Real Options and Land Valuation

An Empirical Study

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Introduction

Real option theory is well-developed

Real option models allow to value

- oil fields
- new pharmaceuticals
- vacant land

How accurate are valuations?

How useful is the approach for making investment decisions?

Investment decisions

Owner of a real asset has to make the following decisions

- Use the asset immediately or later
  - Should oil field be exploited immediately?
  - Should shopping center be developed immediately?
- Sell the asset at market value V
  - How to determine the market value?
  - Depends on asset's use...

Capital budgeting: standard approach

Asset's immediate value

$$\frac{\mathcal{E}[C_p]}{1+R} \quad - \quad I$$

$$\text{Project's present value} \quad - \quad \text{Implementation costs}$$

Use asset immediately whenever

$$\text{Project's present value} \quad - \quad \text{Implementation costs} \quad \geqslant 0$$

(or sell it at its NPV).

What if use decision is irreversible and owner can postpone use?

Option characteristic of some real asset

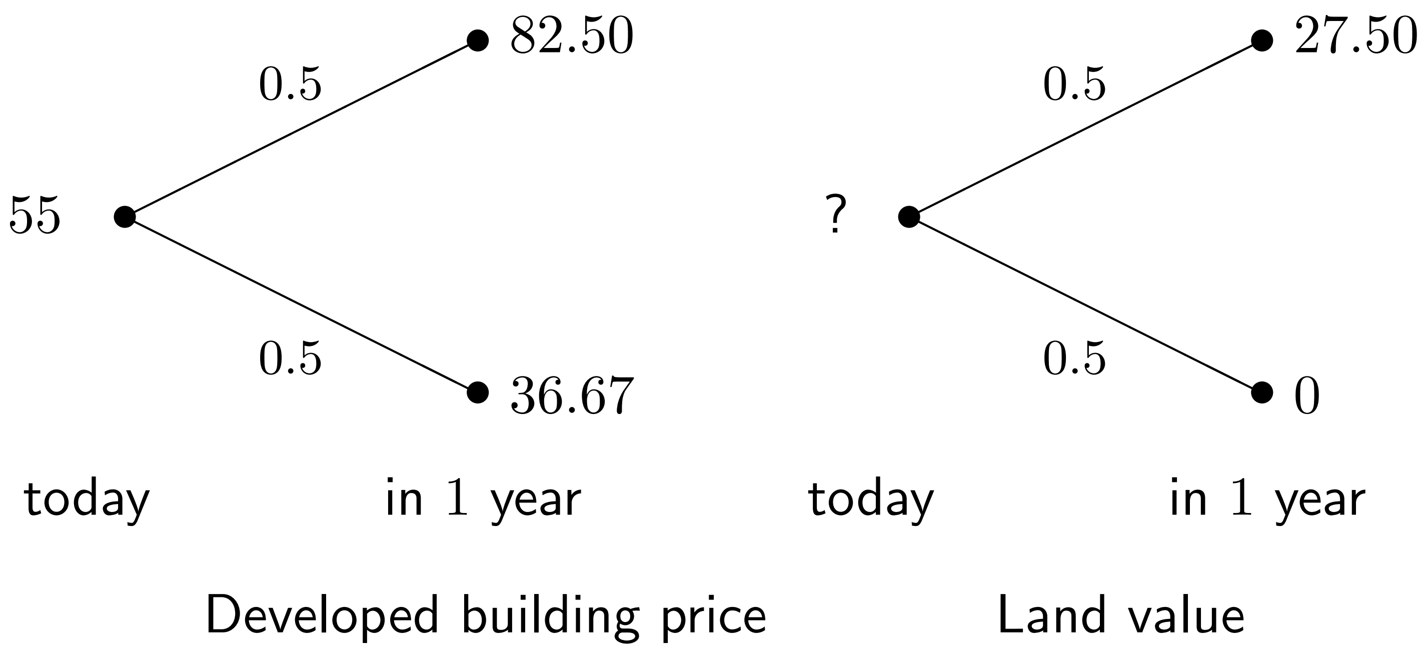
- owner can choose between different alternatives

Different to financial options, real options

- are not standardized
- are not traded at exchanges
- have a real asset as underlying

Example: Property development

Implementation cost are 55 in all states



NPV (residual value) is zero and postponing development is better.

How to value a real option?

