted: if halted, the contracting real options have no further value). Given these complexities, the classical Black and Scholes (1973) formula8 is rarely deemed to be the best way to approach real option valuation. The flexibility and simplifications allowed by binomial option pricing models (first proposed by Cox, Ross and Rubinstein, 1979), compound option pricing models (Geske, 1979, was among the very first to deal with the valuation of these kinds of options, which can apply to a large series of project flexibilities) and Monte Carlo simulations (Boyle, 1977, was among the very first to apply this class of non-parametric models to the pricing of financial options) have often been considered to be more suitable tools to value real options. Of course, the actual preferred model is a matter of the real option to be valued, its financial and real features and the possible interactions and interdependencies with other flexibilities that the investment project has.

[8] The Black–Scholes formula permits the calculation of the value of a European call option written on a non-dividend-paying stock:

$$C_{S,t} = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$

with: $d_1 = \frac{1}{\sigma\sqrt{(T-t)}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right]$

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

where:

$C_{S,t}$ is the value of a call option whose underlying's spot price at time t is S;
N(x) is the cumulative distribution function of the standard normal distribution;
S is the spot price of the underlying asset;
K is the strike price;
r is the annual risk free rate (continuously compounded);
(T-t) is the time to maturity;
σ is the volatility of the returns of the underlying asset.
The price of the corresponding put option can be derived from the put-call parity:

$$P_{S,t} = Ke^{-r(T-t)}N(-d_2) - N(-d_1)S$$

where: $P_{S,t}$ is the value of a put option whose underlying's spot price at time t is S. Other notations are the same as above.
Anyway, the Black-Scholes model relies upon strict assumptions: a) the risk free interest rate is constant during the life of the option, b) the instantaneous log returns of the price of the underlying stock follow a geometric Brownian motion with constant drift and volatility, c) the underlying does not pay dividends, d) there are no arbitrage opportunity, e) It is possible to borrow and lend money of any amount at the riskless rate, f) there are no restrictions in the trading of the underlying stock (i.e. it is possible to go short or to trade fractions of the stock), g) there are not transaction costs, h) the underlying stock is continuously traded.
An extension of the formula permits the calculation of the value of options written on an underlying that distributes dividends.

Anyway, the variables on which the value of a real option depends are the same as those of financial options.

a) The strike price (that is, the price at which the option can be exercised). For call options like the growth ones, the lower the strike price, the higher the value of the real option. For put options, like abandonment ones, the lower it is, the lower is the value of the real option[9].
b) The value of the underlying (that is, the value of the investment project). All other things being equal, it is evident that the higher the value of the project, the higher the value of the real call options written on it (like growth options) and the lower the value of the put real options (like abandonment ones).
c) The volatility of the value of the underlying (that is, the riskiness of the project). The greater is the uncertainty surrounding the project, the higher is the value of the flexibilities that the project has. Thus, the riskier the project is, the higher the value of the embedded real options is, whatever their typology.
d) The maturity (that is, the time until which they can be exercised). It should be obvious that the longer the time until any flexibility of the project can be exploited, the higher its value, regardless of whether the real options embedded in the project are to grow, to delay, to switch or to abandon.
e) The risk-free interest rate. All other conditions being equal, a change in the risk-free interest rate produces an effect of the opposite sign on the value of real put options and of the same sign on the value of real call options. Therefore, it is to be expected that an increase (decrease) in the risk-free rate results in a decrease (increase) of the value of the abandonment real option and in an increase (decrease) of the value of the growth real option. The effect is partly explained by the fact that an increase (decrease) in the risk-free rate results in a decrease (increase) in the present value of the proceeds that will follow the possible exercising of the abandonment option – that is, the recovery price – and in a decrease (increase) in the present value of the strike price to be paid if the growth option is exercised – that is, the cost of the investment.
f) Any cash flow paid by the underlying. If a project distributes the cash flows that it generates, its value reduces by the same amount. Thus, for b) above, the value of a put real option increases and the value of a call real option decreases. All other things being equal, it is better to exercise the option to abandon a project after having collected the cash flows that it

[9] To gain a sense of this, remember that for a growth option the strike price is the amount to be invested to grow and for a ceasing option it is the net recovery price.