Sensitivity Analysis

in

Land Development Projects

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I. Introduction

Discounted cash flow techniques have become a widely utilized method to analyze land development projects. These procedures have generally been applied in a deterministic framework with single-point estimates of the necessary input variables and implicit assumptions concerning the reinvestment rate of released capital. This paper examines the effect of the reinvestment rate assumption and the effect of estimation errors of uncertain variables on the rates of returns in land development projects.

The paper first provides a theoretical perspective and defines a discounted cash flow (DCF) model for land development projects. Next, common estimation errors are discussed and then a simulation methodology to examine the effects of these errors on rates of return is described. The results of the simulations are then presented in tabular and graphic form, and finally, the implications of the research are discussed.

II. Background

Previous Research
In the 1970's, the use of discounted cash flow (DCF) models was advocated by academics, but it was not widely adopted in professional practice. Also, the role of the reinvestment rate with DCF models was debated. Some argued that there was not a reinvested rate assumption in the DCF analysis. To rebut this position, George Gau and the author attempted to demonstrate how the reinvestment rate could be explicitly considered in the DCF framework and that when the reinvestment rate was equal to the internal rate of return, the traditional IRR formulation reappears. This research was expanded to demonstrate how estimation errors of uncertain variables could effect the IRR.[1] The formulation of the reinvestment rate in the traditional DCF framework is presented in the Appendix of this paper for reference.

Previous Professional Experience
The DCF models developed out of the debt-equity valuation framework that was advocated by Leon Ellwood in the 1950's and 1960's. Consequently, real estate was

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[1] George W. Gau and Daniel B. Kohlhepp, "Reinvestment Rate and the Sensitivity of Rates of ReturnIn Real Estate Investment," Journal of the American Real Estate and Urban Economics Association, Volume 4, Number 3 (Winter 1976), pp. 69-83.

valued as two types of capital: debt and equity. Usually, analysts assumed "typical financing" and then solved for equity values or rates of return on equity. In the 1970's, real estate investment was driven by tax shelters for equity investments, and in the 1980's, real estate investment was driven by debt capital with equity participation provisions. After the real estate market collapsed in the early 1990's, real estate investment experienced a 'back to basics' reformation. In this spirit, the author proffers that the analysis of traditional real estate investments and land development investments should focus on the value and profitability of the real estate enterprise; that is, the return on total capital whether debt or equity. Only when the risks and returns of the real estate enterprise are properly understood can viable financing and equity capital participations be structured effectively and successfully executed. Thus, the proceeding analysis will focus on the returns on and the risks of total capital rather than a particular class of capital.

III. Land Development Model

The DCF model used in traditional real estate investment analysis can be specified as:

$$(1) \quad A = \sum_{t=1}^{n} \frac{CF_t}{1+IRR^t} + \frac{R_n}{1+IRR^n}$$

where:

A = Acquisition Cost
CF_t = Cash Flow in year t
R_n = Reversionary Income from property sale in year n
n = number of years in the holding period
IRR = Internal Rate of Return

However, the land development DCF model is modified to eliminate the reversionary income at the end of the holding period since the project should be sold out at that time. Thus, the DCF Model for Land Development can be specified as:

$$(2) \quad A = \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t}$$

Or expanded to:

$$(3) \quad A = \sum_{t=1}^{n} \frac{R_t - H_t - X_t}{(1+IRR)^t}$$

where:

R_t = Revenues in year t
H_t = Holding Costs in year t
X_t = Development Expenditures in year t

In the above DCF models, the annually released cash flows are assumed to be reinvested at the internal rate of return, but this assumption is usually not appropriate in land developments because of the higher returns and the irregular cash annual flows. The reinvestment rate can be explicitly considered by modifying Equations (2) and (3) and the resulting internal rate of return is commonly referred to as the "modified internal rate of return" or MIRR. The simple and expanded DCF models for an explicit reinvestment rate are as follows:

$$(4) \quad A = \frac{\sum_{t=1}^{n} CF_t (1+i)^{n-t}}{(1+MIRR)^n}$$

where:

i = reinvestment rate

MIRR = Modified Internal Rate of Return

$$(5) \quad A = \frac{\sum_{t=1}^{n} (R_t + H_t + X_t)(1+i)^{n-t}}{(1+MIRR)^n}$$

IV. Estimation Errors

This paper examines the effect of different error rates in the estimation of the input variables on the Modified Internal Rate of Return (MIRR). In the above model, equation (5), the uncertainty rests in the estimation of A, R, X, n, and i.

