The use of Real Options in investment decision-making in the context of an emerging LNG infrastructure

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ABSTRACT

Europe's transport sector is predominantly fuelled by oil products, fuels which are finite and emit large amounts of greenhouse gasses (i.e. CO_2 and NO_x) upon combustion. Cleaner fuel alternatives (as for example LNG) are available but require large investments in uncertain times. This paper investigates the concept of real options - which relies on the introduction of flexibility to deal with this uncertainty- by means of a case study at Royal Vopak NV. The case study compares the real options approach to the traditional approach. The use of real options provides insights into considering flexibility as a tool for decision-making under uncertainty on infrastructure investments. Future research should focus on more applications of real options in infrastructure investment decision-making under competition or cooperation.

1. Introduction

Europe's transport sector is predominantly fuelled by finite oil products (IEA, 2013). Two major oil crises occurred in the last century, yet the transition to other fuel sources hardly occurs (both in Europe and globally). Moreover, worldwide growing interest in environmental concerns have resulted in more stringent emission regulations. A transition to cleaner fuel alternatives is inevitable. This transition requires uncertain investments in new energy infrastructures. The use of Liquefied Natural Gas (LNG) as a fuel proves to be a good alternative in terms of emissions, reduced engine noise and diversity of Europe's fuel supply. Although current outlooks (i.e. Vopak LNG (2013), Nationaal LNG Platform (2013) show a profitable future for this commodity, the estimated demand quantities are highly uncertain (see Figure 1). Companies in the business are still interested to invest in this opportunity (Shell, BP, GDF Suez etc.).

One of these parties is Royal Vopak N.V.; the world's largest independent storage provider for oil, gas and chemicals. Various attempts to construct and develop infrastructure to use LNG as a fuel in the marine and road transport sector in the Netherlands have failed; the current investment proposals are not able to cope with the large amount of uncertainty that arises at these new infrastructure investments.

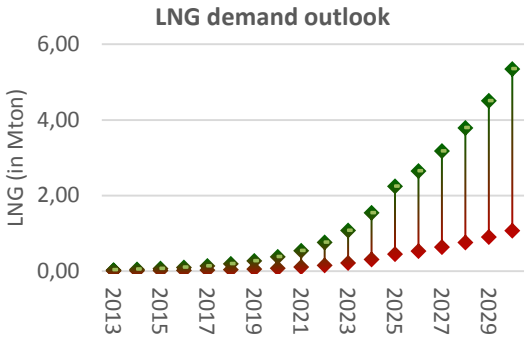

Figure 1 LNG demand outlook for the Netherlands; promising but uncertain

This uncertainty mainly originates from the fact that infrastructure investment in particular are characterized by a classic *chicken-and-egg* problem; the supply side will not invest in infrastructure until sufficient demand establishes while the latter will not retrofit their fuel systems until sufficient (refueling) infrastructure is developed (examples include Hydrogen fuels or electric vehicles).

Some describe that investment valuation based on option theory give guidance for such situation (e.g., Dixit & Pindyck, 1994,

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Trigeorgis, 1998, Kort et al., 2010) by the introduction of flexibility to cope with changes in future needs and requirements.
Yet the link between real options and infrastructure investments is scarcely described in current literature. Since Real options might well be an interesting evaluation method for such decisions, this article has the objective to asses to value the of real options in infrastructure investments by means of a practical case example.
The following section contains a brief literature overview on real options theory and existing case study applications. In section four a practical example case is presented on an emerging LNG infrastructure and its accompanied problems. The conclusions are drawn in section five where after recommendations for further research are presented .

2. Research method

This study is based on a literature overview and a practical example case.

Articles used in literature overview were found by consulting scientific databases such as *Scopus* and *Web of Science* on key words as *Real Options*, *Real Options in Infrastructure, Options in infrastructure*. To compare the real options concept with the current evaluation tool in a practical example case, a book of Jonathan Mun (2012)-*Real Options Analysis*- was used.

