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Uncertainty and feasibility studies: an Italian case study

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Abstract

Purpose – Uncertainty affects all aspects of the property market, but one area where the impact of uncertainty is particularly significant is within feasibility analyses. Any development is impacted by differences between market conditions at the conception of the project and the market realities at the time of completion. This paper sets out to address this issue

Design/methodology/approach – The feasibility study needs to address the possible outcomes based on an understanding of the current market. This requires the appraiser to forecast the most likely outcome relating to the sale price of the completed development, the construction costs and the timing of both. It also requires the appraiser to understand the impact of finance on the project.

Findings – This allows the appraiser to address the issues of uncertainty involved and thus provide the decision maker with a better understanding of the risk of development. This technique is then refined using a "two-dimensional technique" to distinguish between "uncertainty" and "variability" and thus create a more robust model.

Originality/value – The feasibility study needs to address the possible outcomes based on an understanding of the current market. This requires the appraiser to forecast the most likely outcome relating to the sale price of the completed development, the construction costs and the timing of both. It also requires the appraiser to understand the impact of finance on the project.

Keywords Uncertainty management, Property, Investment appraisal, Accounting valuations, Case studies, Italy

Paper type Research paper

Introduction

The valuation of land or property with development potential can be undertaken by one of two methods. The value can be ascertained by comparison of similar and recent sales of land/property with the same development potential (with or without planning permission) or its value can be estimated from a fundamental analysis of the income producing qualities of the completed development. This can be considered as a subset of the income method or a valuation method in its own right. This technique is known by a number of different titles; In the UK it is a residual valuation; in the USA it is called a development appraisal and in continental Europe it is known as a feasibility study. In fairness, these terms have become interchangeable, particularly across the Atlantic, and the name given to the technique is inconsequential as it is the underlying method that is important. It is this that is discussed below.

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Feasibility studies

A feasibility analysis (see Figure 1) is a method used by the appraiser to identify the land value for a site with latent value: that is, by spending money on the site (through development or refurbishment) an increase in value greater than the cost of development is (hopefully) realized. In principle, the method of approach is to ascertain the present capital value of an estimated future income (the gross development value, or GDV), and then to deduct from that the cost of all works needed to complete the development to a standard able to command such a future income, the residual figure representing the developer's maximum bid for the site in question.

Obviously as the basic technique is one of "A − B = C", then the method can be adapted to provided a different residual depending on the inputs. The method can be used to calculate three outcomes:

(1) maximum value (to the purchaser/developer) of the site;

(2) expected profit from the development (the site having been acquired); and

(3) the maximum outlay for construction.

Indeed, it is probable that in the course of development all three calculations will be undertaken. Initially, the developer will analyse the development to determine the maximum bid for the land (see below). Having bought the land, the developer will increase the complexity of the model as more of the variables become known and thus assess the likely profit (see below). Finally, the method can also be used as a project management tool setting cost ceilings for construction to ensure that a set profit is achieved at a given land value (this method is not illustrated here).

The complexity of the model used to undertake this analysis will vary according to the developer's/appraiser's requirement. The model can be extremely simplistic and use only current day figures for cost and values, and as such give a broad ballpark indication of the residual in current-day terms, or it can be more complex and allow for the time value of money through a cash flow approach (see below). A cash flow approach is obviously more robust as it attempts to model the reality of the development process. A development, depending upon its size and complexity, can take anywhere between six months and four years (or more) to complete. During that time it is likely that the estimates of costs and sale values will change. A static, non-cash flow model is unable to incorporate these changes as it does not project forward expenditure and receipts into the future. The simple model can only deal with capital values and costs at one point in time. The two approaches can be illustrated by reference to a real-life case study of the sale of development land by a municipal authority in Italy.

GDV	−	Total Costs	=	Site Value
Gross Development Value: Value of completed development		All construction costs including interest payable on short-term funds, sales/letting fees, developer's profit and professional fees		**Net Residual Value:** Maximum bid for site including acquisition fees, taxes and interest on money borrowed for site purchase

Figure 1.
The feasibility study model

Case study – sale of development land by an Italian municipality

The case study for a feasibility study discussed in this paper is the sale of an urban regeneration area located in a medium-sized city in the North of Italy. The municipality, as with all small and medium-sized cities in Italy, is not a particularly volatile market and is less prone to market change than cities such as Milan and Rome.

The site in question is a redundant industrial site left vacant since 1980 when production was transferred to an out-of-town location[1]. This type of regeneration project involving the refurbishment of industrial buildings for other uses has been seen as a significant opportunity for Italian municipalities to regenerate their town centres. Yet, as is often the case with such opportunities, this also presented the municipality with the problem of financing the regeneration project. The municipality needs to implement a process to progress the project that is a balance between public and private interests. The municipality wants to regenerate the area in accordance with its planning objectives, while the private sector is willing to undertake projects that are financially viable. To achieve this balance, the municipality sells the land subject to an Urban Renewal Plan[2]. This is a detailed plan, prepared by the Municipality, which defines the preferred mixed use for the site and sets the limits for each property type. The land value is determined by reference to this plan, and thus, as the municipality is legally bound to ask for a minimum figure at sale (i.e. "bids in excess of *X*"), a feasibility study needs to be undertaken to identify the potential income and costs of the project.

In this case, the redundant site is a total area of 37,000 square metres, of which disused industrial buildings cover about 13,000 square metres. The Urban Renewal Plan indicates that the existing buildings should be refurbished into small and medium-sized offices and that the surrounding land should be new development. It also dictates that the development should be a mixed-used development (as is the norm in Italian cities) of residential, retail and offices.

