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Real Estate Development, Highest and Best Use and Real Options

The primary aim of this work is to connect the *Real Options Theory* (ROT) with the real estate investment framework. A great deal of theoretical work exist today; it begun with Merton (1973) and Black & Sholes (1973) and provided new insights into capital budgeting decision-making and new models, used today by corporate managers and practitioners too. Unfortunately, the ROT is not widely used by appraisers respect to the traditional DCF model, even though the developers behaviour gives evidence to the model. It is important to remember that the real estate investments are characterized by irreversible decision and by various sources of risk and uncertainty about future returns, especially when the development process is very long. The flexibility in the real estate investment is related to the alternative uses embedded in the land – traditionally interpreted through the Highest and Best Use approach – and to the characteristics of the building. In fact, the value of vacant land should reflect not only the value based on best immediate use, but also its *option value*, if the development is delayed and the land is converted into best alternative use in the future. This is also true for the redeveloped urban lands. In brief, this work shows the limits of the traditional analysis (Discounted Cash Flow Model) to capture flexibility in the real estate investment and presents an application – an industrial urban area – implemented by the real option approach within a backward risk-neutral valuation process.

Key words: *real option theory (ROT), real estate development, uncertainty, Discounted Cash Flow Model, Monte Carlo simulation*

Introduction

Building real options into an investment opportunity may be preferable if the present value of the cost of making changes at a later date is greater than the additional cost of including flexibility into the investment opportunity at the outset. This sentence summarizes the problem of the valuation of possible uses of an undeveloped land or potential transformation of an existing building. But the use that maximizes an investment property value may be associated to the higher risks and the decision is, in any case, irreversible. If property investment is a typical case of irreversible investment (Sing & Patel, 2001), due to its characteristics, such as the specificity and fixity of the physical building structure, rather than the institutional and legal constraints, the timing of investment will be a critical decision of the optimization process. The "to start or not to start" solution – given by the traditional Discounted Cash Flow (DCF) model – may not be the best for irreversible investment. In fact, a simultaneous investment corresponds to a static decision-making process, but a real estate development is not usually characterized by a single phase; it is more probably marked by a series of sequential decisions, everyone with differentiated level of risk.

The Real Option Theory (ROT) can help to include flexibility in this framework and take into account the risk (Bravi, 2003). While the initial application area was financial markets, over the past years many different topics were been included – to defer, to abandon, to switch inputs-outputs of risky assets, to alter operat-

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ing scale, to growth options, to stage the investment, *etc.* – so much that today a huge literature exists (Schwartz & Trigeorgis, 2001; Guthrie, 2009). The extension to the real estate market was initially accomplished with the contributions of Titman (1985), Capozza & Sick, (1991) and further developed until today (Bulan *et al.*, 2009; Hui & Fung, 2009).

Unfortunately, the ROT is not widely used by appraisers respect with the traditional DCF model, even though the developers behaviour gives evidence to the model. As that any decision-making framework can only improve the understanding of the problem and help to make a more informed and consistent decision, we believe that the options-based model is not well known and tested into real estate appraisal practice. Therefore, this work shows the link between the HBU[1] approach and the ROT and highlights the limits of the traditional analysis to capture flexibility in the real estate investment. In this regards, an application to an industrial urban area is presented and implemented by the real option approach within a backward risk-neutral valuation process.

The paper is organized as follows. Section 1 introduces by the existent literature the topic of real estate development and its decision-making framework as an option, while the link between HBU and ROT is relaxed in Section 2. Section 3 illustrates the binomial method, widely employed to consider options in the real world. The case-study, implemented by the ROT, is presented and discussed in Section 4. A concluding remarks are summarized in the last section.

1. Real estate development as an option

An extensive literature, beginning with Titman (1985), has grown around the uncertainty issue and its impact on development decision and urban land values. The fundamental topic is that *uncertainty creates an incentive to defer the investment until the development property value exceeds the construction cost*. Williams (1991) confirmed Titman's results and expanded the investigation focus by considering the effects on the project value as an option to quit the property development. He interpreted the option to abandon as an American put without dividends and uses an analytic model to solve the problem. Quigg (1993) empirically tested the option pricing model on real assets with a large sample of land markets and she concluded that the price cannot be observable and the land option premium increases with uncertainty. Childs *et al.* (1996) focus on a redevelopment option. They use a numeric model to examine the effect of sequential investment on property value by evaluating a sequence of American call options without dividends. In the presence of relatively low costs, flexibility respect with mixed uses contributes significantly to the property value or undeveloped land. In a later model Williams (1997) analy-

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1 In Italian real estate literature we identify a specific economical value aspect of a real estate good, called *transformation value;* it represents the appraisal approach related to the property investment decision making process.

ses the redevelopment option and he confirms the results of the preceding study and adds a comparison between single and sequential redevelopment options. This second opportunity seems of higher value than the single use. Riddiough (1997) examined incentive and valuation effects of debt financing on land investment. Implicit in the existing literature is that real estate investment is 90-100% equity financed. In this case the developers hold both a *start option* and a *default option* for more efficient investments. More specifically: the development option becomes valuable as built property value increases, whereas the default option is preferred as value decreases. Kawaguchi and Tsubokawa (2001) employ a discrete time approach, where the price process of the underlying asset and its options are not specified in advance and does not follow a geometric Brownian motion, but allows stochastic processes to have serial correlation in time series of returns.

In general, a real option is a right – but not an obligation – to take an action on an underlying nonfinancial asset, referred as a real asset. Therefore, from a real option view, property development can be interpreted as the action of choice between a variety of miscellaneous decisions that an investor can choose from. Options can be distinguished in terms of flexibility and growth options: flexibility options comprise operative options which cope with an investment itself. One group of flexibility options are Reduction Options. These include the Option to Abandon, the Option to Shut Down, and the Option to Contract.

Different sets of uncertainty affect different stages of the real estate development relating to the state-variable: administrative permission, interest rate, construction cost, property price, rent level. At the stage of feasibility analysis the uncertainty level is highest, whereas, during the construction, it concerns the financing cost and the marginal profit derived from the difference between costs and prices. At the end of the process the uncertainty – from the investor point of view, single or institutional – is related to the volatility of rents, taxes and operating expenses. The real options set concerns, at the last stage, the selection of tenant mix or the reversion decision, if the property market environment becomes good.