According to Verschuren & Doorewaard (2010) and Dul & Hak (2008) the use of one practical example does limit the general applicability –external validity- of the results. Yet this is a common misunderstanding (Flyvbjerg, 2006). An illustrative case study is used to show the potential value of this method by means of an example. In this paper 'the force of an example' is more of value than formal generalization of results due to the novelty and scarcity of real options case applications.

3. Literature overview

3.1 Definition of a Real Option

A Real Option is a right, but not the obligation, to influence an investment process at a predetermined price and span of time.

The concept of real options is to consider flexibility as a tool to co-exist with uncertainty rather than fighting it (in contrast to many traditional DCF methods) (Herder et al., 2011). According to Wang & de Neufville (2005) a clear distinction can be made between real options 'on' projects – managerial decisions can create flexibility by timing and method of valuation – and real options 'in' projects – in which (small) upfront physical investments create the opportunity to benefit from a more flexible or adjustable design in the future.

3.2 Basics underlying Real Options

In contrast to financial options, underlying assets of real options are physical or real, as the name implies. Myers first described the concept of real options in his articles "Critical insights into the first introduction of the concept of real options" and "Determinants of corporate borrowing" published in January and July 1977, respectively. Eleven years before he coins the term *real options*, Myers & Robichek argue that the biggest drawback of standard valuation methods is the (static) "risk-adjusted discount rate". Therefore they indicate the need of a new "adjusted present value" while making investment decisions (Robichek & Myers, 1966). More criticism can be found in Myers (1984), Brenan & Schwartz (1985), Kester (1984, 1986), McDonald & Siegel (1986), Pindyck (1991), Trigeorgis (1993) that all touch upon the drawbacks of traditional NPV and DCF models. These models ignore the fact that the future is unpredictable which causes needs and requirements to constantly change.

3.3 Differences in Real Options

In 1984 effort was put into classifying and distinguishing different types of real options by Kester. Later in 1988, Trigeorgis made a clear scheme on which Figure 2 is based. Simple and complex real options exists both being either shared or proprietary. The first question that needs to be answered is whether or not the option is *simple* or *complex*[1]. The latter is referred to an option that creates the opportunity for (many) other, and is therefore of strategic value to a company[2].

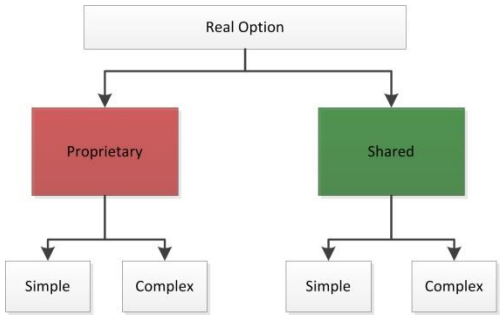

Figure 2 Classification scheme for real options based on (Kester, 1984) and (Trigeorgis, 1988).

The 'sharedness' is determined by the exclusivity the option offers to Firm A with respect to competitor Firm B. For instance, holding a patent gives total exclusivity on the protected product; other firms do not influence this option. When considering infrastructure investments, this classification scheme helps to understand the strategic value of (complex) proprietary options in such situations.

3.4 Real Options and infrastructure investments

The link between real options and infrastructure investment is rarely described in literature. Yet infrastructure investments are typically subject to large amounts of uncertainty, long timeframes and irreversible investments which require vast amounts of money. These characteristics create a perfect environment to apply the concept of real options. Titman (1985), Capozza & Sick (1994) and Quigg (1995) show that a vacant plot should be valued not only on the value of constructing a building now but also on alternative future developments. Using real options in road development is described by Zhao et al. (2004), value of flexibility in toll roads by Ford et al. (2002), Ho & Lui (2002) relate real options to privatized infrastructure projects[3]. Zhao & Tseng (2003) report on expansion of public parking garages with real options and Suttinon & Nusa (2010) report on a case of real options in planning an industrial waste infrastructure. The use of real options in planning of electricity infrastructure has shown potential (see Blanco et al., 2011, Vazquez & Olsina, 2007 and Wijnia & Herder, 2005) but is very scarce in literature. Applications of real options in energy infrastructures planning is negligible. Yet real options can help design future energy systems which have more change in competing with current energy systems.