The acceptable mix of uses was determined to be:

- 52 percent offices;
- 35 percent residential; and
- 13 percent retail.

In addition, the plan provides for substantial public and private parking spaces.

Case study – estimate of costs and incomes

To undertake the feasibility study, the appraiser needs to identify all the crucial variables and use their professional judgement to estimate values for all the critical variables concerned. However, such a study, by its nature, is governed by the exactness of the variables used, and this is discussed below when we consider uncertainty. At this point, we will identify the critical variables and assign appropriate values to them based on an analysis of the current market[3]. The critical variables identified are listed in Table I.

The case study was undertaken in the Summer of 2003. At that time the property market for the town in question was buoyant with constant growth for both capital values and rents in all sectors. In the historical city centre, where the case study site is situated, there was a strong and growing demand for retail and residential. The price of small shops in the city centre was very high and there was a lack of supply of high-quality small and medium-sized apartments, resulting in high prices for residential buildings.

Value/cost	Area m²	per m²
Income		
Refurbishment		
Offices	9,700	2,500
New buildings		
Retails	2,500	5,000
Residential	6,500	3,500
Services		
Parking spaces	3,500	1,500
Costs		
Refurbishment		
Offices	9,700	1,300
New buildings		
Retail and residential	9,000	900
Costs for services		
Building permission fees (infrastructure)	18,700	95
Parking spaces	3,500	790
Other costs	Percent	
Municipality fees (residential/retail)	10	
Municipality fees (offices)	5	
Marketing costs	2	
Professional fees	10	
Profit	20	
Land purchase costs excluding tax	2.5	
Interests	Financial expenses Annum	Half year
Credit (active) interest rate (percent)	2.5	1.25
Debit (passive) interest rate (percent)	3.5	1.75
Discount rate (percent)	4.0	2.00
Timing		
Building period (maximum four years)	Four years	
Void period (maximum of four)	Zero half years	

Table I.
Case study – critical variables

Similarly, the office rented sector was correspondingly strong. An analysis of the local property market produced average prices of €3,500 per square metre for residential, €2,500 per square metre for offices and €5,000 per square metre for retail[4]. These prices reflect the demand for small commercial spaces and new residential spaces located in the historical city centre, with all services and parking spaces in proximity.

A similar market analysis was undertaken to ascertain the costs of refurbishment and new construction. The cost of refurbishment is relatively high, at €1,300 per square metre, as old industrial buildings have to be adapted to the new functions (offices). The cost for new build (retail in the first floors and residential in the upper levels) is lower at €900 per square metre. The professional fees[5] of the architects and engineers were 10 percent of total costs, with marketing costs at a further 2 percent. A specific and relatively high cost imposed in Italy is the "building permission cost". This is in two parts: the first is a charge for servicing the development with appropriate infrastructure, while the second – the Municipality Fee – is more akin to a local tax. The level of both payments is first determined as a range at a regional level and then the municipality decides on an appropriate rate within that range for the city. Both payments are calculated on a *pro rata* or percentage basis.

Finally, the feasibility study estimates the land value to a potential developer based on the project being financed by bank borrowing. The convention in Italy is that the bank agrees to lend money to the developer at a "passive" (debit) rate and will apply a lower "active" (credit) rate if the account is in credit at any point during the construction period. The rates used in our case study are 3.5 and 2.5 percent, respectively. As we are trying to determine market value, the hypothesis of the model is that the developer will borrow all the money needed from the bank regardless of their actual equity position. This is a generally accepted simplification, which effectively assumes that the opportunity cost for the developer's own funds is equivalent to the rates charged by the bank.

The "ballpark" approach[6] to determine land value

As discussed, this is a very simplistic model that determines today's land value by undertaking the analysis as a single snapshot in time.

All the critical variables used are assessed by reference to today's market. Thus the cost of construction is an average cost based on today's prices and similarly the estimated GDV figure should be an estimate of how much the development would sell for today if it were already completed. The residual figure is therefore a quick estimate of land value as an approximate present value (see Table II).

Initially, the simple deduction of total costs from GDV produces a gross residual value (GRV) of €17,795,147. This represents the maximum amount that a developer can afford to pay for the site including all costs of purchasing the land based on current assumptions. It is not the land value. In effect it is the surplus at the end of the development period. This figure does not only represent the land value, but it must also include the acquisition costs for the land, taxation[7] and most importantly, the financing of the purchase of the land. The appraiser therefore needs to determine the net residual value (NRV), which equates to the land value alone. This is a simple algebraic calculation as the costs we are trying to deduct are in fact related to the answer we are trying to find; thus the calculation must be carried out in reverse. The finance cost is 14.75 percent (3.5 percent compounded for the construction period of four years) and the land purchase costs are a further 2.5 percent of the resulting figure. In other words, the GRV is equal to 1.1475 × NRV (before costs), which is €15,507,402, and NRV (before costs) is equal to 1.025 of the NRV of €15,129,212. The NRV is the land value.

