


“Real option analysis. The viability of real estate projects”

Alberto Munoz Cabanes  <https://orcid.org/0000-0001-5425-0564>

 <https://publons.com/researcher/2011714/alberto-munoz-cabanes/>

AUTHORS

Alfonso Herrero de Egana

 <https://publons.com/researcher/2627201/alfonso-herrero-de-egana-e-de-los-monteros/>

Arturo Romero

ARTICLE INFO

Alberto Munoz Cabanes, Alfonso Herrero de Egana and Arturo Romero (2020). Real option analysis. The viability of real estate projects. *Investment Management and Financial Innovations*, 17(4), 271-284. doi:[10.21511/imfi.17\(4\).2020.24](https://doi.org/10.21511/imfi.17(4).2020.24)

DOI

[http://dx.doi.org/10.21511/imfi.17\(4\).2020.24](http://dx.doi.org/10.21511/imfi.17(4).2020.24)

RELEASED ON

Tuesday, 08 December 2020

RECEIVED ON

Monday, 02 November 2020

ACCEPTED ON

Monday, 30 November 2020

LICENSE



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

JOURNAL

"Investment Management and Financial Innovations"

ISSN PRINT

1810-4967

ISSN ONLINE

1812-9358

PUBLISHER

LLC “Consulting Publishing Company “Business Perspectives”

FOUNDER

LLC “Consulting Publishing Company “Business Perspectives”



NUMBER OF REFERENCES

24



NUMBER OF FIGURES

9



NUMBER OF TABLES

0

© The author(s) 2025. This publication is an open access article.



BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

Received on: 2nd of November, 2020

Accepted on: 30th of November, 2020

Published on: 8th of December, 2020

© Alberto Muñoz Cabanes,
Alfonso Herrero de Egaña, Arturo
Romero, 2020

Alberto Muñoz Cabanes, Ph.D.,
Professor, Vice-Dean, Department
of Applied Economics and
Statistics, Faculty of Economics,
Universidad Nacional de Educación
a Distancia (UNED), Madrid, Spain.
(Corresponding author)

Alfonso Herrero de Egaña, Ph.D.,
Professor, Department of Applied
Economics and Statistics, Faculty of
Economics, Universidad Nacional
de Educación a Distancia (UNED),
Madrid, Spain.

Arturo Romero, Ph.D. Student,
Department of Applied Economics
and Statistics, Faculty of Economics,
Universidad Nacional de Educación a
Distancia (UNED), Madrid, Spain.



This is an Open Access article,
distributed under the terms of the
[Creative Commons Attribution 4.0
International license](https://creativecommons.org/licenses/by/4.0/), which permits
unrestricted re-use, distribution, and
reproduction in any medium, provided
the original work is properly cited.

Conflict of interest statement:

Author(s) reported no conflict of interest

Alberto Muñoz Cabanes (Spain), Alfonso Herrero de Egaña (Spain),
Arturo Romero (Spain)

REAL OPTION ANALYSIS. THE VIABILITY OF REAL ESTATE PROJECTS

Abstract

Traditional methods used for real estate project valuation, such as the static Net Present Value, have some limitations, as these methods do not consider the possibility of a change in the initial conditions of the project or during its development. On the other hand, the real options approach allows for flexibility in evaluating a real estate project, improving the decision-making process as it helps identify the optimal strategy and timing for the construction phases. The paper deals with evaluating an actual real estate project in La Rioja (Spain) using different options to estimate its final Net Present Value. The results show that the real estate project would be profitable under several scenarios, although the valuations can vary significantly among the different types of options. This is because some options add more value to the project than others, depending on their cost and the uncertainty they eliminate. In contrast, the results obtained using the traditional static method would have led a real estate developer to discard the project completely, as its Net Present Value would have been negative. This confirms that the introduction of flexibility in real estate developments creates additional value by allowing developers and investors to dynamically react to changes in the market, thus making better investment decisions and finding real estate investment opportunities that otherwise would not be considered at all.

Keywords

real estate, investment evaluation, real options

JEL Classification

C15, G13, O22

INTRODUCTION

Since its inception at the end of the last century, research on real options has intensified worldwide. However, the question that arose was whether the transfer of this research results to the real economy was taking place. The answer depends on the economic sector analyzed. For example, specific industries such as pharmaceutical or mining companies use them continuously, while in other areas, such as real estate, it has not taken place yet. In this article, the real options method is adapted to analyzing real estate projects, one of the most relevant economic sectors in the Spanish economy.

Currently, the most used method of analysis is the Net Present Value (NPV), followed by others, such as the Internal Rate of Return (IRR) or the Payback Period (PP). All these methods present some limitations, as they cannot assess the projects' flexibility, assume the discount rate constant, consider the projects as additive, or do not consider the possible synergies between them. In the case of the PP method, it does not consider the magnitude of the income after the year of recovery. Considering their limitations, it is advisable to complement them with other methods of analysis.

As Trigeorgis (1993) indicates, the solution used up to now was to rely on the developers' intuition, judgment, and experience. That is some-

thing not acceptable in an environment so competitive as the current one, making it necessary to rely on the real options technique.

Real options analysis has many advantages over NPV. For example, it provides the developer with flexibility in decision-making, which is very important in volatile economic environments. Moreover, such volatility is potentially favorable, providing higher value through the possibility of handling it, which in the NPV method was considered a negative influence. Therefore, projects that were previously discarded by an NPV evaluation could be approved when evaluated using real options.

The analysis with real options allows evaluating whether a company has to abandon a project if the market changes or to postpone it until the market conditions are favorable. Likewise, it also allows expanding the project if the changes are favorable. Finally, another advantage that can be highlighted for research or very innovative sectors is that undertaking a project allows a company to acquire knowledge.

1. LITERATURE REVIEW

In this section, an overview of real options methods to assess investment projects is provided. Next, a review of the current state of the research in applying real options for real estate investment valuation is presented.

1.1. Valuation using real options

Real options methods have been used successfully in different areas, especially those requiring high investment requirements while facing notable uncertainty. For example, real options valuation methods are frequently used in mining or oil extraction projects and refineries. García (2017) and Mascareñas (2007) evaluate oil projects through real options.