Articles that do combine infrastructure planning and real options also stress the importance of a game theoretic perspective. Smit (2003, 2001), Smit & Trigeorgis (2009) and Ferreira, Kar & Trigeorgis (2009) all argue that due to the nature of these specific type of real options (i.e. complex options) game theory approaches are preferred. The combination of real options and game theory is often referred to as *real options games*.

4 Practical example case on Real Options in an emerging LNG infrastructure

This case study is focused on LNG as a fuel for the transport sector in the Netherlands. Royal Vopak's LNG department is interested in developing the 'supply' infrastructure needed to start using LNG as a fuel. After the

[1] Many authors use the term *compound* instead of *complex*, in this paper the term complex is more relevant of such class of options.

[2] A good analysis on strategic acquisitions of real options can be found in Smith & Triantis (1994).

[3] The trade-off between private or public infrastructure development is investigated by Altamirano (2010). Her conclusions on private infrastructure investments resulted in the connection between transaction costs and real options in this article.

successful commission of the Gate terminal together with Gasunie in 2011, Vopak and Gasunie are now investing in small-scale LNG infrastructure projects. As an example case the construction and development of an LNG truck loading bay on the Gate terminal (see Figure 3) area is selected. The financial structure behind this project is modelled in a Microsoft Excel ® sheet.

Figure 3 First LNG truck loading on the 20th of January, 2014. Gate terminal, Rotterdam, NL. Courtesy of Paddy Hudig.

4.1 Infrastructure investments

The use of LNG as a fuel in the maritime and road transport sector in the Netherlands requires more infrastructure than currently present (see Figure 4).

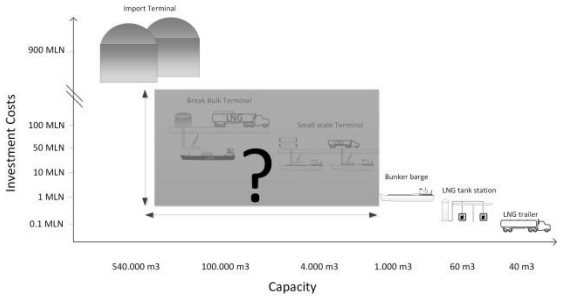

Figure 4 A physical gap (grey box) exists between the import terminal and the distributors and end-consumers. Indicative investment amounts (in €) on vertical axis and storage capacity (in m^3) on the horizontal axis.

Table 1 Key financial figures generated with the traditional approach.

Key Financial Metrics (in 1000 EUR)	After-tax
Investment capex	[redacted]
Capitalized interest	[redacted]
Grand total	[redacted]
WACC	8,0%
IRR (RV @ book value)	9,1%
NPV (in 1000 EUR)	137

In order to supply the end-consumers and distributors medium- and small-scale infrastructure is needed to 'break bulk'.

A LNG truck loading bay is capable of loading one truck trailer with approx. 40 m^3 of LNG in 30 minutes. To calculate the NPV of this project, the following details were used

- The initial investment is [redacted] MLN Euro
- 10 % capitalized interest increases the total investment to [redacted] MLN Euro
- The LNG truck loading bay is depreciated over 20 years with a discount rate of 8%
- Revenue is generate by selling capacity (i.e. slots) for [redacted] Euro each

Table 1 shows the financial details which are generated by the standard financial model of Vopak.

4.2 Adjusting the model to use real options methodology

In this case study the traditional model is adjusted based in the real options framework as described by Jonathan Mun (2012) in *Real Options Analysis* on pages 86-97. This framework prescribes four steps;

1. Simulation
2. Real options problem framing
3. Real options modeling and analysis
4. Reporting

In **step 1**, sensitivity analysis is applied to indicate the variables that most influence the project's resulting NPVs. The projected revenue has a major influence on the NPV outcomes. A scenario analysis of the worst, middle and best revenue scenario is shown in Figure 5.