2. Highest and Best Use and Real Options Theory (ROT)

The real estate appraisal theory holds that, when the value of the vacant land exceeds the value of the improved property, the Highest and Best Use (HBU) becomes the use of the land as though vacant. In effect, HBU may be defined *as the reasonably probable and legal use of vacant land or an improved property, which is physically possible, appropriately supported, financially feasible and that results in the highest value*. It is possible to remember with Ratcliff (1949) that, while the use is variable and flexible – except for the legal constraints –, the location is fixed, as well as essential, to determine the value. In this direction, the HBU is an important, competitive factor of the investment decision-making process. But the HBU of a specific parcel of land is not determined through subjective analysis by the property owner – the developer – or the appraiser; it is, rather, shaped by the competitive forces within the market where the property is located.

In effect, the value of a vacant land is a function of the present value of the property and the construction costs necessary for the improvement. The present value of a property depends, in turn, from:

- the future income of renting properties or the reversion value of sales-destination projects related to the demand for a special use;
- the market growth rate;
- the expected return, depending, in turn, on the performance of interest rates.

But in different configurations of supply and demand, the effect of the uncertainty is not always clear, i.e. the possibility that the changes become important, influencing incomes, prices or interest rates. In such a complex scenario, the developer does not need to start building at the time of land purchase, especially if, at the moment, the trend of the real estate market is not favorable. If an upswing in the housing market makes the investment more affordable, he will undertake the project at a later time. On the other hand, the wait could not pay, with a decline in the housing market; in this case, the project should not be made.

The traditional approaches consider only the alternatives and legally feasible uses at the actual time, but they do not include uncertainty as a possible, future, change of the initial criteria, as, for example, an use shift, as a result of a negotiation between public and private sectors. Within the legally supported, the use that maximizes the value represents the highest and best, so that the DCF model – with its rules and its criteria – appears to be the more consistent. But real estate investments have different levels of risk in different functional segments and, consequently, distinctive risk premiums; for example, the greatest risk differential is obtained by comparing the development of income-producing *vs.* sales-destination properties. The strong difference in the risk level of these types of investments is due to so-called *operating leverage* (Geltner *et al.*, 2007). This last arises from the lower volatility of construction costs, in relation to the dynamic of the sales market, especially in the medium term.

To determine the financial feasibility of potential income-producing uses, the appraiser estimates the future gross income that can be expected from each. Vacancy and collection losses and operating expenses are subtracted from each gross income to obtain the likely NOI (*Net Operating Income*) from each use. A rate of return on the investment capital is also calculated for different uses. Side by side, to determine the financial feasibility of a sales-destination properties, the appraiser compares the sales revenues against the involved costs for each use. If the revenues exceed the cost and the NPV (*Net Present Value*) is positive, the use is feasible. Usually, the latter is more risky than the first situation, as previously mentioned.

As it is well known, risk analysis is certainly a critical step in the feasibility analysis because it shows the risk-return relationship, the expected return and volatility of cash flows and, therefore, the likelihood that they are superior or lower than expected; however, it does not include the examination of possible strategic alternatives in the project management; in other hands, what could be undertaken if certain conditions occur (Mun, 2007). Moreover, real estate projects cannot be evaluated using risk-adjusted rates of return, because it is difficult, if not impossible, to know the specific expected return from *that* project, always characterized by *uniqueness.*

3. The *Binomial Lattice* model

The relationship between risk and return is, in effect, a fundamental topic of the real estate investments for two reasons:

- if the relationship is strong, the investor knows that, at high rates of return, will correspond, in all probability, high levels of risk;
- if the relationship is weak, the investor knows that, in some cases, he will achieve high rates of return compared with less risk.

Thus, the strength of this relationship, tells the investor about the degree of market efficiency. In capitalistic economies, some investors prefer to undertake safe investments, while others prefer riskier ones. A risk taker developer, however, would like to achieve a higher expected return but, if the performance of the alternatives is the same, in any case, would like to undertake the more secure. This is the general rule, but the investor is faced with uncertainty and, consequently, has, at least, the possibility to postpone or to abandon the decision. In this context, the ROT is an ideal instrument to capture this flexibility. When there is a little uncertainty and not much room for managerial flexibility, the real options approach[2] offers little value. But how much this flexibility does it cost?

The simulation method for solving real options problems is similar to the *Monte Carlo* technique for DCF model. It involves simulations of thousands of paths the underlying asset value can take during the time span of the project, given the boundaries of the cone of uncertainty. More specifically, considering an investment over several years, the *random walk* type model shows us that volatility increases with the square root of time; thus, the two-year volatility is equal to $2^{1/2}$ times the annual, while, for ten years, it is $10^{1/2}$ times the annual and so on. It is obvious that it is much easier to predict a market condition in the short term, than