Another case for this kind of method is the valuation of Internet companies. Schwartz and Moon (2000, 2001) use real options applying the Monte Carlo method. Their conclusions claim that the results are very dependent on the values provided as data, so a very detailed preliminary study must be done. Also, González (2003a) uses real options to evaluate companies like Yahoo! and detects that the company was overvalued and immersed in a bubble.

Pardo et al. (2004) use real options to value marine aquaculture projects, allowing to take into account price volatility and fish mortality and the possibility of expanding or reducing the project.

The work of Alonso et al. (2009) is of great interest. They analyze the real options in the electrici-

ty sector. They study Endesa's expansion in Latin America, where it was observed that Endesa's investment in Enersis was made with a negative NPV, but the investment rationality is found in the valuation of the expansion option into Brazil. They also found that Endesa's stock price reveals this.

The valuation of real options can also be used in the retail sector. For example, a change of preferences in consumer habits has been observed during the current decade in Spain, switching from the hypermarket to the neighborhood supermarket. Loporati (2013) applies Game Theory to the analysis of convenience stores' implementation, adding the rival companies' movements to the advantages of real options.

There are also several real options applications in infrastructure or energy projects. For example, Balibrea (2011) analyzes the changes in the results for a renewable energy generation project in the case of changes in regulations or subsidies given to a sector.

In the area of infrastructures, long-term projects such as toll roads are ideally suited for this method. Ford et al. (2002) find that in the design of infrastructures, the projects are underestimated because, in the presence of uncertainty, the management of the real options is not valued.

1.2. Real options valuation for real estate projects

All sectors reviewed above share similar features: high capital requirements, high uncertainty, high

risks (whether planned or unforeseen), long investments over time, etc. The real estate sector possesses them all, so real options are more than justified as it can benefit the project.

In particular, real estate projects face many risks, such as:

- Urban risks, which are very common as urban development of land is not automatic and increasing problems can arise along with the project's duration. These include increasing interest rates on loans for the land, leaving competition free to act accordingly. For example, unexpected planning changes can occur, leading to a suspension of licenses for several years, modifying the land's development potential, or even its requalification.
- A drop in housing demand. Generally, housing demand fluctuations are not abrupt and require time to occur, as economic cycles span several years. However, real estate development takes several years, so that demand may change during its development. A reduction in housing prices would have a similar impact, although changes occur more quickly.
- Costs increase due to inflation in materials, human resources shortage, or an increase in taxes.

These risks require the developer to adopt a more flexible approach to take them into account when it comes to real estate project valuation. That is why many authors have adopted real options to evaluate real estate projects in the literature.

Titman (1985) was the first to conduct studies on real options applied to the real estate world. He observed that on many occasions, the promoters decided to delay urban development construction, so he created a model to calculate the current price of urban land, based on the binomial method. It also considers that the type of building to be constructed could even change during the delay. The main conclusions are that the land's value increased as market uncertainty did, resulting in a decrease in the construction activity in the current period. This conclusion leads to another paradigm: if a central bank initiates a monetary policy to increase con-

struction, the resultant reduction in uncertainty will reduce activity by decreasing real options' value.

Following Titman (1985), Williams (1991) focuses mainly on abandon options, which compares with American put options. He also observes that the value of the option increases with uncertainty.

On the other hand, Capozza and Li (1994) build a model in which they find that the value of a real estate project and its optimal investment moment are dependent on the investment capital. His study clearly shows that if capital can be varied, the project's value is subsequently influenced. They also concluded that the existence of administrative fees before development accelerates the time to begin and decreases the projects' value, but it also reduces the density of the developments.

Quigg (1993) makes a study taking market values of land and focusing mainly on the option to wait. He finds very interesting results; for example, the value of the options to wait can be 6% of the land value.

Grenadier (1995) applies real options to the spaces in a shopping center and creates a model that compares the different destinations of the rentals, such as offices, commercial, industrial, business type and quality, etc. Conclusions obtained suggest that the difference in value between dynamic and static strategies comes from the real options.

González (2003b) builds a model that includes two sources of uncertainty: housing prices and changes in interest rates, keeping volatility constant over time. He observed that the project's value increases with the price of housing and decreases with the interest rate, and that depends on both, so when one parameter changes, the value of the project differs, therefore affecting investment decisions.

Applying a real options model for a car parking building, Neufville et al. (2006) concluded that this method to calculate real options would be used more by developers who do not have extensive mathematical knowledge.

Finally, Rocha et al. (2007) applied real options to a real estate project where they found that the application of this methodology increases the value of the project by 10% and decreases risks by half.

2. METHODOLOGY

The difference between financial options and real options is their underlying asset: while financial options are applied to stocks, exchange rates, or interest rates, real options deal with physical projects instead of financial assets.

Using real options, Net Present Value (*NPV*) can be obtained according to the following formula (Trigeorgis, 1993; Mascareñas, 2007):

$$NPV_{expanded} = NPV_{passive} + PV_{real\ options}, \quad (1)$$

where $NPV_{passive}$ is the traditional Net Present Value of direct cash flows, $PV_{real\ options}$ is a flexible value representing the project's real options. $PV_{real\ options}$ depends on the project's cash flows, which will be the underlying asset; the price to be paid for the project, or strike; the time to expiration; the volatility, and the risk-free interest rate. While there are different methods to calculate its value, binomial trees have been chosen due to their ease of use when applied to any kind of real option.

As it can be seen in Equation (1), the real options approach provides higher value if managerial flexibility is needed to start or modify the project, adapting it to changes in different parameters, such as demand, prices, etc. The appearance and magnitude of these changes are linked to the current uncertainty (Kodukula & Papudesu, 2006). Sometimes, despite having flexibility and uncertainty, the options do not add value to the analysis. This occurs for those projects in which the NPV is either very positive or very negative, and therefore it is unlikely that the developer's decision will be changed despite having the ability to choose.

Two essential aspects have to be considered when calculating the second term of the previous equation: volatility and risks associated with real estate projects discussed in the next subsection.

2.1. Volatility estimation

As explained in subsection 1.2, real estate projects face several risks that have to be modeled by estimating the volatility (that is, the standard deviation of the annual rate of return) of the possible project's final value.