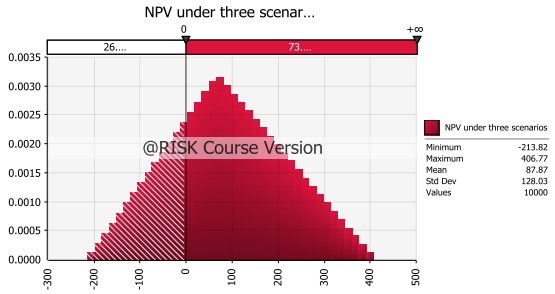

Figure 5 Scenario analysis under three scenarios

Step 2 consists of real option problem framing. The most basic real option is the option to wait or defer an investment. It is a strategy which waits until some of the market uncertainty has resolved and the decision to invest is taken later. In this example two versions of this particular option are presented.

Option to defer (passive wait-and-see-strategy)

The market for small scale LNG was a hot topic in the last year. Still we might not be certain of the fact whether or not the Dutch market is ready for this type of LNG usage. Therefore the decision is made to wait two years and gain more information on the potential market for LNG. Since the economic climate does not allow Vopak to invest in projects with such small cash returns, the project will only be executed if the best case demand scenario becomes reality. We can represent this by a simple decision tree (Figure 6).

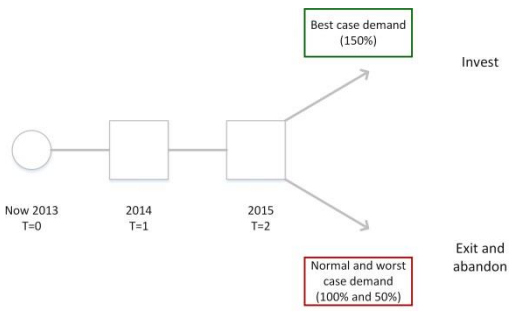

Figure 6 Passive Wait-and-see-strategy presented as a decision tree

The result is a NPV of 1584k Euro and IRR of 20.8%. The decision tree displays the option for management to invest or abandon the project after one or two years.

Option to defer (active market-research strategy)

The two-year passive waiting strategy can have a negative outcome if competitors are taking this risk and do enter the market. Management could also resolve some of the market uncertainty by initiating an active-market-research strategy. Let's assume that it takes one year to do some proper market research. An analyst which can do this research is estimated to ask a salary of 150.000 euro per year. The analyst also shares its information with other departments and the data gathering methods might be used for other projects (this can in itself be seen as a *complex* option). After the research is finished, management can decide to execute the project or abandon and exit the opportunity.

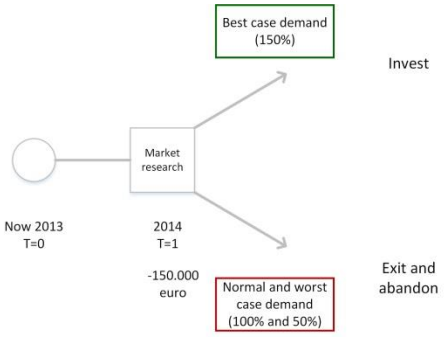

Figure 7 Active market research strategy presented as a decision tree

Again the project will be executed if the market research shows a best case demand scenario. The question is; is the extra pre-investment in market research beneficial, and if it is, what may be the maximum amount to spend on it? The answer is shown trough calculation; the resulting NPV is 1483k Euro with an IRR of 17.5%. These numbers are lower than the passive-wait-strategy but reduces the chance of losing market share to

competitors. Furthermore, the NPV is 1.483k Euro after accounting for the 150k research costs. This means that the NPV of option one minus the NPV of option two determines the value of the market research (1.584k -1.483k Euro = 101k euro). A maximal amount of 150k-101k = 49k euro can be spent on market research. If the amount needed for research exceeds this 49k euro than the company is better off waiting for another year with the risk of losing its position in the small scale LNG market.

Step 3 includes the modeling and analysis of the real option. *Monte Carlo* simulation is used to model the second (real) option to defer into the financial template. The results are displayed in Figure 8.