1. Initial Acquisition Cost, A
The estimation of the initial acquisition cost will usually be known with a high degree of certainty at the time of closing, time period zero. However, the initial acquisition cost and terms of acquisition are usually extensively negotiated sometimes up to the time of closing. Besides the purchase price, other acquisition costs can include transfer taxes, environmental tests and reports, geotechnical studies, market studies and appraisals, environmental remediation costs and insurance premiums, letters of credit, as well as legal and accounting fees.

2. Revenues, R
The revenues in a land development can vary by amount and time. Revenues are usually determined by the price of land and amount of land sold in a particular year. Consequently, this variable is influence by market conditions as well as land production considerations. In a mixed-use project, multiple land use markets must be evaluated and the production considerations are usually more complex.

3. Capital Expenditures, X
The capital expenditures in a land development are determined by the production schedule which is influence by physical and engineering considerations as well as perceived market conditions. The costs of required off-site utilities are often very difficult to estimate as are the cost of municipal proffers and other subdivision

requirements because the open-ended nature and dynamic specificity of these expenditures.

4. The Development Period, n

The development period is usually estimated based on market conditions and production schedules. However, changing market conditions can dramatically alter sell-out projections. Also, delays in obtaining municipal approvals or building permits can be caused by changing political sensitivities and neighborhood concerns (NIMBYs).

5. Reinvestment Rate, i

The estimated reinvestment rate is determined by the expected available returns on alternative investments. Deviations from the expected reinvestment rate would be caused by changes in the financial markets, interest rates, and amount and timing of annual cash flows

The error rates of the input data are defined as the actual (realized) value of the variable minus its estimated (expected) value divided by the estimated values, so that:

Error rate = (actual value – expected value)/ expected value

The resulting change in the MIRR (% Diff) for a given error rate for an input variable would be similarly defined as:

% Diff = (Actual MIRR- Expected MIRR)/ (Expected MIRR)

Finally, the elasticity or sensitivity of the MIRR to given error rates would be defined as:

Elasticity = % Diff / Error Rate

The elasticity's would be interpreted as follows:

If Elasticity < 1.00, then the MIRR is inelastic or insensitive to errors of estimation.

If Elasticity = 1.00, then the MIRR is perfectly elastic or sensitive to errors of estimation.

If Elasticity is > 1.00, then the MIRR is highly elastic or highly sensitive to errors of estimation.

V. Methodology

A simulation study was used to examine the sensitivity of the MIRR to errors of estimation. Equation (5) was used and applied to the Potomac Yard land development

project which is currently being developed by Crescent Resources, LLC. A 300-acre, former rail-switching yard, Potomac Yard is adjacent to Reagan National Airport and the George Washington Memorial Parkway in Arlington County and the City of Alexandria, Virginia. This mixed-use development has approximately 10 million square feet of building development, of which 5.5 million is in Alexandria and 4.5 million is in Arlington. The land uses are broken down in terms of building area as follows:

Residential	4,100,000
Office	4,400,000
Retail	500,000
Hotel	1,000,000

The development was analyzed in 2000 and acquired in 2001. The following estimated values were used as the "expected values" in the base case:

Acquisition Cost, A	123,300,000
Total Revenues, R	478,800,000
Total Development Expenditures, X	112,700,000
Total Cash Flow, CF	242,200,000
Development Period, n	13 years
Reinvestment Rate, i	15.00 %
MIRR	15.06%

Given the above expected values, the MIRR was calculated for each variable, except development period, given the following error rates:

    Plus   50%
    Plus   25%
    Minus 25%
    Minus 50%

The Development Period was given "whole year" error rates of plus or minus six years and three years. Consequently, the error rates for the Development Period were:

    Plus   46%
    Plus   23 %
    Minus 33 %
    Minus 54%

The results of these simulations are discussed in the next section.