Thus, this approach can be a useful approximation of site value, but as a static model it fails to take into account the time value of money. This is particularly the case where (as in our case study) the development benefits from a phased completion, resulting in incomes being received during the development period. The reality of this can have a

Gross development value		
Offices (refurbishment) (€)	24,250,000	
Retail (new build) (€)	12,500,000	
Residential (new build) (€)	22,750,000	
Parking spaces (new build) (€)	5,250,000	
Total capital value (€)		64,750,000
Building costs		
Refurbishment costs – office (€)	12,610,000	
Construction costs – retail and residential (€)	8,100,000	
Construction costs – parking spaces (€)	2,765,000	
Professional fees		
Building permission fees (infrastructure) (€)	1,776,500	
Municipality fees (€)	1,440,500	
Engineers'/architects' fees (€)	2,525,150	
Agents' fees (€)	1,295,000	
Total building cost (€)	30,512,150	
Funding of construction [a]		
Interest rate per quarter (percent)	3.50	
Construction period	16 periods (half yearly)	
Finance cost (€)	4,452,703	
Developers' profit		
Profit – 20 percent of GDV (€)	11,900,000	
Total costs (€)		– 46,954,853
Gross residual value (€)		17,795,147
Interest on land purchase (€)	2,287,704	
Net residual value (before costs) (€)		15,507,402
	2.5%	
Costs of land purchase	€378,230	
Net residual value (site value) (€)		15,129,212

Note: [a]It should be noted that, as this is a static calculation, the finance costs need to be taken into account by "averaging" out the building period (normally by half) and then applying interest to this figure. In this case interest is calculated at 1.75 percent for eight half-yearly periods (i.e. half the actual building period)

Table II.
Case study – simple "ballpark" calculation

significant impact on the financing of the scheme and thus any resulting savings will be passed through to the residual land value. Similarly, the ballpark model fails to account for present valuing at the developer's target rate, and thus ignores the perceived risk inherent in the project. An alternative and preferred method is a cash flow approach.

The "cash flow" approach to determine land value

It has been seen that the ballpark approach (as its name suggests) can be used effectively as "rough indicator" of a development's viability, but is not sufficiently detailed to provide a full analysis of the scheme's sensitivity to changes in the input variables. A better and more accurate valuation should therefore take into account differences in the developer's likely cash flow, such that the capital outstanding at any point in time is known, and an accurate estimation of finance charges may be made. The use of a cash flow approach also allows the appraiser to accurately reflect the phasing of the development, as well as allowing for any changes in value or building costs over the development period.

The cash flow approach estimates the timings of the expenditure on the construction and the capital receipts upon completion. This produces a period-by-period net cash flow, which then allows the appraiser to determine the capital outstanding (or in credit) at the bank for each respective period. The model can then calculate the accrued interest to each payment/receipt and carry it forward to the next period. The total accumulation represents the surplus of funds at the *end* of the development. To find the GRV today, the future amount needs to be discounted at the debit rate (as this will allow for the finance on the land purchase) to derive a present value sum that represents the land value plus acquisition costs. This figure is then adjusted (as illustrated in the ballpark valuation above) to derive the land value.

The only inputs that are required in addition to those used in the ballpark valuation (see Table I) are the timings that should be applied to the construction costs and, correspondingly, the capital receipts. These are detailed in Table III. The advantage of the cash flow technique is that the appraiser can build in outgoings such as professional fees and sales fees more realistically, relating them to the construction costs/sales income as they occur, and not to a total figure as with the ballpark method.

The use of a cash flow table also allows the appraiser to accurately reflect the timing of the development, as well as allowing for any changes in value or building costs over the development period[8]. By introducing a timing of expenditure input table, the appraiser can specify, in percentage terms, the likely timing of the expenditure. The percentage of costs better represents the "S" curve expenditure profile, which mirrors the normal expenditure profile of a development of this nature. This input table is then related to the building costs to produce a more realistic actual expenditure cash flow. Similarly, the phasing of the project has been allowed for within the timing table and shows that capital receipts for the various parts of the overall development will be received prior to the completion of the whole. The total costs and revenues have not been increased, but the timing of the expenditure/receipts has been altered significantly and this may have an effect on the financing of the project. This is illustrated in Table IV, the cash flow feasibility study.

The cash flow approach takes the net cash flow and calculates the accrued interest to each payment/receipt and carries it forward to the next period. The total accumulation in the final row of the final column of the cash flow (in this case €34,732,075) represents the surplus of funds at the end of the development and represents profit and land value (with associated cost). To find the maximum amount somebody could afford to pay for the site today, this figure needs to be adjusted to allow for the profit and the finance on the land purchase together with acquisition costs. This is shown in Table V.

The cash flow approach can be developed so that it may be used to calculate the developer's profit where the site has already been acquired and, because the technique allows for the time value of money, it allows the appraiser to analyse the profit on a net

Table III.
Case study – timing of critical variables

	Year 1		Year 2		Year 3		Year 4	
	Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7	Sem 8
Revenues								
Refurbishment								
Offices	0	0	0	10	10	30	30	20
New buildings								
Retail	0	0	0	10	10	30	30	20
Residential	0	0	0	10	10	30	30	20
Services								
Parking spaces	0	0	0	10	10	30	30	20
Costs								
Refurbishment								
Offices	0	0	25	25	25	25	0	0
New buildings								
Retail and residential	0	0	0	25	25	25	25	0
Services								
Building permission fees (infrastructure)	0	0	10	10	10	20	30	20
Municipality fees	0	0	10	10	10	20	30	20
Parking spaces	0	0	0	25	25	25	25	0
Other costs								
Professional fees	10	10	15	15	15	15	15	5
Marketing costs	0	0	0	10	10	30	30	20
Profit	0	0	0	0	0	0	0	100