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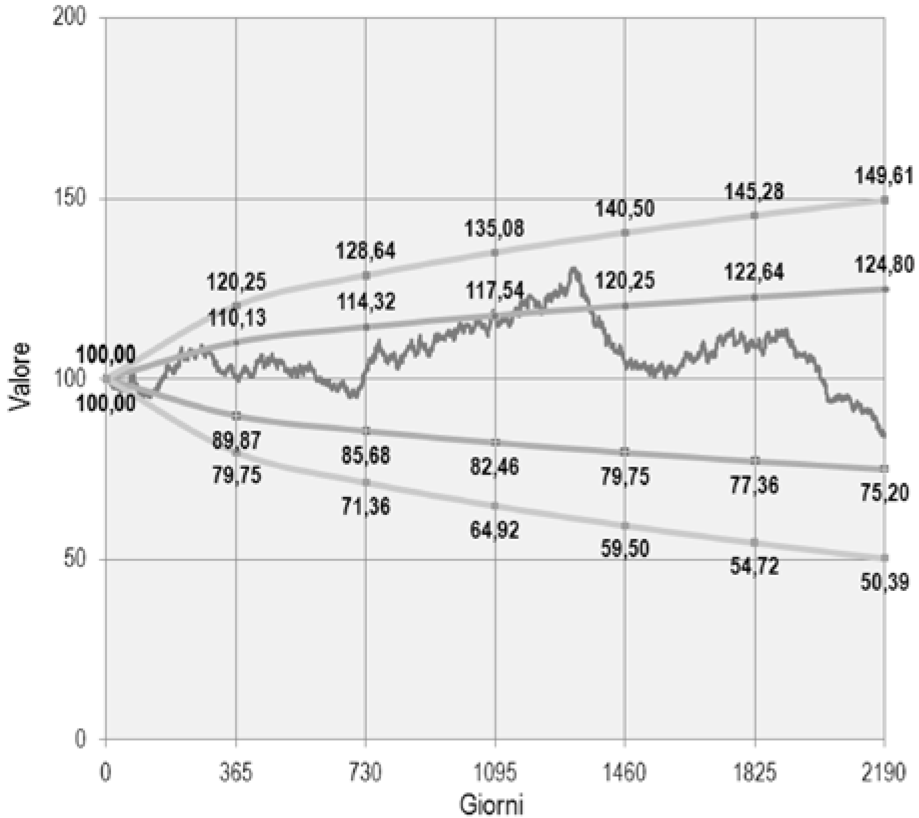
[2] Options can be grouped into two basic categories: simple and compound. An example of a simple option is a deferral option, where there is the right to delay the project. This option exists on every single project. Option to expand is another common example, where there is the right to expand the project through additional future investments. Both of these are American call options, where they can be exercised at any date before the expiration. Option to contract involves, instead, the right to scale back the project by selling some of the assets when market conditions are not favorable. Option to abandon exists in any project and gives the right to sell off the assets. Options to contract and abandon are American put options, where there is the possibility to exercise before the expiration time. Finally, a switching option is the right to switch between two operating modes: an example in the real estate market could be represented by renting or sales. The second category groups the options that depend on the value of another, rather than the underlying asset value. Compound options are common in many multiphase project, as real estate development process.

in the long-term, though volatility remains the same. In Figure 1 is detailed the invariance of volatility (10.13%), the width of the cone of uncertainty – with a 95% confidence interval – increasing over time.

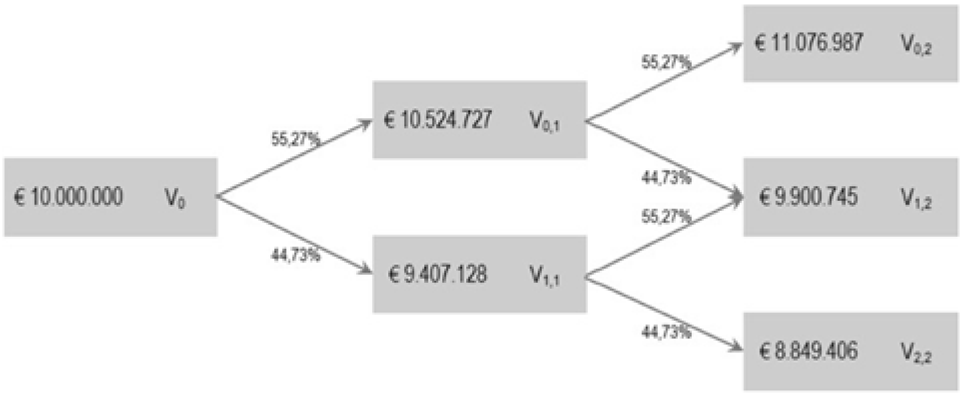
Figure 1. Cone of uncertainty and random walk with $\mu = 0$ and σ =10%.



However, a random walk so conceived does not help because it is a continuous random simulation process when what is needed is that the cone of uncertainty has to be defined by a grid of discrete values, uniquely determined even internally, as a function of volatility and growth rate for single-periods. In 1979, the three economists Cox, Ross and Rubinstein worked out a *Binomial Lattice* model, which is nothing that a process of discrete event simulation of the cone of uncertainty, defined by two parameters: volatility and growth rate. When the length of periods tends to zero, or the number tends to infinity, the *Lattice* model tends to the random walk.

Lattices look like decision trees analysis and, basically, lay out, in the form of a branching tree, the evolution of possible values of the underlying asset during the time span of the project. An optimal solution to the entire problem is obtained by optimizing the future decision al various temporal points and folding them back in a backward recursive fashion into the current decision (Kodukula & Papudesu, 2006). The most commonly used *Lattice* model are the binomial trees[3]. The *Binomial Lattice* can be represented by a tree as shown in Figure 2.

Figure 2. Example of Binomial Lattice for two months.



In the first increment, the value either goes up or down and from there continues to go either up or down in the following time increment. The up and down movements are represented by u and d factors, where $u > 1$ and $d < 1$ and is assumed that $u = 1/d$. The magnitude of these factors depends on the volatility of the underlying asset. The first time step of the tree has two nodes, showing the possible asset value ($V_{0,1}$ and $V_{1,1}$) at the end of that time span. The second time step results in three nodes and asset values ($V_{0,2}$, $V_{1,2}$ and $V_{2,2}$). The Binomial Lattice can be solved to calculate option values using basically two approaches: the risk neutral probability and the market-replicating portfolios. The first is that applied in the following pages.

4. An empirical application

The case presented concerns a parcel of improved land of 150.000 sq. m. for industrial use – sub L1 "areas for large and medium industries" – located in the quadrant east of Rome, next to the exit n° 15 "*La Rustica*" of the "*Grande Raccordo Anulare*" or GRA (Figure 1). The land is limited, at north, by "*Osvaldo Licini*"

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[3] Trinomial and quadrinomial lattice also can be used to solve real option problems. They are fairly similar in concept to binomials but are more computationally complex.

road, at south by "*Collatina*" road and, at west, by the GRA, where it is connected through the business center.

Figure 3. Development project area.

Source: Company own the area.