VI. Results

The results of the simulation runs are summarized in Table 1. This matrix has the error rates on the vertical axis and the input variables on the horizontal axis. Each cell displays the actual MIRR, the percentage difference form the estimated MIRR (15.06%) and the elasticity of the MIRR to the error level or changes in the input variable.

Table 1
Sensitivity Results

	Total Revenues	Development Expenditures	Acquisition Cost	Reinvestment Rate	Development Period
Base Case	478,800,000	112,700,000	123,300,000	15%	13 years
MIRR	15.06%	15.06%	15.06%	15.06%	15.06%
plus 50%					
MIRR	20.11%	12.89%	11.53%	18.81%	12.28%
% Diff	33.49%	-14.41%	-23.46%	24.90%	-18.49%
Elasticity %	66.99%	-28.82%	-46.92%	49.80%	-36.97%
plus 25%					
MIRR	17.90%	14.04%	13.10%	16.89%	14.73%
% Diff	18.88%	-6.79%	-13.00%	12.16%	-2.18%
Elasticity %	75.51%	-27.18%	-52.01%	48.64%	-8.71%
Minus 25%					
MIRR	11.00%	15.99%	17.64%	13.32%	17.42%
% Diff	-26.99%	6.14%	17.09%	-11.54%	15.64%
Elasticity %	107.94%	-24.55%	-68.38%	46.16%	-62.55%
Minus 50%					
MIRR	3.52%	16.83%	21.36%	11.68%	23.29%
% Diff	-76.62%	11.74%	41.84%	-22.43%	54.61%
Elasticity %	153.24%	-23.48%	-83.68%	44.85%	-109.22%

The results demonstrate that the MIRR is most sensitive to errors in the estimation of the revenues, development period, and acquisition cost. The MIRR was highly elastic (E>1) to over-estimation errors in the total revenues and large over-estimation errors in the development period.

Table 2 regroups the results in terms of the most important "Big Mistakes."

Table 2
Most Important Big Mistakes
50% Error Rate

Error	Variable	Elasticity	% Difference	Result?
Over-estimating	Revenue	153.24	-76.62%	Bad
Over-estimating	Development Period	-109.22	54.61%	Good
Over-estimating	Acquisition Cost	-83.68	41.84%	Good
Under-estimating	Revenue	66.99	33.49%	Good

Clearly, over-estimating the project revenues by 50% is a very bad mistake. Significant market research combined with an appreciation of Murphy's Law can significantly minimize this error.

Over-estimating the Development Period can be the kind of mistake that makes marginal projects look very attractive in hindsight. This is a "good" mistake in the sense that the error significant raises the actual MIRR. Like-wise, over-estimating the Acquisition Cost and under-estimating the Revenues would be good mistakes that improve the profitability of the project.

Table 3 summarizes the most important "Small Mistakes."

Table 3
Most Important Small Mistakes
25% Error Rate

Error	Variable	Elasticity	% Difference	Result?
Over-estimating	Revenue	107.94	-26.99%	Bad
Under-estimating	Revenues	75.51	18.88%	Good
Over-estimating	Acquisition Cost	-68.38	17.09%	Good
Over-estimating	Development Period	-62.55	15.64%	Good

Once again, the importance of the accurate estimation of Revenues is critical to achieving the expected returns. Of course, the effect of over-estimating revenues is bad, while the effect of under-estimating revenues is good. Also, the actual profitability or MIRR of the project is sensitive to the smaller errors in estimating the Acquisition Cost and Development Period.

The effect of estimations error on the MIRR is shown graphically in Figure 1.