Note: All figures given are percentages

Table IV. Case study – the cash flow of the feasibility study

	Total	Year 1 Sem 1	Year 1 Sem 2	Year 2 Sem 3	Year 2 Sem 4	Year 3 Sem 5	Year 3 Sem 6	Year 4 Sem 7	Year 4 Sem 8
Revenues									
Offices (€)	24,250,000	0	0	0	2,425,000	2,425,000	7,275,000	7,275,000	4,850,000
Retails (€)	12,500,000	0	0	0	1,250,000	1,250,000	3,750,000	3,750,000	2,500,000
Residential (€)	22,750,000	0	0	0	2,275,000	2,275,000	6,825,000	6,825,000	4,550,000
Parking spaces (€)	5,250,000	0	0	0	525,000	525,000	1,575,000	1,575,000	1,050,000
Total (€)	64,750,000								
Costs									
Offices (€)	12,610,000	0	0	3,152,500	3,152,500	3,152,500	3,152,500	0	0
Retails and residential (€)	8,100,000	0	0	0	2,025,000	2,025,000	2,025,000	2,025,000	0
Infrastructure fee (€)	1,776,500	0	0	177,650	177,650	177,650	355,300	532,950	355,300
Municipality fees (€)	1,440,500	0	0	144,050	144,050	144,050	288,100	432,150	288,100
Parking spaces (€)	2,765,000	0	0	0	691,250	691,250	691,250	691,250	0
Professional fees (€)	2,525,150	252,515	252,515	378,773	378,773	378,773	378,773	378,773	126,258
Marketing costs (€)	1,295,000	0	0	0	129,500	129,500	388,500	388,500	259,000
Total (€)	30,512,150								
Financial costs									
Capital debit/credit (€)		−252,515	−252,515	−3,852,973	−223,723	−223,723	12,145,578	14,976,378	11,921,343
Credit interest at 2.5 percent (€)		0	0	0	0	0	0	88,518	276,829
Debit interest at 3.5 per cent (€)		0	−4,419	−8,915	−76,498	−81,752	−87,098	0	387,561
Cash flow (€)		−252,515	−256,934	−3,861,888	−300,221	−305,475	12,058,479	15,064,896	12,585,733
Cumulative cash flow (€)		−252,515	−509,449	−4,371,337	−4,671,558	−4,977,033	7,081,447	22,146,342	34,732,075

present value (NPV) and/or an internal rate of return (IRR) basis. However, in this case study, we are assessing land value on behalf of the municipality and thus do not consider profit calculations.

Thus, in this case, the feasibility study is being used to determine the land value, which represents the minimum acceptable bid for tender. The municipality is required to offer the land to the private sector by stating that they will consider offers in excess of the land value figure calculated. As such, the fact that we have been conservative in our analysis by using only current-day figures and ignoring any advantages of gearing (by the use of the developer's own equity) means that, in reality, the interested parties who are likely to bid will be able to offer figures in excess of the land value calculated on behalf of the municipality.

However, it should be stressed that even with this conservative view incorporated into the model, the cash flow approach is preferred to the ballpark approach as it allows for the phasing of the development over the build period that must be reflected in the land value. Indeed, the ballpark approach only produced a land value of €15,129,212 compared to the €19,388,588 of the cash flow approach. The cash flow analysis is to be preferred.

However, regardless of the method adopted, one of the principal problems with feasibility studies is that method is very sensitive to changes in any of the input variables. A small change in any of the variables (value, cost, time or interest rate) can disproportionately affect the resultant residual land value. In other words, although the appraiser will have ascribed values to each of the critical variables (see Figure 1), the feasibility study is a single point analysis based upon a single set of "likely" inputs. Each of the variables is based on the subjective professional judgement (expertise) of the appraiser and the model does not allow for the susceptibility to change among the various constituent components through time. In short, there is uncertainty.

Allowing for uncertainty in the "cash flow" approach

Uncertainty is a real and universal phenomenon in feasibility studies. The process of development is, by its nature, particularly open to changes over time. Yet, the feasibility models discussed above only identify one possible set of variables and the land value is only "correct" if the numbers ascribed to that set of variables turn out to be correct themselves. If the model was adapted to better reflect the uncertainty of the variables, it would produce a range of possible outcomes and provide the client, in this case the municipality, with a better understanding of the likely outcome as reflected in the tender bids.

Surplus at *end* of development (€)	34,732,075
Less profit (20 percent of GDV) (€)	− 11,900,000
Fund to purchase land (€)	22,832,075
Present value[a] of the land value fund (€)	19,873,303
Costs of land purchase (2.5 percent of land value) (€)	− 484,715
Land value (€)	19,388,588

[a]The present value function is carried out at the debit (passive) interest rate as this is implicitly accounting for interest on the land purchase

Table V.
Case study – the cash flow: calculation of land value

Uncertainty impacts on the feasibility study in two ways:

(1) the cash flows from development are, to varying degrees, uncertain; and

(2) the resultant valuation figure is therefore open to uncertainty.

This paper looks at how uncertainty can be accounted for in the feasibility study and how it can be reported to the client in an effective and meaningful way. This can be achieved by recognising that the inputs are not single figures but are, in fact, a possible range of figures that can be modelled statistically by a probability distribution. The resulting output will therefore also be a range.

Thus, to undertake this new analysis we needed to adopt a standardised approach and we suggest the use of a generic forecasting software package, in this case Crystal Ball[9], which acts as an overlay to the cash flow model already developed on Excel (or Lotus 123) and working with a predetermined set of probability distributions. The argument for using such a technique is that a single value may not provide the client with sufficient information to make an informed decision, and thus a range of values might be more meaningful (Brown, 1991).