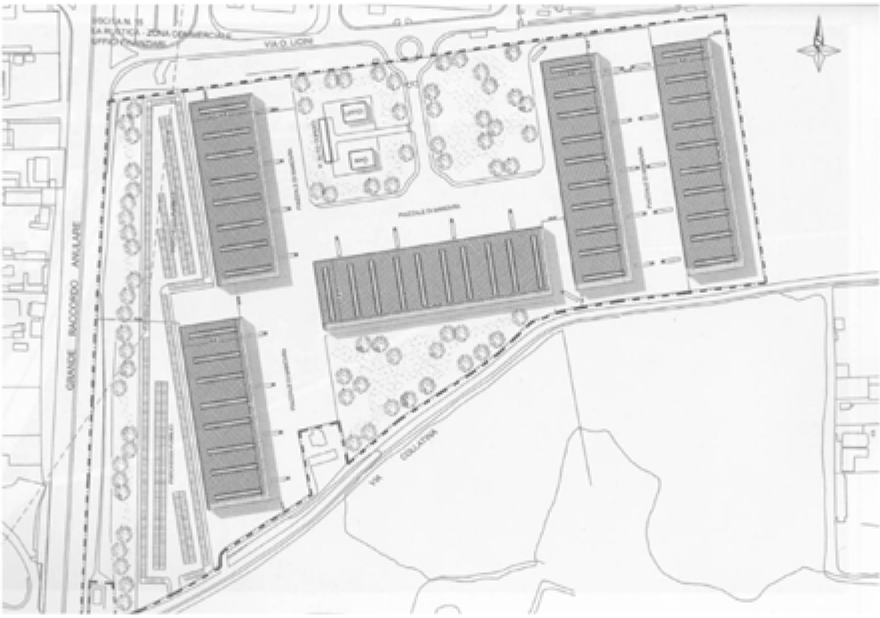
The area is characterized by a marked presence of non-residential uses, such as the Service Centre of the Ministry of Finance, the "*Metro*" wholesales, hotels and public or private offices.

The real estate development project (Figure 4), being valued in 2008 as part of the institutional activity, but still not yet implemented, contemplates the creation of a complex set of five industrial buildings – internal net height equal to ml. 9,50, for a total space of 50.000 sq. m. –, two office and warehouse buildings, each of 300 sq. m., and a public parking area, private car parks, driveways, loading and unloading wares docks, power plants, walkways and green areas with trees. The structure of the main buildings involves the use of precast reinforced concrete and prestressed normal REI 120; the external cladding panels are cm. 20 of thickness and reinforced concrete REI 120; the insulated roof slab is of usable type, without direct access inside the building. The subdivision for each module of 2.000 sq. m. is realized – for compliance with fire regulations – with cladding panels of precast concrete cm. 20 of thickness with ceiling tops for a minimum of ml. 1. For each compartment are provided the following furnitures and services:

- Metallic interlocking-Light-Rapid-Lock shelving, with walkways ml. 1,20 of width, allocated over three floors of ml. 3.00 of height to each, connected by twel-

ve stairs and two lifts, all with lighting and electrical equipments, with shelves of surface of ml. 2,00 x 1.00 and 240 kg. of flow rate;
- Air-conditioning, heating, anti-intrusion, telephone, sanitation, automatic sprinkler systems installed in the shelves, complete with pumping station and water storage tank;
- Fire detection system with a vacuum system consisted of VESDA laser scanner machine, analogical central MX with addressed intelligent detection, optical and acoustic alarm panels fire.

Figure 4. Plan of the project.



Source: Company own the area.

Purpose of this application is the identification of the project starting point in different years, in a period included between 2003 and 2009, where the economic scenario was gradually changing, until the recent crisis in the housing market. Given the time needed for construction, the goal is the observation, year-by-year, of the option value shifting and the presence of an option premium.

To do this, in the binomial model, the expected return data, deduced from the market, are employed, with the assumption, *ceteris paribus*, that these parameters remain constant during the construction phase. So, for example, the option value in 2003 is determined by considering the expected parameters as constants for two years from the starting point, by virtue of the existence of an option period of one year, starting on January 2003 or December 2003.

The input data are the following:

- the project time span, to complete the five buildings, is two years;
- the maturity of the option is one year;
- the costs of construction of the building – industrial plant, warehouse and offices – are elicited by the "DEI" prices list considering the "E7" type – "*Industrial complex, including industrial warehouse, office building, concierge and external arrangements*" – by deducting, from the costs, the provision not expected or those consisting of more sophisticated plant, by obtaining the following costs:
  - industrial building cost: € 600 / sq. m.;
  - office building cost: € 700 / sq. m.;
  - warehouse cost: € 700 / sq. m. x 0.50 = € 350.00 / sq. m.;
  - outside arrangement cost: € 50 / sq. m.;
  - the shelving cost is a lump sum of € 500.000 /module, inclusive of delivery of twelve stairs connecting the floors and two lifts;
  - the cost of the automatic shutdown of the power plant and fire detection system is € 300.000 /module;
  - the construction concession fees are € 4.500.000;
  - the technical expenses are estimated, as usual, at 8% of the cost of construction;
  - the company general expenses is € 75.000 / *per* year;
  - the marketing costs are the 2% of the sale price.

All for a total construction cost of € 68.000.000 approximately, with reference to the year 2008 (Table 1).

The selling prices of the five sheds is estimated with reference to the prices range, published by the Real Estate Market Observatory of the Italian Land Registry for the "*Industrial buildings*" type, under normal conditions of maintenance and preservation, in the municipality of *Monterotondo* and *Monterotondo-Scalo*, an area characterized by a marked presence of this type of buildings, in the period 2003-2009 (Figure 5).

Considering that, in this case, the structures are characterized by high levels of plant equipment, complete with metal shelves, in excellent condition – while the REMO quotations are referred to ordinary buildings, in normal condition – and considering the quality of outdoor spaces, the location near the GRA, certainly more attractive than Monterotondo Scalo, more peripheral, the selling price forecasting is € 1.700 / sq. m., with reference to the year 2008. The price of the whole complex is, of course, equal to:

10.000 sq. m. x € 1.700 x 5 sheds = € 85.000.000

Data on effective return rates achieved by the industrial use are taken from the annual reports prepared by the Investment Property Databank (IPD), which performs processing on the basis of operating results of individual properties that are part of complete portfolios, directly collected from individual investors. More specifically, we found Total Return, Income Return and Capital Growth *per annum* of the actual Italian industrial sector, mainly composed of real estate located in Rome and Milan, achieved between 2003-2009. The returns for the risk free rate

Table 1. Total Costs Budgeting.