Figure 1
MIRR Chart
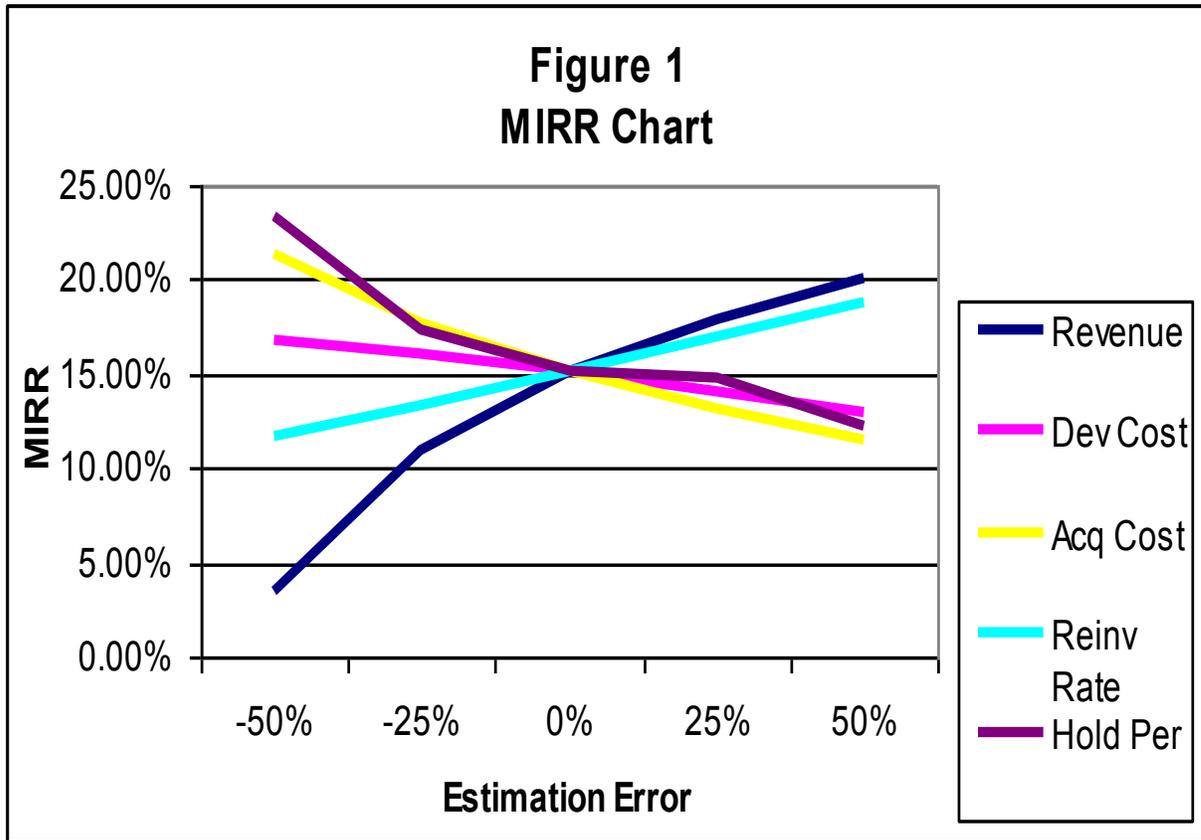
Reinvestment Rate
The effects of incorrectly estimating the reinvestment rate were not as great as estimation errors of revenues, acquisition costs, or development period. However, the probability of incorrectly estimating the reinvestment is very high, especially if the traditional IRR calculation is used and the reinvestment rate is assumed to be equal to the IRR. In the base case analysis, the reinvestment rate is estimated to be 15% which is essentially the same as the IRR so the resultant base case MIRR is 15.06%. There is a very strong likelihood that the reinvestment rate should be closer to 7.5%, which would be a 50% error. The resultant MIRR drops 44.85 % to 11.68% and would usually be considered too low to justify taking the risks in a land development.

VII.   Conclusions and Implications

Conservatism, Optimism, and Realism
When one makes economic and financial projections for land development projects, the only certainty is that the projections will be incorrect. The issue therefore becomes what types of errors are made and what are the consequences of those errors. This analysis has demonstrated that there are good mistakes and bad mistakes and some mistakes are more costly (or profitable than others). Some may conclude that by being conservative bad

mistakes can be avoided because the actual results will be better than the predicted ones. However, if the developer is overly conservative, then the contemplated land development will be under-priced, and his competitors will out-bid the conservative developer every time. Conversely, overly-optimistic developers have a very short expected life-span, economically speaking. The best approach to making economic and financial projections for land developments is to be as realistic and accurate as possible and then be philosophically able to live with the effect of the uncertain outcomes on the profitability of the project.