Risk and uncertainty

Before we can consider uncertainty within the development process, it is important to define what is meant by uncertainty. Both the academic literature and more so the property profession use the terms "risk" and "uncertainty" interchangeably. The academic literature has discussed extensively the distinction between risk and uncertainty (for example, see Byrne and Cadman, 1996; Byrne, 1995, Kelliher and Mahoney, 2000; French and Gabrielli, 2004). It is generally agreed that uncertainty is due to the lack of knowledge and poor or imperfect information about the inputs required in the model. Furthermore, the further the analysis is taken into the future, the more uncertain are the outputs of that analysis. The outcomes of an analysis are only certain when we can foresee the future. On that basis, the risk is the measure of the difference between the actual and the expected outcomes of our analysis.

Probability theory is a way of measuring uncertainty. It permits the appraiser to identify a range of outcomes for the most important variables and to assign probabilities to these variables. Simulation is a further development of this probability analysis, and Monte Carlo simulation has been an important component of quantifying risk since the 1960s (see Hertz, 1964). The basis of the analysis is an iteration process that carries out multiple calculations of the cash flow by randomly selecting an input figure for each of the critical variables identified. It selects a value from the ascribed probability distribution and uncertain input values are specified as probability distributions.

Probability distributions

For the purposes of this paper we are seeking to identify the substance and the characteristics of the uncertainty that applies to the inputs involved. Thus we need to address the probability and range relating to the inputs. The outcome can still be described as a single valuation but an understanding of the uncertainty relating to the inputs used in the model will allow the appraiser to report to the municipality the uncertainty related to that specific single valuation figure.

As we have seen, the ascribed inputs were ascertained by an analysis of the market. This is not a mathematical exercise but a heuristic approach and the appraiser's judgement of the uncertainty pertaining to his or her final choice of inputs will vary according to market conditions. If the market is strong and there is a lot of transactional data available, it is likely that the observations will be closely aligned and that the range of the observed inputs will be small. The appraiser will be more certain in the single point estimate for each input in current-day terms. However, as market conditions deteriorate, the amount of direct comparable information falls and the appraiser will be less certain of the input choices. Here the range of possible inputs will be greater. In each scenario, the appraiser will not be 100 percent certain of the input figures. In effect, they will ascribe a degree of uncertainty to their belief in the input variable being "correct". This is a subjective probability and will vary according to the confidence level that they feel applies for that variable (see Figure 2).

The simulation analysis effectively tests the robustness of the single point estimates and produces a range of possible outcomes, the mean of which can be considered to be the expected land value and the maximum and minimum results the extent of the range and thus an indication of the uncertainty pertaining to the single point figure.

Probability distributions and choice of critical variables

In statistics there are many forms for probability distributions, which describe both the range of the input values and the likelihood of their occurrence. The normal distribution (bell distribution) is the most well known and its parameters, the mean and the standard deviation, are the most used. In our analysis the most likely figure will be represented by the central figure (the mean) and the uncertainty by the range around that number. There is equal probability that the observed figure will be above or below the central assumed figure. The majority (99.74 percent) of the possible observations will lie within plus or minus three standard deviations of the mean. The standard deviation is a measure of how widely values are dispersed from the average value (the mean). The exact standard deviation will vary according to the uncertainty pertaining to the average value; the greater the uncertainty, the higher the standard deviation. Equal likelihood of the adopted figure being higher or lower would be a symmetrical distribution; an unequal probability would result in a skewed distribution. In the real world, and particularly in a property market, market values, interest rates and other

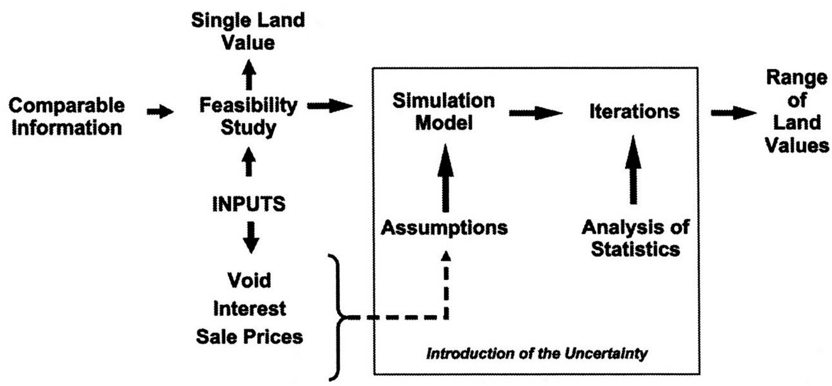

Figure 2.
Incorporating uncertainty in the feasibility study

factors might be skewed, and this model allows for the appraiser to develop the analysis on this basis if required.

Crystal Ball allows for different probability distributions to be ascribed to each variable as appropriate. The normal, triangular, uniform or lognormal distributions are the most used in the simulations. The choice of one or more distributions depends on the market analysis and the market information about the inputs considered and on the ability and experience of the appraiser in assigning them the proper parameters which describe the characteristics of the market values, interest rates, costs, etc.

The expanded model used in this case study considers all the inputs to be normally distributed, and the original inputs used in the cash flow model spreadsheet are the means (the most likely) of these distributions. Although there are other probability distributions that may be considered (e.g. lognormal, beta, etc), the purpose of this paper is to use a language that might be readily understood by the client. In Italy, one of the accepted valuation approaches is to statistically analyse published comparable data, and as such the representatives of the municipality will be familiar with normal distributions and the associated parameters. Thus, this chosen approach will be readily understood by the client.