	Quantity	Amount (Euro)	Current Costs/Revenues (Euro)	
			Euro	%
Technical Expenses	10%	56.513.000		
Concession Fees			5.631.000	8,28
			4.500.000	6,61
Total			10.131.500	14,89
Industrial Buildings	50.000	600,00	30.000.000	44,09
Offices	300	700,00	210.000	0,31
Wharehouses	300	350,00	105.000	0,15
Fire-detection System	50.000	150,00	7.500.000	11,02
Metallic Shelves	25	500.000	12.500.000	18,37
Outside Arrangements	120.000	50,00	6.000.000	8,82
Total			53.315.000	82,76
General Expenses	2	75.000	150.000	0,22
Marketing Costs	2%	72.358.900	1.447.178	2,13
Total			1.597.178	2,35
Total Costs			68.043.678	100

Source: our elaboration.

and the growth of the construction costs are, however, detected, respectively, by the Bank of Italy and ISTAT (“*Istituto Nazionale di Statistica*”), as shown in Table 2.

In the binomial model the expected returns are implemented by assuming – year-by-year for the construction time span the following criteria:

- the expected return of the new building is equal to the total return;
- the expected return of the rent properties is equal to the income return;
- the expected growth rate of the real estate value is equal to the capital growth;
- the risk-free rate for 3 years is equal to the BTP (“*Buoni del Tesoro Poliennali*”) actual return;
- the expected growth rate for the construction costs is equal to its effective real growth rate.

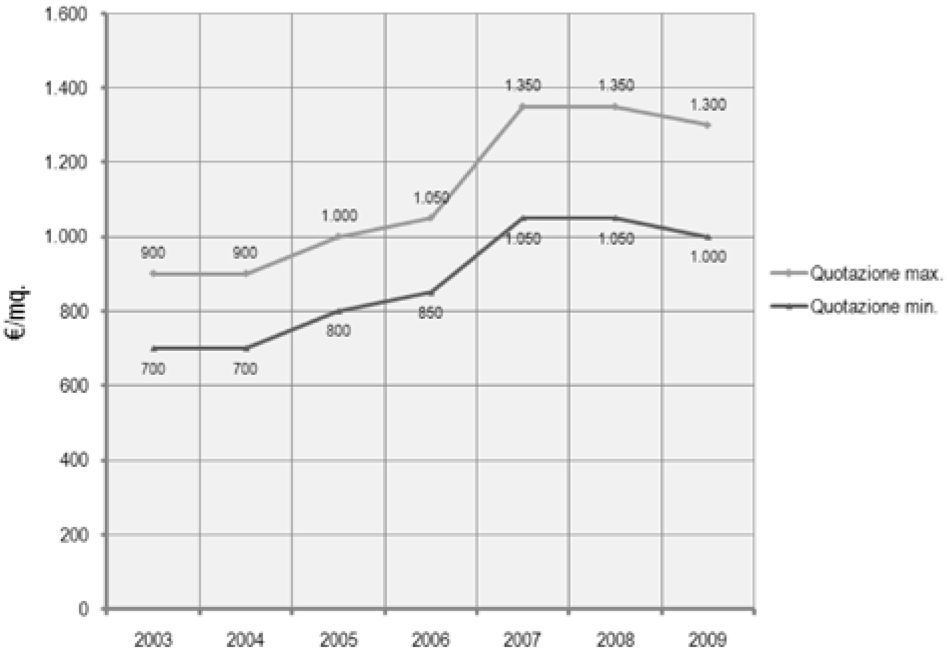
It should be noted that the annual returns volatility of the real estate – in the case of valuation of the development of a single property – includes the specific risk associated with the uncertainty of the cash flows; it is, therefore, greater than the volatility measured by market indexes or by a properties portfolio. Specifically, the following expected annual volatility is considered:

2003-2006: 10%; 2007: 15%; 2008-2009: 20%

The performed valuation results are summarized below. It may be noted that:

- the option value is equal to € 8.393.000, on average, and – between 2003 and 2009 – is included within a range of € 8.000.000 and € 10.000.000;
- the minimum values occur in 2004 and 2005, due to the highest levels of income return (7.50% for 2004 and 7.10% for 2005) and to the growth of the construction

Figure 5. Prices trend between 2003-2009, for "Industrial buildings" in *Monterotondo.*



Source: REMO - Italian Land Registry

Table 2. Option Value and Option Premium between 2003-2009 (Euro).

	2003	2004	2005	2006	2007	2008	2009
Revenues	76.641.991	77.944.681	79.113.851	82.753.088	84.325.397	85.000.000	82.110.000
Costs	57.144.168	59.761.371	61.906.804	63.429.712	65.713.181	68.000.000	70.162.400
Option Value	8.806.579	5.186.135	5.490.213	9.763.101	8.419.883	13.082.326	8.004.265
Volatility	10%	10%	10%	10%	15%	20%	20%
Action	Exer	Exer	Exer	Exer	Exer	Hold	Hold
Time	0	0	0	0	0	2	3
Option Premium	0	0	0	0	0	469.588	1.961.580

Source: Our elaboration

costs (4.58% for the 2004 and 3.59% for 2005). These parameters are inversely proportional to the option value, which decreases also because of the construction time span, during which it is obviously not possible to perceive a net operating income; for these reasons would be unwise to undertake this project during the observed time;

- the sharp downturn of the income return (-3.80%) determines, in 2008, the rise in the option value to more than € 13,000,000, which is still very high compared with other economic data (+55 % compared to 2007). It should be noted that 3.6% of that value is the premium option that comes from the ability to wait two months before the starting point, provided that, at that time, the market value registers two positive increments;
- the downward trend (-0.40%) in 2009, and the simultaneous descent of the risk free rate – from 4,13% in 2008 to 2,38% in 2009 – lead to the decline in the option value at € 8.004.265; the 24,5% (€ 1.961.580) represents the option premium induced by the ability to wait three months before the construction starting point, assuming that, at that time, the market value registers three positive increments (Table 3).