This section introduces several methods to estimate the volatility, taken from Kodukula and Papudesu (2006) and Mascareñas et al. (2003), and can be found further.

The easiest way to calculate it is by using the standard deviation of the logarithms of the cash flows as in Equation (2):

$$\begin{aligned} r_t &= \ln \frac{S_t}{S_{t-1}} \quad \bar{r} = \sum_{t=1}^n \frac{r_t}{n}, \\ \sigma^2 &= \frac{1}{n-1} \cdot \sum_{t=1}^n (r_t - \bar{r})^2, \end{aligned} \quad (2)$$

where S_t – forecast project cash flows at time t (years, months, ...), n – number of cash flows, r_t – natural logarithms of the relative return for each time interval, σ – standard deviation of the natural logarithms of the relative returns or volatility.

Despite its simplicity, several problems may arise when calculating its value, as logarithms cannot be calculated for negative cash flows.

A more sophisticated approach is required to achieve greater accuracy, such as the Monte Carlo method, which allows obtaining the cash flows through the simulation of thousands of scenarios on some of the variables involved in calculating the cash flows, such as sales prices costs, etc.

Another way to estimate volatility is to take a previous similar project as a reference and apply Equation (2) to its cash flows, estimating that the project's volatility under study will be the same as the previous one. Companies with several projects already built can use this method, though it has not been used in this research.

An additional procedure is through market comparison by taking the observed volatility of financial securities that are sensitive to property prices' behavior. Despite its simplicity, this method is not considered good as the previous ones, as stock prices are conditioned by many other factors that do not influence a project's cash flows, so it is usually considered a last resort.

Finally, the developer can apply the estimation method, where three scenarios are evaluated. An optimistic scenario exceeded only 2% of the cases, a pessimistic scenario lower only in 2% of the cases and an intermediate scenario with a 50% probability. For each of the scenarios, the expected payoffs are estimated and assuming a lognormal distribution for payments, and volatility can be calculated using the following formulae:

$$\sigma_1 = \frac{\ln\left(\frac{S_{opt}}{S_{avg}}\right)}{2\sqrt{t}},$$

$$\sigma_2 = \frac{\ln\left(\frac{S_{avg}}{S_{pes}}\right)}{2\sqrt{t}},$$

$$\sigma_3 = \frac{\ln\left(\frac{S_{opt}}{S_{pes}}\right)}{4\sqrt{t}},$$
(3)

where t – project lifetime, S_{opt} – optimistic estimation of expected payoffs in project lifetime, S_{pes} – pessimistic estimation of expected payoffs in project lifetime, S_{avg} – average estimation of expected payoffs in project lifetime.

There is no consensus on which method is the best, and none can be discarded, so one has opted to average the results obtained with the different estimation methods.

2.2. Binomial tree method

The binomial tree method can be found in the literature, such as in Cox et al. (1979). The basis of the method is summarized further.

The inputs required to build the binomial trees and calculate the option value are σ , r , S_o , X , T , and δt , where σ is the volatility, r is the risk-free rate, S_o is the present value of the operating cash flows of the project, X is the cost of exercising the option that it will be different depending

on the type of option, T is the life of the option, and δt is the time step chosen for the calculations.

The up and down movements are represented by u and d factors, which depend on volatility and the time step, being $u = e^{\sigma\sqrt{\delta t}}$ and $d = e^{-\sigma\sqrt{\delta t}}$. From the equations, it can be seen that $u > 1$, $d < 1$, and $u = 1/d$. The first movement across the tree has two nodes, ($S_o \cdot u$, $S_o \cdot d$). The second movement has three nodes, ($S_o \cdot u \cdot u$, $S_o \cdot u \cdot d$, $S_o \cdot d \cdot d$), and so on. The last nodes at the end of the binomial tree represent the range of possible asset values at the end of the options life.

In the last nodes, the option will be exercised if the value of that node is greater than X or the exercise price. There are several possibilities for the values to be put in Tree 2. The general procedure puts the difference between the maximum value and the value of Tree 1.

Another variant is to put the maximum value. Depending on which one you choose, you will proceed differently in the end.

The next step is to go back node by node. For every two nodes that come from the same origin node, the following procedure will be applied. The value obtained in each one of them from exercising the option will be multiplied by the risk-neutral probability p and $(1-p)$, respectively, and its sum will be discounted with the risk-free interest $e^{-r \cdot \delta t}$. To calculate the risk-neutral probability $p = (e^{r \cdot \delta t} - d) / (u - d)$. Following the same process up to the initial node, in the general procedure the value of the real option will be obtained, and in the variant, it will be necessary to subtract from Tree 2, the value of Tree 1.

The great advantage of the binomial tree method is that it can be adapted to each type of option's characteristics.

3. RESULTS

Real options analysis has been applied to an actual real estate project testing different types of options. The obtained results are compared with those of other traditional techniques, such as the Net Present Value (NPV) and the Internal Rate of Return (IRR).

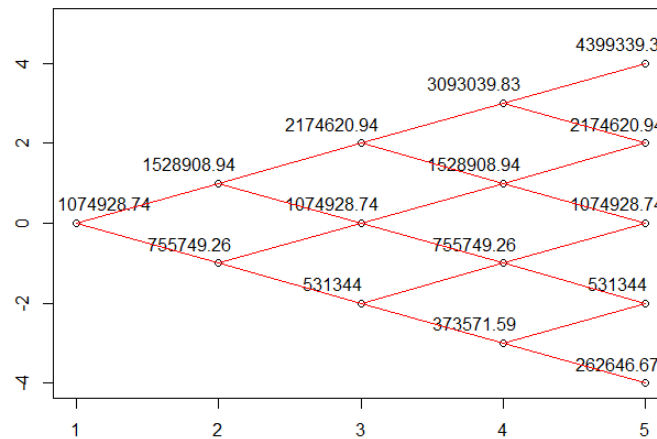


Figure 1. Tree 1 option to expand

The real estate project¹ is located in an undeveloped area in Santo Domingo de la Calzada, a municipality in La Rioja, Spain. The land has a surface of 2,932.41 m², can be built in 5 floors, a buildable area of 5,242.60 m², and a maximum of 48 units. The final configuration is 12, 26, and 10 units, of 2, 3, and 4 bedrooms, respectively, and a living area of 104, 83, and 66 m², respectively, a retail space of 95 m² and 48 parking spaces with collective green.