Know the Facts; Know Thyself; Know Thy Deal; and Know Thy Comfort Zone
Fact gathering is a critical first step in making accurate projections. Many times, a developer chooses to ignore certain fact because they are uncomfortable or don't fit into the developer's view of the world. These are the most important facts to have. Ignoring soil conditions, new competitive projects, buyers' preferences or political power can lead to disastrous consequences.

All developers have personal biases that help them understand the world in which they live. Understanding these perceptions, biases, and propensities will make the developers better able to have a clear-sighted view of the future into which they developing. A panel of experts (inside or outside the firm) can be very useful for making accurate projections and overcoming these personal biases.

Each land development is unique and quirky in its own way.   A thorough understanding of how the development will be staged, constructed, marketed, and exited is critical to good decision-making. Different ways of doing the development should be considered almost to ad nauseam. Again, the tendency to decide "this is the way it's going to be done", must be overcome to allow for a full understanding of the risks inherent in the enterprise. Each member of a multi-disciplinary development team will have a unique perspective about what can go wrong and what can go right in the development process.

This paper has discussed risk from an economic and financial perspective as a "deviation from the expected." (If things are expected to go bad and things do go bad, then there is no risk.) However, from the perspective of human decision-making under conditions of uncertainty, risk is also an emotional experience. There are certain risks that some individuals should just not take. Environmental risks, political risks, or market risks can cause individual anxiety that is disproportional to the uncertainty involved. If this occurs, then these risks should be avoided.   Also there may be some financial and economic risks that an individual or a company can not afford to take because if they are wrong the person or company will go bankrupt. In these instances, these risks should be avoided or transferred to other more financially capable parties.

Match the Financial Deal to the Real Estate Enterprise
This paper has not dealt with the additional risks that are created by various financial schemes. The estimation errors in the financial risks cannot be properly analyzed until the full complexity of the land development (the real estate enterprise) is understood. The biggest mistake that the author has observed and experienced is structuring financial

and ownership arrangements that cannot be supported by the enterprise. When estimation errors occur in the land development process, what will happen to the financing scheme? Will debt partners take over? Will minority partners gain control? Or will developers lose interest and leave? The financing and ownership structure will only be successful if it is robust enough to withstand errors of estimation and still allow the real estate enterprise to be viable.

The Law of Off-setting Errors
Finally, many successful developers have survived serious miscalculations and detrimental blunders through the operation of the Law of Off-setting Errors. Only in the luxury of scientific analysis of economic models can the analyst assume "all other things remaining constant." Given the dynamic nature of the development process, almost all things don't remain constant. Fortunate developers have their bad mistakes more than off-set by their good mistakes while unsuccessful developers have their good mistakes more than off-set by their bad mistakes. Understanding the inter-relation between estimated variables is critical but very difficult. Non-quantifiable, intuitive decision-calculus, tempered by experience and personal relationships, is often the best way to determine the relationships between pricing and absorption, between development costs and sales prices, or between the political approvals and the development costs. Like Murphy's Law, respect for the Law of Off-setting Errors is vitally important to evaluate properly the effect of estimation errors on rates of return in land development projects.

Appendix

Derivation of the Discounted Cash Model with a Specified Reinvestment Rate

Basic Model

The discounted cash flow method identified as the internal rate of return (IRR) calculates the value of a real estate project by determining that rate of discount which equates the net cash inflow of an investment of its initial cash outflows. The IRR model often cited in the analysis of real estate investments takes the basic form:

(1) $E_o = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} + \frac{R_n}{(1+r)^n}$

where:

E_o	= equity invested in the project at origination (t=0)
CF_t	= net cash flow (after financing charges) in period t
R_n	= reversion at end of holding period t=n
r	= rate of return on the equity or the internal rate of return

Specifically, the two major sources of cash inflow of a real estate project consist of the flows resulting from the operation of the investment during the holding period and changes in the net value of the project by the end of the holding period. The cash flows in each period are determined by the net operating income (O_t), the interest payments on the debt (I_t), the mortgage amortization payments (A_t), and the income taxes accruing to the project (T_t). The reversion flow at the end of period t=n is a function of the selling price of the project (S_n), the capital gains tax (GT_n), and the unpaid mortgage balance at the time of the sale (UM_n).