Table 3. Total Return, Income Return, Capital Growth, BTP_{3Y} Return, Growth Rate of Construction Costs, between 2003-2009 (%)

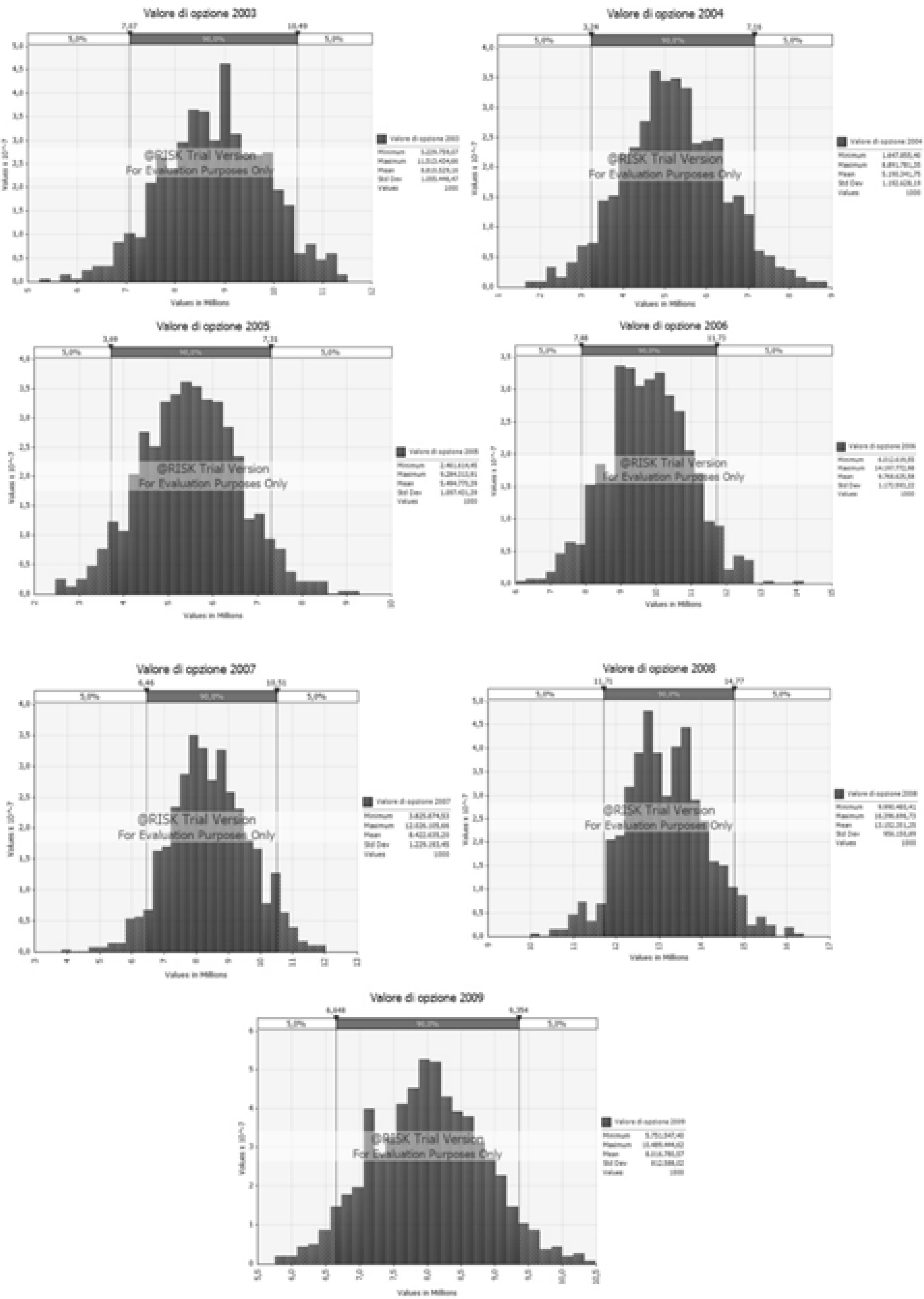
	2003	2004	2005	2006	2007	2008	2009
Total Return	8,9	9,2	8,6	11,7	8,9	4	-0,4
Income Return	6,9	7,5	7,1	7,1	7	3,2	3
Capital Growth	2,0	1,7	1,5	4,6	1,9	0,8	-3,4
BTP3Y Return	2,81	2,79	2,57	3,55	4,21	4,13	2,38
Growth Rate of Construction Costs	3,54	4,58	3,59	2,46	3,6	3,48	3,18

Source: Our elaboration on IPD, Bank of Italy, ISTAT data

It should be clear that, in the analysis, the expected return of the project is omitted, because, using the present approach, it seems to be unrealistically high; this is due to the expiration time of the option, of one year, whereas, in this case, the option may be regarded as perpetual (Geltner *et al.*, 2007). In this regard and facing the results presented in Figure 4, it is plausible to believe that the negative and positive peaks of the option value – resulting from the analysis of the years 2004, 2005 and 2008 – match the expected returns, respectively, too high or too low for the specific type of investment, given that the risk-return relationship involves also the value[4].

[4] Imagine two new buildings, absolutely identical in every aspect – especially because they provide the same return – except that the property B is riskier than the property A. With the assumption of perfect information, it is clear that no investor would prefer B, instead of A, or, at

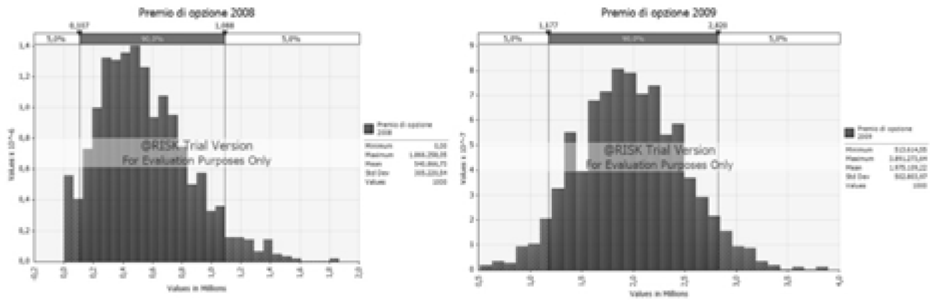
Figure 6. Probability distributions of the option value between 2003-2009.