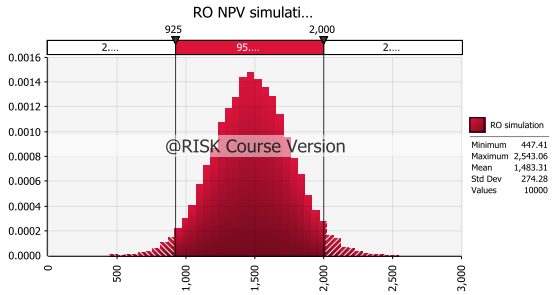

Figure 8 Real Option (option to defer; active market strategy) valued by means of Monte Carlo simulation

Step 4 is finalizing the introduction of real options by a reporting stage. The most important numerical results of this case study can best be presented when being compared with the traditional approach. Figure 9 shows the distribution comparison of the traditional approach (black), scenario analysis (blue) and the simulation of a real option (red).

Table 2 Key financial figures of implementation the active-market research option

Key Financial Metrics (in 1000 EUR)	After-tax
Investment capex	[redacted]
Capitalized interest	[redacted]
Active market research	150
Grand total	[redacted]
WACC	8,0%
IRR (RV @ book value)	17,5%
NPV (in 1000 EUR)	**1483**

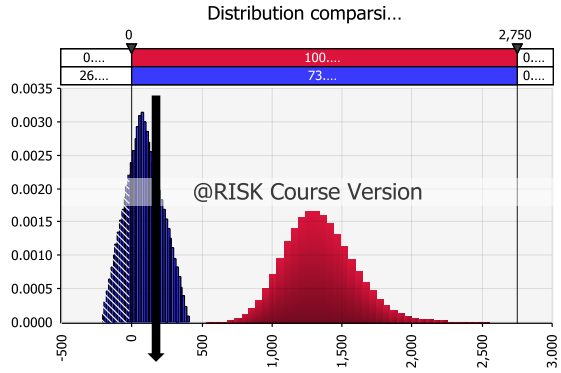

Figure 9 Distribution comparison of the traditional, simulation and real option calculation methods.

5 Conclusions

The number of case studies on infrastructure investment valued with real options is limited. This paper presented a practical case example on the use of basic real option concepts at Vopak's LNG department. The objective of this paper is to asses to value the of real options in infrastructure investments. The concept is applicable and provides, in contrast to the traditional approach, more insights in the underlying assumptions and data for a decision. Flexibility as a tool can help in making tough investment decisions in uncertain times. Yet, it requires more steps and sophistication (simulation and market research) in the investment process, hence resources as time and knowledge.

This results in the situation that the use of the real options methodology becomes a real option in itself. While this practical example has shown potential, the trade-off to invest in this methodology requires more case applications at Vopak (hence money and time). Moreover there is the trade-off to attract an external party or develop the knowledge in-house. If other efforts also show potential then the small investment now to generate the knowledge in-house could significantly lower the transaction costs for future applications. Overall can be concluded that the real options methodology is more than an alternative evaluation tool. It is different a mind-set.

6 Future research

Real options can provide a competitive advantage for a firm in a uncertain market. But what if more companies consider real options as their strategy? Investments in a competitive market can in essence be seen as 'games' between different firms; firms implicitly take into account the possible reactions of their competitors. A merger of the latter, known as a game theory, and real options is therefore a logical step. In this case study, competition appears to be inextricably linked with the investment in infrastructure. This can partly be explained by the fact that these investments open opportunities for follow-up investments and can exclude a competitor from entering a/the market. Furthermore, infrastructural investments can introduce regional and national growth both for a location, country or company and are therefore important. As the game theoretical approach can help value a proposal more realistically, infrastructure investments can also be executed as cooperative events (shared complex options). Unfortunately no literature exists on this perspective of real options in combination with infrastructure investments.

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Possible publication Journals

1 Review of Financial economics

- Interested in case studies (empirical results)
- Similar work of Smit (2003); *Infrastructure Investment as a Real Options Game: the Case of European Airport Expansion*

2 California management Review

- Interested in analysis and practice oriented work
- Also for scholarly publications
- Work that can be used by managers in their daily practice