Defining the input values

The first step in the simulation is to define the probability distribution for each chosen input in statistical terms (mean, standard deviation, minimum, maximum, etc.). The size, shape and dispersion of the distribution will affect the selection of the variable during the random iteration.

Monte Carlo simulation is a re-sampling iterative process. In simple terms it changes the input in the calculation by randomly choosing a figure within the defined probability distribution. It then calculates the corresponding value using that chosen input and records that value. It then repeats the process by randomly choosing another input figure. It will continue to do this until the chosen number of iterations, normally several thousand, is complete. The output is expressed as the mean of all the calculated values. For this case study, the assumptions about the variables (inputs) shown in Table VI were chosen.

Input	Distribution	Mean	SD	Minimum	Maximum
Market values					
Offices (€)	Normal	2,500	250	2,000	3,250
Residential (€)	Normal	3,500	200	3,000	4,100
Retail (€)	Normal	5,000	400	4,000	6,200
Costs					
Refurbishment (€)	Normal	1,300	100	1,000	1,600
New construction (€)	Normal	900	70	690	1,110
Interest rates					
Credit (active) (percent)	Normal	2.5	0.40	1.30	3.40
Debit (passive) (percent)	Normal	3.5	0.50	2.50	5.00
Void (half years)	Normal	2	0.70	0	4

Table VI. Probability distributions of chosen variables

In Table VI, the chosen figures are determined by an analysis of the market. The minimum and the maximum values are the limits of (approximately) three standard deviations in market values and costs. These limits are duly adjusted if experience suggests that they are less or more than the numbers identified by the statistical analysis. With the interest rates (debit and credit rates) we have chosen an upper and a lower limit according to the rates normally used by banks.

The Crystal Ball programme provides a structured approach that allows the user to incorporate uncertainty into the analysis in a relatively simple form because each input is defined by the chosen probability density function. As there is more than one variable to be analysed, it is very important to define the interrelationships between the chosen variables. This is known as the correlation. For example, it is likely that if retail values increase in the market then this is an indication that the market is strong and that the value of offices and residential will also increase. Thus, retail values will be positively correlated with both office values and residential values.

A perfect positive correlation will have a value of +1 and a perfect negative correlation will have a value of −1. A variable that is totally independent will have a correlation of 0. The chosen correlations, based on an analysis of past data, are shown in Table VII.

In the cash flow model above, one of the fixed assumptions was that each part of the development would be sold upon completion. Even in cases where the market is strong, this is an unrealistic assumption as it is likely to take at least six months from completion to market and sell the property. In a poorer market, this void may be longer. The model has therefore been adjusted to allow for variations in the void period (up to two years, assessed half-yearly). If a one-year void is built into the cash flow model above, the land value changes to €17,803,440. It is against this figure that we will be comparing the Crystal Ball analysis.

The application of Crystal Ball to feasibility studies

By using the assumption criteria noted above, we have made a number of assumptions about the way in which we expect the market to evolve in the future. First, we feel that the market values of retail buildings are more variable. Residential is a more secure investment, particularly as the time for selling new apartments in the city centre is relatively low.

All values are negatively correlated with the void. That is, if the economy is slow then we would expect longer voids and that the values would be relatively low when sold.

Table VII.
Correlations between the chosen variables

	Offices	Residential	Retail	Refurbishment cost	New build cost	Credit rate	Debit rate	Void
Offices		+0.70	+0.70				−0.50	−0.50
Residential	+0.70		+0.70				−0.50	−0.50
Retail	+0.70	+0.70					−0.50	−0.50
Refurbishment cost					+0.90		+0.40	
New build cost				+0.90			+0.40	
Credit Rate							+0.75	
Debit rate	−0.50	−0.50	−0.50	+0.40	+0.40	+0.75		+0.80
Void	−0.50	−0.50	−0.50				+0.80	

We have also taken the view that a principal driver in the market will be the debit (passive) rate of interest. As this rate increase, the market will slow and values will be expected to fall; costs increase and voids extend. We have also curtailed the limit of both interest rates; the credit rate has an upper limit of 3.4 percent while the debit rate has a lower limit of 2.5 percent.

Using these numbers, we used Crystal Ball to run the cash flow feasibility study 10,000[10] times using Monte Carlo simulation. This produced the outcome in numerical terms as illustrated in Table VIII or graphically in Figure 3.

Here it can be seen that the expected mean (land value) of €17,498,164 is not significantly different from the €17,803,440 produced by the discreet use of the cash flow model. But the advantage of the Monte Carlo simulation (using Crystal Ball) is that it provides additional information about the certainty of the result. In this case, the standard deviation (of €4,132,711) is a representation of the uncertainty. The skewness (of 0.08) represents the degree of asymmetry of the distribution around its mean. In this case, the output is near normal, but in other cases a more positive skewness indicates a distribution with an asymmetric tail extending toward more positive values. A negative skewness would indicate a distribution with an asymmetric tail extending toward more negative values.