In conclusion, a sensitivity analysis of the option value and option premium is implemented, referring to the total return, the income return, the btp three years, the growth rate of construction costs and the expected volatility, and assuming that these are random variables Normal shaped, with mean value of the observation year and standard deviation of 0,10 – with the aim to define the upper and lower limit of the confidence interval within the 90% of the values distributions. Using the software @ Risk© is then carried out a Monte Carlo simulation with 1.000 iterations for each year in observation. The outputs are shown in Figure6 that follow.

Instead, concerning the two probability distributions of the option premium, it is clear that both are right skewed, considering that negative values of the option premium are not possible. It appears also verified that this phenomenon is more accentuated if the option premium tends to zero, as clearly the probability distribution shows with reference to year 2008 (Figure 7).

Figure 7. Probability distributions of the option premium in 2008 and 2009.



In order to identify, between the variables implemented in the *Monte Carlo* simulation, those most closely correlated with the option value, a *Tornado graph* is created, i.e. a particular type of bar chart, where the input variables are listed vertically, the longest appears at the top and the length of each bar indicates the degree of correlation, positive or negative, with the output variable considered; in this case, the option value or the option premium.

Graphic analysis shows that the option value is more correlated with the expected return from the rent market, followed by the risk-free rate and the rising cost of construction, while the volatility assumes greater importance when it goes over the 20% – correlation index of 0,30 –, until confirm itself, at the end of the period, as the variable most influential, with a correlation index of 0,58. Of course, the overall expected return, as previously mentioned, does not affect the option value.

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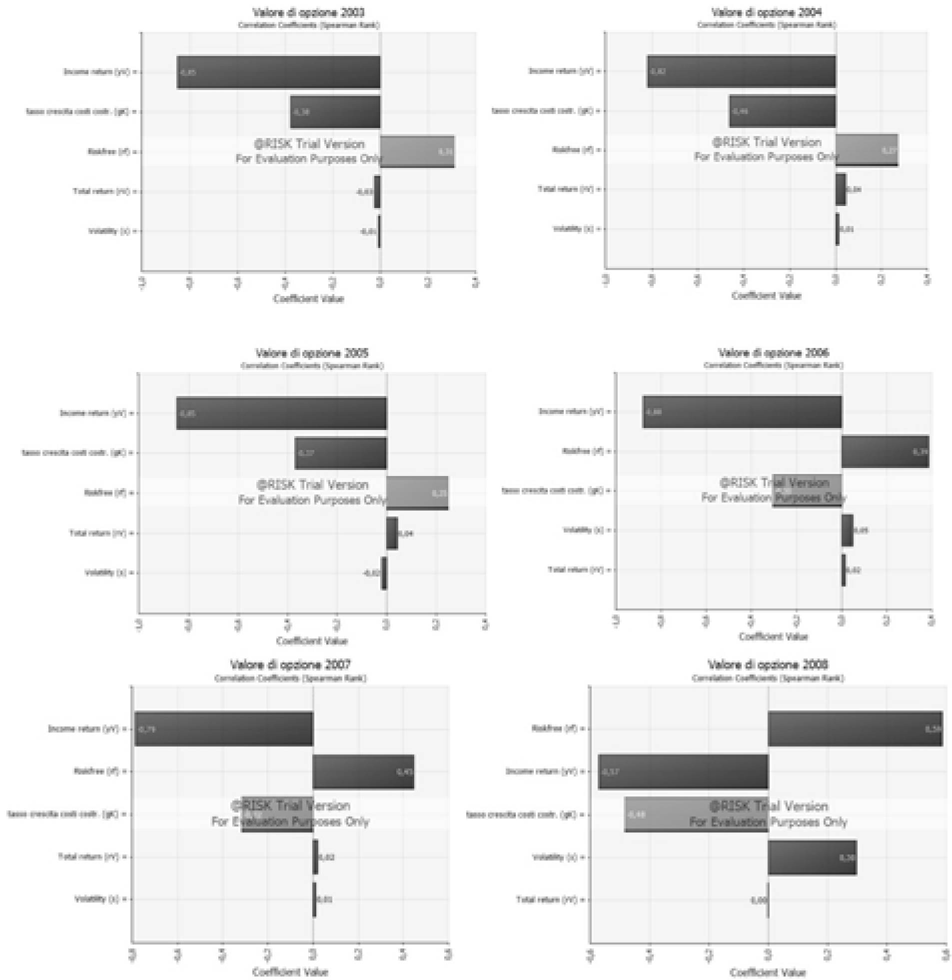
least, not at its current price. In a financial market, it would immediately observed an increase of the value of A – and, therefore, a decrease of its performance – and a decline in the value of B – and, therefore, a growth in its rate of return –.

Figure 8. Tornado graph of the option value between 2007-2008.



The option premium – graphs of which are omitted – is, however, entirely related to the volatility, since the correlation is 0.99 for the year 2008 and 0.98 for the year 2009. For more clarity, Figure 9 shows, for any given year, the upper and lower bounds of confidence interval within which falls the 90% of the distribution of the option value and option premium.

Conclusions

This study was born and has been structured with the goal – at least in intention – to present and apply the ROT to the field of real estate investments. As

Figure 9. Tornado graph of the option value in 2009.