Net Present Value and Internal Rate of Return values for the project have been estimated using Monte Carlo techniques. Construction costs and housing prices have been modeled using their empirical distributions², which have been used to generate thousands of simulated scenarios, obtaining a Net Present Value of -116,860.51 € with an average IRR of 2.96%.

On the other hand, averaging the different values obtained using the different methods explained above³, a volatility of 35.25% was obtained.

Using these data, several real options valuations have been obtained using the binomial tree method for different types of options. In the literature, such as Kodukula and Papudesu (2006), there are classifications of different types of real options, such as to abandon, wait, expand, contract, choose, etc. Some of them have been adapted to

the particularities of real estate projects and are developed further.

3.1. Option to expand

The option to expand begins if the company can increase the size of the original project. Thus, it is possible to buy a nearby land with half the surface, buildable area, etc. The new land price will be assumed 10% more expensive per square meter than the original land, and the costs and revenues will be proportional to the expansion of the project. A more accurate calculation of income and costs could be made because there are constructive elements that appear only one time regardless of the building's size, such as the access to the parking.

The data used to compute the option to expand is the underlying price $S_0 = 1,074,928.74$ € (which is the average of the original project's operating cash flows), interest rate without risk $r = 2\%$, and volatility $\sigma = 35.25\%$. The cost of exercising the option to expand (cost of new land) will be 55% of the original project, $X = 1,191,789.25 \cdot 0.55 = 655,484.09$ €. The duration of the option will be assumed to be $t = 4$ years, and the incomes of the expanded project will be 150% of the originals.

Tree 1 shows price evolution for the original project (Figure 1).

1 Project details are available upon request.

2 Statistical distributions have been obtained empirically, using data of prices and construction costs from Banco de España (2015) and Ministerio de Fomento (2016).

3 The standard deviation of the cash flows' logarithms generates a value of 0.58. The volatility of the shares of listed companies in the Spanish stock exchange (Merlin Properties Socimi, S.A., LAR España Real Estate Socimi, S.A., Axiare Patrimonio Socimi, S.A., Hispania Activos Inmobiliarios Socimi S.A.) yields an average value of 0.25. The volatility of Merlin Properties Socimi, S.A. warrants produces an average value of 0.31. Finally, the estimation method produces a value of 0.27.

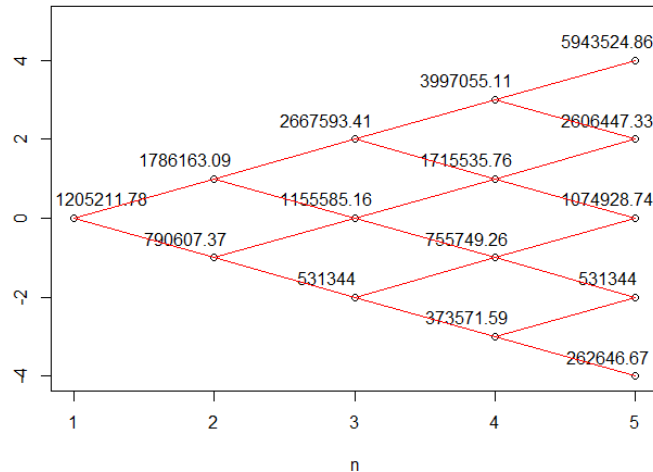


Figure 2. Tree 2 option to expand

As indicated in the methodology, the binomial tree method is very flexible and can be modified to facilitate each option's calculation, which is done in this case using the variant procedure. Tree 2 allows comparing the benefits obtained with the option to expand. It shows in each node the value obtained from choosing the maximum between the value of the original project shown in Tree 1 or the value of the project expanded (150% of Tree 1 in this case) minus the value that must be paid to carry out the expansion (X). Thus, if it is not profitable to expand the project, value Tree 1 is maintained.

From the possible paths of the project, there are two nodes (5,4) and (5,2) that add more value to the project and where the option to expand is profitable since the value of the option is obtained from the subtraction of the number obtained from Tree 1 to Tree 2. As Tree 2 has used the variant procedure exposed in the methodology, to obtain the option's value to expand, it is necessary to subtract the value of the first node of Tree 1 to the node of the Tree 2: $1,205,211.78 - 1,074,928.74 = 130,283.04$ €.

The NPV expanded is obtained with Equation (4):

$$NPV_{expanded} = -116,860.51 + 130,283.04 = 13,422.53. \quad (4)$$

Whose value is already positive but not much greater than zero, since only 2 of the last 5 nodes recommended to expand the project. This is due to the restrictions imposed: benefits growing 50%, while costs are higher than in the initial project.

Considering the project's expansion as a project itself, it is still worse than the initial one without real options.

It could be concluded that the option to expand is good, but that it would be better if it were negotiated the cost of the land. The company must also ensure that it is exclusive since, if competing companies began to build, the option to expand would lose value. In this case, therefore, the project is not considered profitable.

3.2. Option to contract

The option to contract appears when one company owns a divisible project, and another company makes an offer to purchase one of the parts of the project, such as selling half of a land. At that time, the first company can sell a part or not, which adds value to the project as it decreases its risk.

This option has differences from the option to wait. For example, it receives the sale value, which is good for companies that have cash needs but ends the possibility of winning or losing with the part of the project that has been sold.

To contract the project, the new lands have to be geometrically viable. An important point to consider is that the incomes are always reduced more than the expenses since facilities are going to be duplicated in the new situation. Some examples are access to the garage, solar panel tanks, etc. However, if a large project is not viable due to low demand or lack of funding, to contract is very valuable.

Source: Own study.