(2) $Eo = \sum_{t=1}^{n} \frac{O_t - I_t - T_t - A_t}{(1+r)^t} + \frac{S_n - GT_n - UM_n}{(1+r)^n}$

The net cash inflow stream can be further divided into two components: a flow derived from the productivity of the investment and a flow resulting from the tax shelter benefits.

(3) $E_0 = \sum_{t-1}^{n} \frac{(1-x)(O_t - I_t) - A_t}{(1+r)^t} + \sum_{t=1}^{n} \frac{x(I_t + D_t)}{(1+r)^t} + \frac{S_n(1-cx) - UM_n}{(1+r)^n} + \frac{cx(B_o + L_o)}{(1-r)^n}$

where:

x	= income tax rate
D_t	= depreciation allowance in period t
cx	= capital gain tax rate
B_o	= building cost at t=0
L_o	= land value at t=0

The first term in the equation (3) represents the net cash flow without tax shelter benefits; the second term is the tax shelter benefits resulting from leverage and depreciation; the third term is the net cash flow reversion at time of sale; and, the final term is the tax shelter benefits derived from the favorable treatment of capital gains.

Reinvestment Rate

One of the problems with the application of either the internal rate of return or present value framework is the question of the correct specification of the rate of the investment of the cash flows from the real estate investment. The well-known proposition is that the present value approach implicitly assumes the reinvestment of intermediate cash flows at the discount rate, while the IRR approach assumes the reinvestment is at the derived rate of return. According to this proposition, the model specified in equation (1) assumes that the CF_t will be reinvested with a return $= r$. However, as has been noted by Dudley, the reinvestment rate problem results not just from the implicit assumptions, but rather because there are no assumptions implicit in the techniques. The assumptions about the reinvestment rates are implicit in the decision to employ a technique and <u>not</u> make any explicit estimate of this rate.

One method of developing an alternative IRR model that includes a reinvestment rate $\neq r$ is through the initial employment of the capital budgeting decision criterion of net terminal value (NTV). In terms of our basic model, the NTV of the equity will equal:

$$(4)\ NTV = \sum_{t=1}^{n} CF_t \prod_{t=1}^{n} (1+i_t) + R_n - E_0(1+k)^n$$

with:

      k = required rate of return on the equity
      i_t = reinvestment rate in period t

If i_t is assumed to be constant over the holding period,

$$(5)\ NTV = \sum_{t=1}^{n} CF_t(1-i)^{n-t} + R_n - E_0(1+k)^n$$

The project return can be derived from the above NTV formulation by finding the r that will equate E_o in NTV terms with CF_t and R_n in NTV terms.

$$(6)\quad Eo(1+r)^n = \sum_{t-1}^{n} CF_t(1+i)^{n-t} + R_n$$

Dividing through by $(1+r)^n$ to transform equation (6) into present value terms,

$$(7)\quad E_o = \sum_{t=1}^{n} \frac{CF_t(1+i)^{n-t}}{(1+r)^n} + \frac{R_n}{(1+r)^n}$$

Equation (7) thus represents an IRR model that explicitly considers the effect of the reinvestment rate on the rate of return of a real estate investment.

Notice that is i=r, equation (7) reduces to the basic model, equation (1). Substituting r for i in equation (7),

(8) $E_o = \sum_{t=1}^{n} \dfrac{CF_t(1+i)^{n-t}}{(1+r)^t} + \dfrac{R_n}{(1+r)^n}$

(9) $E_o = \sum_{t=1}^{n} \dfrac{CF_t(1+r)^{-t}}{(1+r)^t} + \dfrac{R_n}{(1+r)^n}$

(1) $E_o = \sum_{t=1}^{n} \dfrac{CF_t}{(1+r)^t} + \dfrac{R_n}{(1+r)^n}$