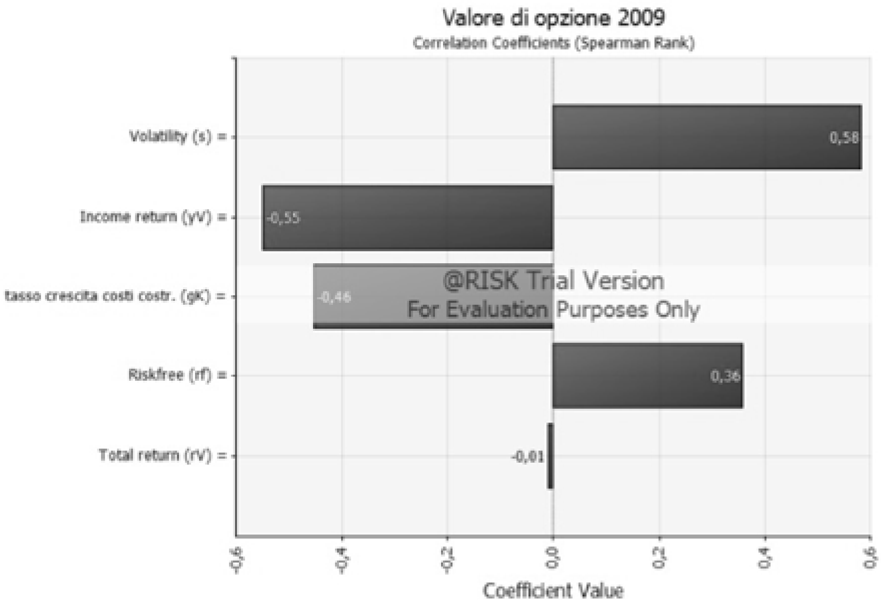
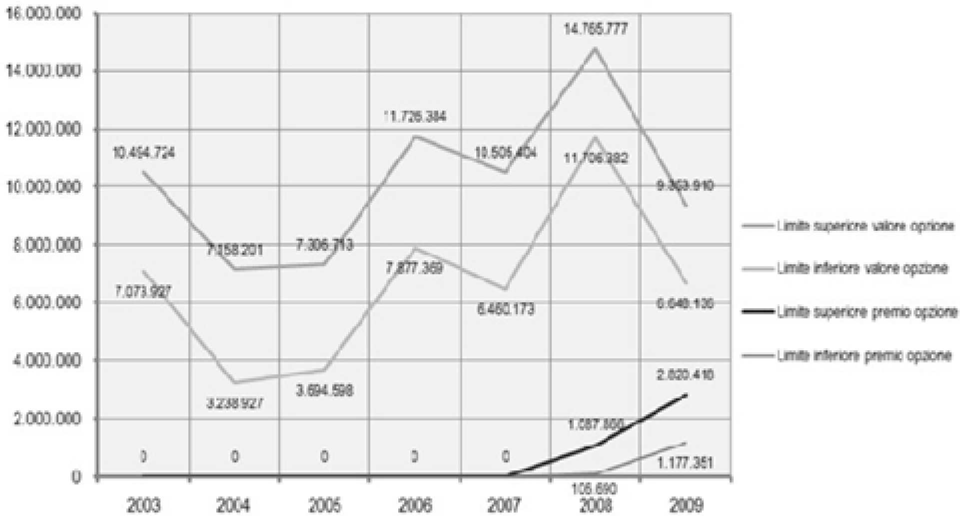


Figure 10. Upper and lower bounds of confidence interval of option value and option premium.



Source: our elaboration.

mentioned previously, it does not seem to become part of the real estate appraisal practices, perhaps because of its apparent complexity.

The intention was, therefore, to emphasize the following assumptions:

- the fundamental importance of the knowledge of risk-return relationship, in the light of the different purposes of the real estate investment and in respect of the alternative and feasible final uses;
- when the HBU analysis is critical, a different way to perform the risk analysis is to analyze the option value;
- how to use the uncertainty to change the course of a real estate development project and introduce flexibility.

In particular, the case study showed that the option value is clearly affected by the impossibility of obtaining an income before the end of the construction phase, estimated at twenty-four months. It seems particularly related to the trend of the expected return from the rent market, generally high in the examined time spam, with the exception of the last two years. This turnaround, related to the financial crisis of 2008, indicates precisely the importance of the uncertainty in determining the values.

More generally, the output of the *Binomial Lattice* model – an approach that employs at least ten variables and parameters, each more or less correlated with the option value in direct proportion or inverse – is still very variable, because the data exposed by IPD vary considerably from year to year. It was, however, possible to recognize a trend in the option value and to verify the presence of an option premium in the light of the increased volatility of the expected values of the property (+20%) – for the two last years – and draw useful conclusions for the investment decision making process.

Moreover, in the presence of uncertainty associated with all input variables of the model, *Monte Carlo* simulation has been useful; it was able to detect the corresponding uncertainty in the value and the option premium, and to test how much closely the inputs data were correlated with the two outputs.

The technical limits of the binomial model are, however, due to:

- the use of discrete time units and values, where the real world is rather continuous;
- the assumption of finite expiration time of the option, while it is, in principle, perpetual.

Both these factors can have significant effects on option value and the definition of the optimal time of option exercising, although the first limit could be passed by considering very short periods, while the perpetuity could be approximated by a long time span. A more accurate valuation would require, however, the use of a completely different model, as, for example, the Samuelson-McKean Model, developed in 1965 by the MIT Nobel Prize Paul Samuelson and his colleague, the mathematician Henry McKean. The model was applied in the financial field, but it seems possible to extend it to the real estate development. A further improvement of the present study could therefore consist in the adoption of this model in alternative to the binomial one, especially in terms of quantification and data reliability related to the expected returns.

It is after all shown as the ROT can explain something about the *overbuilding*; in the other hands, the *post*-boom of the real estate cycle, in which there is an oversupply, resulting in an increase in the proportion of vacant properties and a downward trend in prices. In particular, it can shed light on the rational behavior of the developers, who are anyway looking to reach the profit maximization.

If, for example, in a given area, there is a demand for office buildings for one million of square meters and there is a developer able to satisfy the request, creating a building on its land, surely this would have a negative effect on the option value of other parcels of land. This inelasticity of the real estate supply highlights the importance of the project timing – however uncertain – because, when some investors decide to exercise their option earlier, saturating the whole demand, the others would remain with an expired option. The only possibility that such case occur could lead a such pressure on competitors, who could tend, in a favorable market situation, to trigger the project all together, even though it means giving up a possible option premium. This would entail a large amount of space built, exceeding the demand, in a relatively short time, with the result of the elimination of the flexibility associated with the opportunity provided by the option of waiting, leading to *overbuilding*.

On the other hand, it is important to note that, in reality, improving land and development projects, present a certain degree of uniqueness, which, in fact, makes the competition less than perfect. If the described above dynamics had occurred systematically, probably we would observe lower values than those emerging from the market, especially in light of the inelasticity of the traditional landowners supply.

Be able to make a comprehensive study in this direction could be a further development of this work.

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