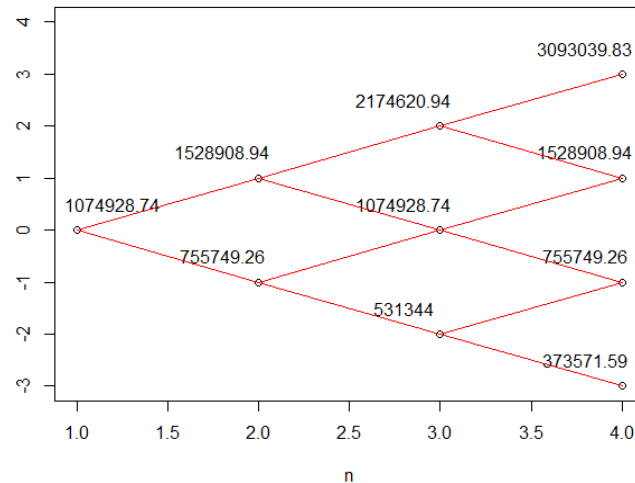


Figure 3. Tree 1 option to contract

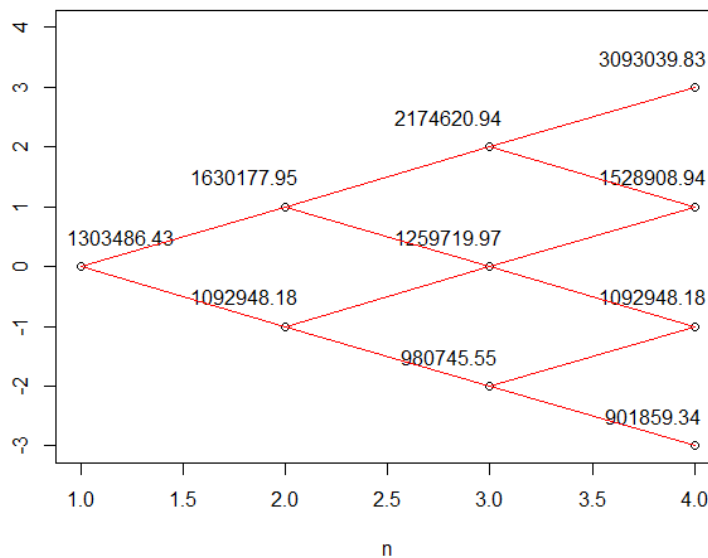
In this case, it will be assumed that it will be contracted half of the project, with a sale price of the land of 60% of the initial price. In case the sale price was lower, other options would be more attractive, such as waiting, since selling off-plan allows the developer to get liquidity, but on the other hand, it will attract competitors, which could make the project fail.

The data used to compute the option to contract where the underlying price $S_0 = 1,074,928.74$ €, the average of the original project's operating cash flows, interest rate without risk $r = 2\%$, and volatility $\sigma = 35.25\%$. The cost of exercising the option (the sale price) will be 60 % of the original project $X = 1,191,789.25 \cdot 0.60 = 715,073.55$ €. The duration of the options will be assumed to be $t = 3$ years,

and the incomes of the contracted project will be 50% of the originals.

Tree 1 shows the price evolution for the original project (Figure 3). As expected, it is identical to Figure 1, but with one column less.

As with the option to expand, the variant procedure has been used to construct Tree 2. Tree 2 allows you to compare the benefits obtained with the option to contract. It shows in each node the value obtained from choosing the maximum between the value of the original project shown in Tree 1 or the value of the project contracted (50% of Tree 1 in this case) plus the value obtained from the partial sale of the project (X). Thus, if it is not profitable to contract the project, the value Tree 1 is maintained.



Source: Own study.

Figure 4. Tree 2 option to contract

Among the possible paths of the project, in the end, there are two nodes (5, -3) and (5, -1) that add more value to the project and where the option to contract is profitable since the value of the option is obtained from the subtraction of the number obtained from Tree 1 to Tree 2. As in the option to expand, the option's value at the beginning is therefore obtained from the following calculation: $1,303,486.43 - 1,074,928.74 = 228,557.69$ €.

The NPV expanded is obtained with Equation (5):

$$NPV_{expanded} = -116,860.51 + 228,557.69 = 111,697.18. \tag{5}$$

The resulting value is already positive. The option to contract the project, in this case, is very valuable because it allows knowing the evolution of the demand and the prices over three years, and besides obtaining liquidity to dedicate it to other necessities. Of course, this does not mean that it is risk-free because the price trend may change once the project has started, but some uncertainties will have been eliminated.

3.3. Option to choose

It is possible to find only one real option in a project, but it is also very common to find several real options acting simultaneously. It is common for a project to have two or more of them. In this research, four options have been found in the project: to abandon, expand, contract, or continue.

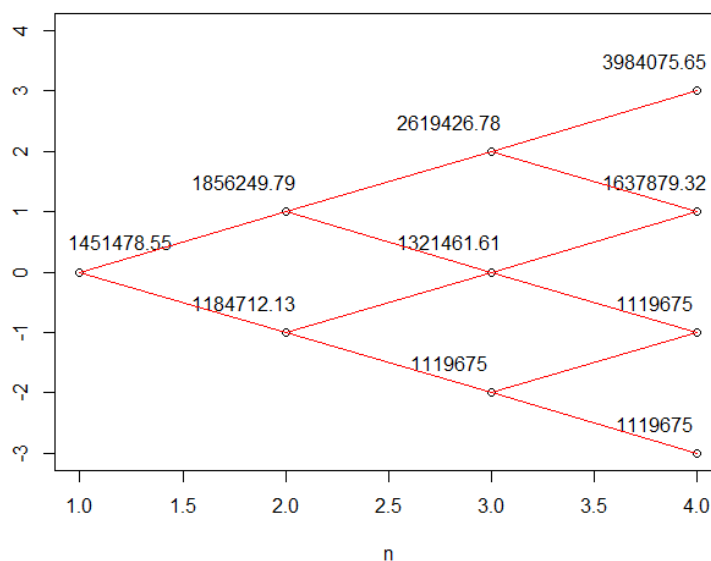
When the project has begun, depending on its evolution, the developer will have to choose the option that brings more value, but until it comes time to choose, all the options provide value to Equation (1). This is why they are grouped under the name of the option to choose.

The data used to compute the option where the underlying price $S_0 = 1,074,928.74$ € was the average of the operating cash flows, interest rate without risk $r = 2\%$, and volatility $\sigma = 35.25\%$. The options in the project were: to continue with the original project; to abandon it by obtaining a rescue value of $X = 1,119,675.00$ €; to expand the project 50% of initial S_0 with a cost of $XE = 655,484.09$ €, or to contract the project 50% of initial S_0 receiving in exchange $XR = 715,073.55$ €. The duration of the options will be assumed as $t = 3$ years.