As expected the outcome of this simulation is to provide the client – the municipality – with a display output range[11] from €6,753,115 to €28,243,212. Statistically, the majority of outcomes (95 percent) lie within two standard deviations of the mean. In this case the important range is from €9,232,742 to €25,763,586, and it is this distribution that helps the client to assess the uncertainty. Because we have

Table VIII. Crystal Ball cash flow analysis to land value (statistics)

Statistics	
Trials	10,000
Mean (€)	17,498,164
Median (€)	17,452,151
Standard deviation (SD) (€)	4,132,711
Skewness	0.08
2 × SD range minimum (€)	9,232,742
2 × SD range maximum (€)	25,763,586

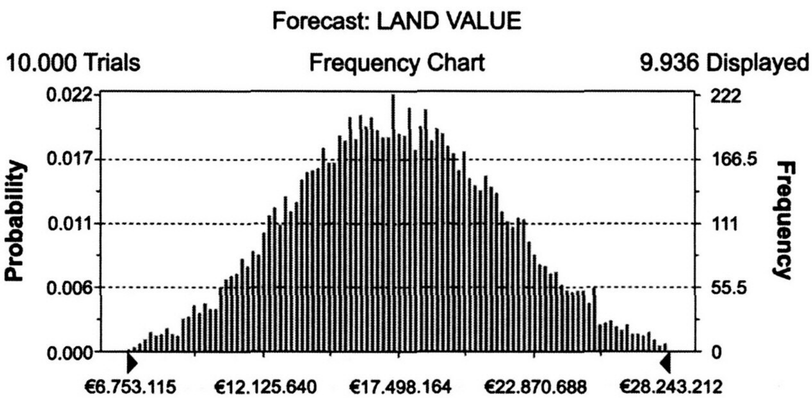

Figure 3. Crystal Ball cash flow analysis to land value

modelled the uncertainty in the inputs, the analysis allows the appraiser to describe the uncertainty in the output. By a comparison of the output range (or standard deviation) the client is able to realise that the land value is less certain than the original feasibility study would suggest. The advantage of expressing the uncertainty as a normal distribution is that it succinctly conveys the output uncertainty (variation in possible land value) to the representatives of the municipality in a way that they can understand.

However, the model can be further modified to provide a better representation of the mechanics of the market. In the standard Crystal Ball analysis above, each variable is considered and modelled in the same way, yet in reality there is a difference between an input being treated as a variable and one that is uncertain.

Uncertainty and variability

For many types of risk assessment it is important to distinguish between uncertainty and variability. Inputs can be *uncertain* due to insufficient information about a true, but unknown, value (e.g. void in the future) while some inputs are *variable* because they describe a population with different values (e.g. value per square metre). Theoretically, uncertainty can be eliminated with sufficient data, whereas variability is inherent.

Thus, *uncertainty* inputs are uncertain because one has insufficient information about a true, but unknown, value (e.g. interest rates in the future). One can describe an uncertainty assumption with a probability distribution. However, *variability* inputs change because they describe a population with different values. Examples of variability include the capital value of individual residential properties. One can describe a variability assumption with a frequency distribution (or approximate it with a probability distribution). As there will always be variability, it is not possible to eliminate it by gathering more information.

The separation between the two concepts in a simulation process allows the appraiser to accurately detect the variation in land value due to the lack of knowledge and the variation caused by natural variability in a measurement of capital values and costs.

The Crystal Ball programme allows the appraiser to distinguish between these two concepts by running one randomisation to simulate the uncertainty inputs, and then freezing the uncertainty values while running a second simulation (of the whole model) to simulate the variability. In our analysis we chose to test the uncertainty of the void period and both interest rates in tandem with the variability of the prices of all the property types and all costs. This is known as a two-dimensional simulation. Using these numbers, we ran the first simulation 100 times and the second simulation 1,000 times using the same Monte Carlo simulation. This produced the outcome in numerical terms illustrated in Table IX.

Here it can be seen that the expected mean (land value) of €17,373,537 is almost identical to the €17,498,164 produced by the one-dimensional cash flow model above. Yet, the standard deviation of €3,186,754 is substantially lower that the corresponding figure from the one-dimensional simulation (€4,132,711). This indicates that the two-dimensional analysis suggests that the variation of land value is less than previously determined by the one-dimensional analysis. In the two-dimensional analysis the majority of outcomes (95 percent) lie within two standard deviations of the mean in a range from €11,000,029 to €23,747,045. This is a smaller and more robust range than the one produced by the one-dimensional simulation.

An alternative way of representing the increased robustness of the two-dimensional simulation over its one-dimensional counterpart is to look at the upper percentile. A percentile is simply a division of the range of all outcomes into 100. It is a measure of the certainty of achieving a value below a particular threshold. Thus, at the 95th percentile, 95 percent of all results will lie below that value, or, in other words, we are 95 percent certain that the value of the land will be less than that value (see Figure 4).

In the one-dimensional simulation, the 95th percentile was €24,457,339, whereas the 95th percentile for the two-dimensional simulation was lower at €22,521,981. Thus, at the same level of certainty, the two-dimensional model produces a smaller range of outcomes than the corresponding one-dimensional model. Again this indicates the tendency of one-dimensional simulation results to overestimate the population risk.