Tree 1 shows price evolution for the project and is the same in Figure 3. In this case, Tree 2 shows the maximum between the following values: the value of the expanded project minus the cost of expansion XE ; the value of the reduced project plus the value obtained by the XR reduction; the value if the project is abandoned, that is, the rescue value X ; and the initial value of Tree 1.

Tree 2 obtained is shown in Figure 5.

In this case, it was not possible at first glance to check the chosen option in each node: continue, expand, abandon, or contract. For this, it was nec-



Source: Own study.

Figure 5. Tree 2 option to choose

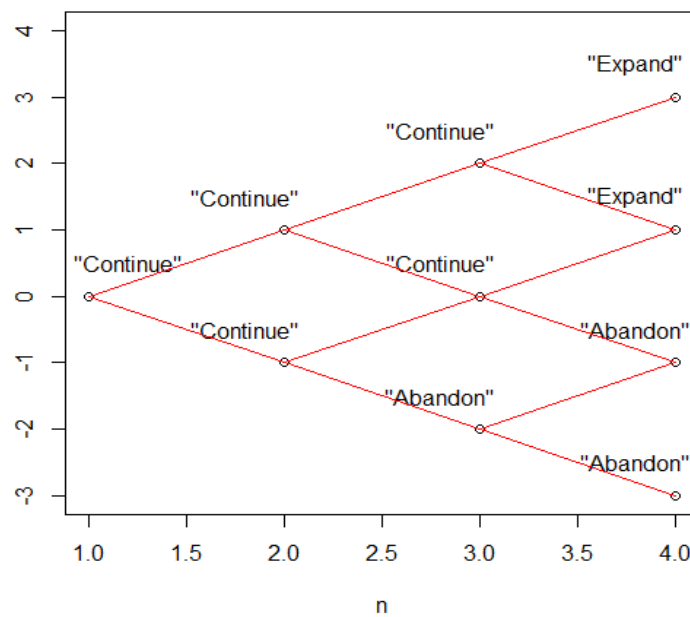


Figure 6. Option to choose. Tree with chosen options in each node

essary to transform Tree 1 with the necessary conditions for the expansion, reduction, and abandonment and compare it with the corresponding value of the values of the decision in Tree 2 and if the value is the same means that at that moment, the corresponding option has been exercised. After completing this analysis, the result with the decision taken in each node can be seen in Figure 6.

The value of the option was obtained by subtracting the value obtained from Tree 1 for Tree 2: $1,451,478.55 - 1,074,928.74 = 376,549.81$ €.

It is also interesting to calculate the value of the project with each option separately. A value of 271,161.90 € was obtained for the option to abandon, 105,389.00 € for expansion, and 228,557.69 € to contract the size of the project. Several conclusions were obtained.

If there are several options in a project, their values are not cumulative because of their interaction. The sum of them individually will always be higher than the combined value.

It is also observed that the option's value is higher for the other options separately. If the project is a success, the developer will choose to expand, but if the project fails, he will choose to abandon, so in the two scenarios, the project adds value.

The NPV expanded is obtained with Equation (6):

$$NPV_{expanded} = -116,860.51 + 376,549.81 = 259,689.30 \tag{6}$$

When the value was already positive and with a value far greater than zero, if you have these three options, or check via the decision tree, only the expansion and abandonment options together would be enough to decide not to discard the project.

3.4. Option to wait with call barrier

Once the investment decision is taken in the real estate business, it is very difficult to go back because it is not easy to re-sell the land. Therefore, sometimes developers prefer to create a security barrier, and although the market would have recommended investing, they prefer to wait to check if the market's evolution is favorable. These options are highly recommended and widely used.

In the analyzed project, a barrier can be raised to start investing only if the profits are at least 400,000.00 €. The parameters to compute are, price of the underlying $S_0 = 1,074,928.74$ €, the exercise price of the option will be the initial investment to be made $X = 1,191,789.25$ €, barrier price will be the value that must be exceeded by the earnings to invest, which therefore will be the new exercising price $XB = X + \text{barrier} = 1,591,789.25$ €, duration

Source: Own study.

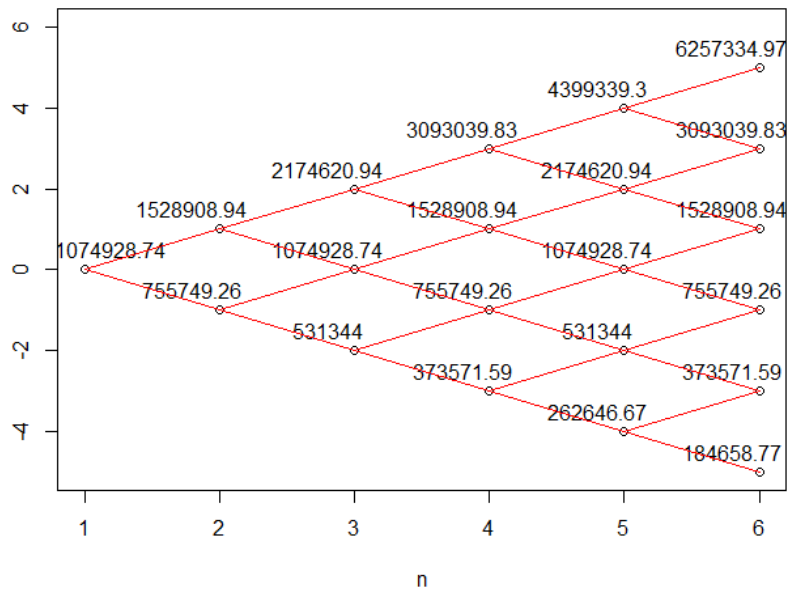


Figure 7. Tree 1 option to wait

$t = 5$ years, interest rate without risk $r = 2\%$, volatility $\sigma = 35.25\%$. Tree 1, with the evolution of the project's prices, is the same with or without barrier, and it is shown in Figure 7.

of Tree 1 must exceed the XB barrier. Furthermore, in this case, the value of Tree 1 has already been subtracted directly, so that the value shown is directly the value of the option to wait, being "0" in the cases in which it does not provide value. This is the general method explained in the methodology.

In this case, Tree 2 shows the value obtained from the maximum between the initial project or the sale value of the project, but with the difference that to make the comparison between those values first, the value

Tree 2 obtained without barrier is shown in Figure 8, and tree 2 with barrier is shown in Figure 9.

Source: Own study.

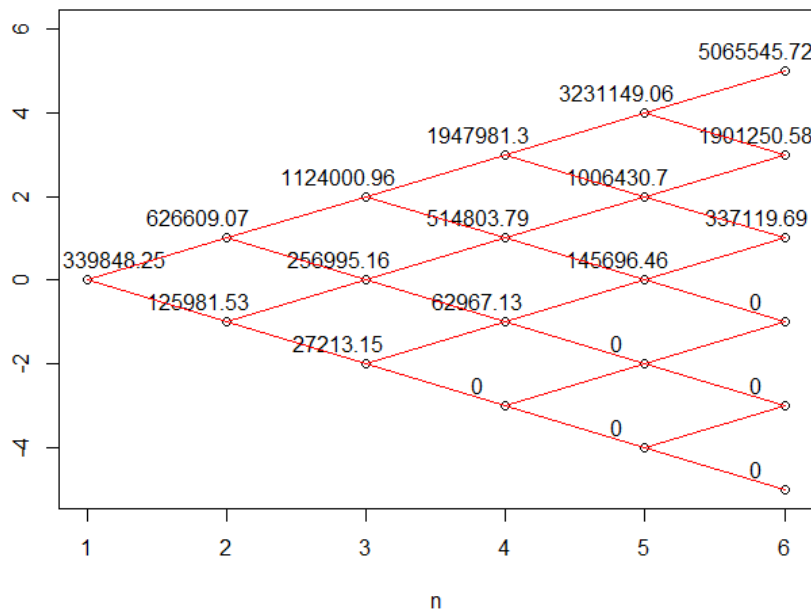


Figure 8. Tree 2 option to wait without barrier

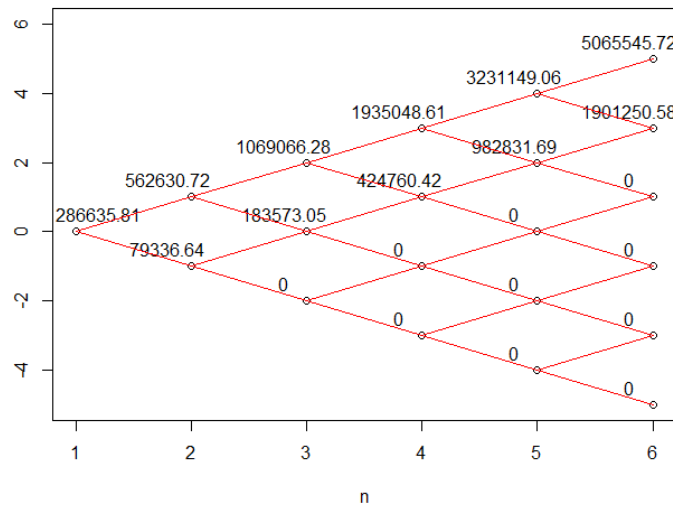


Figure 9. Tree 2 option to wait with barrier

It can be observed that the value of the option to wait with barrier is lower than without barrier. The reason is that imposing more restrictive conditions results in fewer occasions where the project can be built (the appearance can see it of one more zero rows). The value of the project, using the expanded NPV formula (6), would be for the option without barrier:

$$NPV_{expanded} = -116,860.51 + 339,848.25 = 222,987.74. \tag{7}$$

In the case of the option with barrier, the result is:

$$NPV_{expanded} = -116,860.51 + 286,635.81 = 169,775.30. \tag{8}$$

It can be concluded that the option with barrier decreases the value of the project for the option to wait without barrier, but it provides greater security to the developer about a positive result.

CONCLUSION

Despite its complexity, real options valuation of projects in highly competitive sectors, with significant capital and long periods of investment, such as real estate, should be used to value projects more accurately and reliably. Real options analysis has many advantages over Net Present Value method, as it provides the developer with added flexibility in decision-making, which is quite important in volatile economic environments. Moreover, such volatility could be potentially favorable, providing greater value through the possibility of handling it, which in the NPV method was considered a negative influence. The real options method allows a combined study of project valuation obtained by using other techniques such as NPV with the value derived from the possibility of making decisions based on the evolution of the market.

In this article, a straightforward method was shown to incorporate some flexibility in evaluating real estate developments using real options. To incorporate the project's uncertainty, one has estimated the volatility of the price of the project using several methods proposed in the economic literature.

This approach has been applied to evaluate a project in La Rioja (Spain). Most developers statically calculate NPV and IRR, choosing fixed values for the parameters involved in the calculation, such as incomes and costs, but in this case, one has opted for Monte Carlo techniques, as they provide greater flexibility. Using the empirical distributions of construction costs and housing prices, a Net Present Value (NPV) of -116,860.51 € and an average IRR of 2.96% was obtained.

Then, several real options valuations have been obtained using the binomial tree method for different types of options. In particular, options to expand, contract, choose, and wait with call barriers have been analyzed, obtaining the final NPV for the project, which results in positive amounts in all the cases. However, the results vary significantly among the different types of options, because some options bring more value to the project than others, depending on their cost or on the uncertainty they eliminate. That's the case of the option to wait, which removes uncertainty, or the option to choose, which allows picking the best performing scenario.

In contrast with these results, the negative value obtained using the traditional NPV static method would have led the developer to discard the project completely.

In conclusion, the analysis of real options should be considered in any profitability analysis of a real estate project, as it allows correctly assessing its potential, especially in those cases where the static NPV is close to zero. Therefore, the real options approach can help the developer make better-informed decisions and find those real estate investment opportunities that otherwise would not be considered.

AUTHOR CONTRIBUTIONS

Conceptualization: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Data curation: Arturo Romero.

Formal analysis: Alberto Muñoz Cabanes, Arturo Romero.

Investigation: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Methodology: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Project administration: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Resources: Arturo Romero.

Software: Alberto Muñoz Cabanes, Arturo Romero.

Supervision: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña.

Validation: Alberto Muñoz Cabanes, Arturo Romero.