Conclusion

This paper began by looking at the simple application of a static feasibility study to the problem of assessing land value for a regeneration site in a Northern Italian municipality. It was seen that the ballpark approach could provide a rough estimate of land value, but as it failed to account for timing and the possibility of phased receipts it was argued that a cash flow model should be preferred. The same calculation was therefore undertaken projecting forward the most likely timings of expenditure and revenue receipts. In the second approach – the cash flow model – a higher land value was estimated. However, both versions of the feasibility study worked within the

Statistics	
First simulation (uncertainty)	100
Second simulation (variability)	1,000
Mean (€)	17,373,537
Median (€)	17,356,436
Standard deviation (SD) (€)	3,186,754
Skewness	0.009
2 × SD range minimum (€)	11,000,029
2 × SD range maximum	23,747,045

Table IX. Crystal Ball 2D cash flow analysis to land value (statistics)

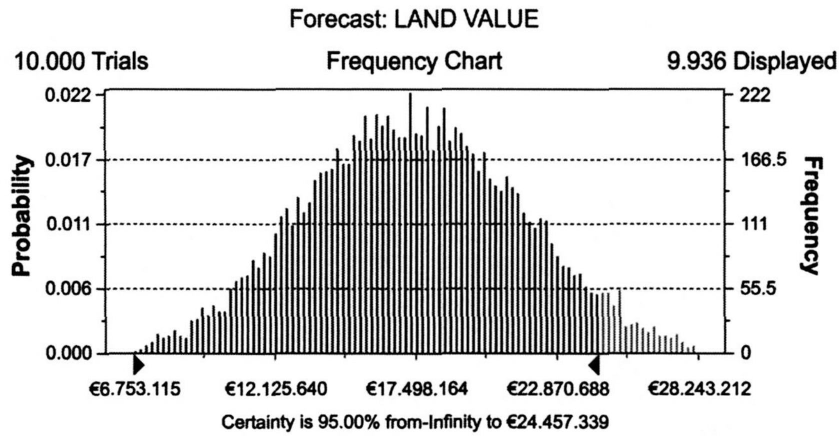

Figure 4. 1D cash flow analysis – 95th percentile

parameter of a fixed, predetermined, set of variables. The appraiser ascribes a figure to each of the inputs based on an analysis of the market coupled with his or her expert opinion. But, as with all models of this type, by fixing the input variables the appraiser will produce a single point answer for the land value. In reality, there will always be uncertainty. The appraiser will not be absolutely certain of any of the chosen input figures yet the model effectively ignores uncertainty in the inputs and thus suggests certainty in the output, i.e. the land value figure. This may be misleading.

It was therefore suggested that the cash flow model could be adapted, with the use of a generic computer programme called Crystal Ball, to introduce a range for each of the critical inputs and thus produce a range of outcomes. The argument is that the introduction of uncertainty into the feasibility analysis allows the decision maker, the municipality, to quantify the upside and downside risk of the project as indicated by the range of possible land values. This adaptation of the cash flow approach was undertaken by ascribing a probability distribution to each input variable to better reflect market conditions. As each variable operates in a distinct fashion, the distributions were expanded or contracted as appropriate with corresponding changes to the skewness and the maxima and minima of the ranges. There will always be debate about the choice of the probability distribution chosen. However, for illustration of the model, normal distributions were chosen for each variable.

The Crystal Ball programme allows the appraiser to model this uncertainty by carrying out multiple calculations (using a Monte Carlo technique) that give a range of outcomes. A single point value can still be produced by reference to the mean (or median) of the outcome distribution. The outcome of this simulation model (one-dimensional) was to produce a mean not dissimilar to the static cash flow model, but through the use of the standard deviation it was possible to present the municipality with a range of possible outcomes, which implicitly gave an indication of the risk of the project. Thus a one-dimensional simulation is better than single-point estimates for showing the true probability of risk.

For this reason, it is argued that the one-dimensional analysis should be preferred to the static cash flow model. However, the model can be improved further by separating out the concepts of uncertainty and variability. Statistically these are distinct concepts: if allowed for in the analysis in the correct way, the simulation (called a two-dimensional simulation) allows the appraiser to reflect more accurately the variation in an input due to lack of knowledge (uncertainty) and the variation caused by natural variability in a measurement or population. The use of the two-dimensional simulation produced a very similar mean result but the standard deviation was much lower, resulting in a smaller more robust range.

More work will be required to develop these techniques for the real estate profession, but we believe that the use of a Monte Carlo model coupled with an analysis that recognises the difference between uncertainty and variability will provide the client with a robust and accessible way of expressing and understanding risk and thus lead to better decision making. Ultimately any model is only there to aid the decision maker by providing information in an appropriate form to support, in this case, the city regeneration process.

Notes

1. Recent national laws and local planning regulations have tried to move all production activities located very close to the city centres to new localities on the outskirts.

2. Piano di Riqualificazione Urbana (PRU).
3. The starting point of any analysis is to determine "today's" values. The question of whether these current values should be projected forward to give future estimates will be considered in the cash flow analysis later on.
4. In Italy, as with most continental European countries, capital values are estimated per unit area, in this case € per square metre.
5. Based on Law 143/49, the professional fees are calculated as a percentage of the total costs of the works, divided into classes and categories (art. 14).
6. In the UK, this approach is referred to as the traditional residual approach.
7. It is the convention in Italy to ignore the taxation element on the land purchase due to the complexities of the Italian local and national fiscal systems. The tax rate varies significantly according to the nature of the buyer, the seller, the municipality, the property type, etc. As such, all valuations are carried out gross of tax. Obviously, this distorts the resulting land value figure but it is still the market norm.
8. It is the convention in Italy is to keep all expenditure and revenue figures in current-day terms. However, the model can easily incorporate inflationary growth in costs and sale prices. The impact of working only in current day terms is that the resulting figure is a conservative estimate that may help to offset the fact that tax on land purchase is also omitted.
9. An alternative would be to use @risk, which is a very similar software package.
10. We chose 10,000 iterations as it is sufficient to allow consistent results between different simulations.
11. This captures 99 percent of possible outcomes based on approximately 2.6 standard deviations from the mean.

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Further reading

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