Visualization: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Writing – original draft: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

Writing – review & editing: Alberto Muñoz Cabanes, Alfonso Herrero de Egaña, Arturo Romero.

REFERENCES

- Alonso, S., Azofra, V., & de la Fuente, G. (2009). Las opciones reales en el sector eléctrico. El caso de la expansión de Endesa en Latinoamérica. *Cuadernos de Economía y Dirección de la Empresa*, 12(38), 65-94. [https://doi.org/10.1016/S1138-5758\(09\)70030-1](https://doi.org/10.1016/S1138-5758(09)70030-1)
- Balibrea, J. (2011). *Desarrollo de una metodología basada en la teoría de opciones reales para la valoración de proyectos de inversión en energías renovables* (Tesis doctoral). E.T.S. de Ingenieros de Caminos, Canales y Puertos. Universidad Politécnica de Madrid. Retrieved from <https://www.semanticscholar.org/paper/Desarrollo-de-una-metodolog%C3%ADa-basada-en-la-teor%C3%ADa-Iniesta/19996c51b00b1037efc161de2f92ef7b9a5a999>
- Banco de España. (2015). *Boletín Estadístico del Banco de España*. Retrieved from <http://www.bde.es/webbde/es/estadis/infoest/bolest.html>
- Capozza, D., & Li, Y. (1994). The Intensity and Timing of Investment: The Case of Land. *The American Economic Review*, 84(4), 889. Retrieved from https://econpapers.repec.org/article/aeaarec/v_3a84_3ay_3a1994_3ai_3a4_3ap_3a889-904.htm
- Cox, J. C., Ross, S. A., & Rubinstein, M. (1979). Option pricing: A simplified approach. *Journal of Financial Economics*, 7(3), 229-263. [https://doi.org/10.1016/0304-405X\(79\)90015-1](https://doi.org/10.1016/0304-405X(79)90015-1)
- Ford, D. N., Lander, D. M., & Voyer, J. J. (2002). A real options approach to valuing strategic flexibility in uncertain construction projects. *Construction Management and Economics*, 20(4), 343-351. <https://doi.org/10.1080/01446190210125572>
- García, E. P. A. (2017). Aplicación de opciones reales en la valoración financiera de un campo petrolero. *ODEON*, 12, 7-54. Retrieved from https://www.researchgate.net/publication/320965329_Aplicacion_de_opciones_reales_en_la

- [valoracion_financiera_de_un_campo_petrolero](#)
8. González, E. (2003a). Valoración de empresas de internet mediante opciones reales. In *Anales de economía aplicada. XVII Asepelt*. Asociación Española de Economía Aplicada, ASEPELT.
 9. González, E. (2003b). Valoración de un proyecto de edificación mediante opciones reales. In *Anales de economía aplicada. XVII Asepelt*. Asociación Española de Economía Aplicada, ASEPELT.
 10. Grenadier, S. R. (1995). Flexibility and tenant mix in real estate projects. *Journal of Urban Economics*, 38(3), 357-378. <https://doi.org/10.1006/juec.1995.1038>
 11. Kodukula, P., & Papudesu, C. (2006). *Project valuation using real options: a practitioner's guide*. J. Ross Publishing. Retrieved from <https://www.amazon.com/Project-Valuation-Using-Real-Options/dp/1932159436>
 12. Leporati, M. (2013). Valoración de proyectos Retrieved from de tiendas de conveniencia en nuevos mercados a través de opciones. *Análisis financiero*, 123, 6-30.
 13. Mascareñas, J. (2007). *Opciones reales en la valoración de proyectos de inversión* (Monografías de Juan Mascareñas Sobre Finanzas Corporativas). Universidad Complutense de Madrid.
 14. Mascareñas, J. M., Lamothe, P., López, F. J., & de Luna, W. (2003). *Opciones reales y valoración de activos cómo medir la flexibilidad operativa en la empresa*. Madrid: Pearson Educación.
 15. Ministerio de Fomento. (2016). *Boletín estadístico y estadísticas del Ministerio de Fomento*. Retrieved from <http://www.fomento.gob.es>
 16. Neufville, R. de, Scholtes, S., & Wang, T. (2006). Opciones reales en Hoja de Cálculo: Caso de un edificio de aparcamiento. Traducido por Escudero, Laura de Valuing Options by Spreadsheet: Parking Garage Case Example. *Journal of Infrastructure Systems*, 12(2), 107-111.
 17. Pardo, L., Rodríguez, J. J., & Rodríguez, M. (2004). Opciones reales en la valoración de proyectos de inversión en acuicultura. In *Anales de Economía Aplicada. XVIII Asepelt*.
 18. Quigg, L. (1993). Empirical testing of real option-pricing models. *The Journal of Finance*, 48(2), 621-640. Retrieved from <https://www.jstor.org/stable/2328915?seq=1>
 19. Rocha, K., Salles, L., Alcaraz, F., Sardinha, J. A., & Teixeira, J. P. (2007). Real estate and real options. A case study. *Emerging Markets Review*, 8(1), 67-79. <https://doi.org/10.1016/j.ememar.2006.09.008>
 20. Schwartz, E. S., & Moon, M. (2000). Rational pricing of internet companies. *Financial Analysts Journal*, 56(3), 62-75. Retrieved from <https://www.jstor.org/stable/4480248?seq=1>
 21. Schwartz, E. S., & Moon, M. (2001). Rational pricing of internet companies revisited. *Financial Review*, 36(4), 7-26. <https://doi.org/10.1111/j.1540-6288.2001.tb00027.x>
 22. Titman, S. (1985). Urban Land Prices Under Uncertainty. *The American Economic Review*, 75(3), 505-514. Retrieved from <https://www.jstor.org/stable/1814815?seq=1>
 23. Trigeorgis, L. (1993). The nature of option interactions and the valuation of investments with multiple real options. *The Journal of Financial and Quantitative Analysis*, 28(1), 1-20. Retrieved from <https://www.jstor.org/stable/2331148?seq=1>
 24. Williams, J. T. (1991). Real estate development as an option. *Journal of Real Estate Finance and Economics*, 4(2), 191-208. Retrieved from <https://link.springer.com/article/10.1007/BF00173124>