Real options can be valued with the replicating portfolio approach

Construct a portfolio consisting of

- underlying asset (building in the example)
- riskfree bond

so that

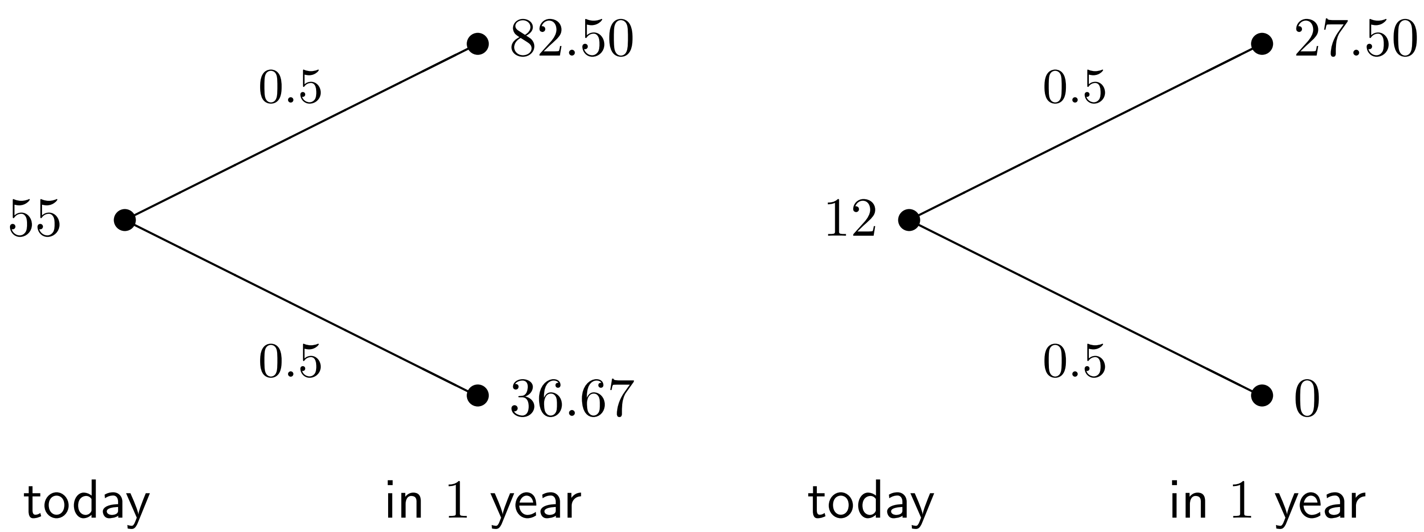
- portfolio replicates real option's cash flows

Rule out arbitrage opportunities

$$\text{Value of portfolio} = \text{Value of real option}$$

Example, continued: Property development

Replicating portfolio: Buy 0.6 'buildings' today, which cost $0.6 \times \$55 = \$33$ and borrow $\$21$ at the riskfree rate of 5%.



Developed building price

Land value

Literature overview

McDonald and Siegel: 1986, The value of waiting to invest, *QJE* 101

Paddock, Siegel, and Smith: 1988, Option valuation of claims on real assets: The case of offshore petroleum leases, *QJE* 103

Titman: 1985, Urban land prices under uncertainty, *AER* 75

Capozza and Li: 2002, Optimal land development decisions, *JUE* 51

Quigg: 1993, Empirical testing of real option-pricing models, *JF* 48

Flexibility of land ownership

When to develop?

- option of deferral

What to built?

- option of use (if multi-use is possible)

With which size?

- option of scale

Bewag data

Electricity company Bewag in Berlin had

- old transformer stations not needed for operation
- listed buildings
- costly if held undeveloped

Feasibility analysis

- find ideas for redevelopment
- estimate the value of developed site
- estimate the implementation costs

Action

- develop? or sell sites + ideas?
- contact potential buyers

Projects

- MetaHaus (MetaDesign)
- Atelierhaus Zeppelin
- Vitra Design Museum
- Administrative building ‘Substation Scharnhorst’

Data

Information on 12 sites

- current state of sites
- cash flow forecast after development
- surveyor valuations

Research questions

- What are real option land values?
- How good are they compared to other valuations?
- What has happened with the sites?

Table 1: Descriptive Statistics

Most sites have listed buildings on them

- low flexibility of use choice
- low flexibility of size choice

Flexibility exists in timing of redevelopment (deferral option)

Allows use of a 'simple' real options model

- only value driver are rents
- land is indestructible $\Rightarrow$ American option

The model

$D(t)$ is the rent in period t, R the required return rate

Rental growth rate follows a Brownian motion

$$\begin{aligned} \frac{dD(t)}{D(t)} &= G \times dt + \sigma \times dW \\ \text{Rental growth rate} &= \text{Expected growth rate} + \text{Shock} \end{aligned}$$

The current value of building is then

$$\begin{aligned} V(t) &= \frac{D(t)}{R-G} \\ &= \frac{D(t)}{\theta} \end{aligned}$$

Residual value

Residual value gives value of land under the premise that land can be developed only now or never.

The NPV of immediate development is

$$\text{NPV} = V(t) - I \ ,$$

where I are the implementation costs of the development project

Residual value is then

$$L_R(t) = \max[V(t) - I, 0]$$

Real option value

Real option value gives the value of land under the premise that land development can be postponed.

It holds that

$L_O(t)$	$\geqslant$	$L_R(t)$
Real option value	is at least as large as	Residual value

If $L_R(t) = 0$, then $L_O(t) > L_R(t)$ because

- immediate development would mean $V(t) - I \leqslant 0$
- leave land undeveloped and wait for higher $V(t) \Rightarrow$ positive value

If $L_R(t) > 0$, the following aspects are important

1. undeveloped land is like holding building's capital value
   - expected return rate on $V(t)$ compensates for risk
   - money value of implementation costs sinks

   $\Rightarrow$ benefit of waiting

2. land produces no income D

   $\Rightarrow$ cost of waiting

Develop if benefit of waiting = cost of waiting and

$$L_O(t) = L_R(t) > 0$$

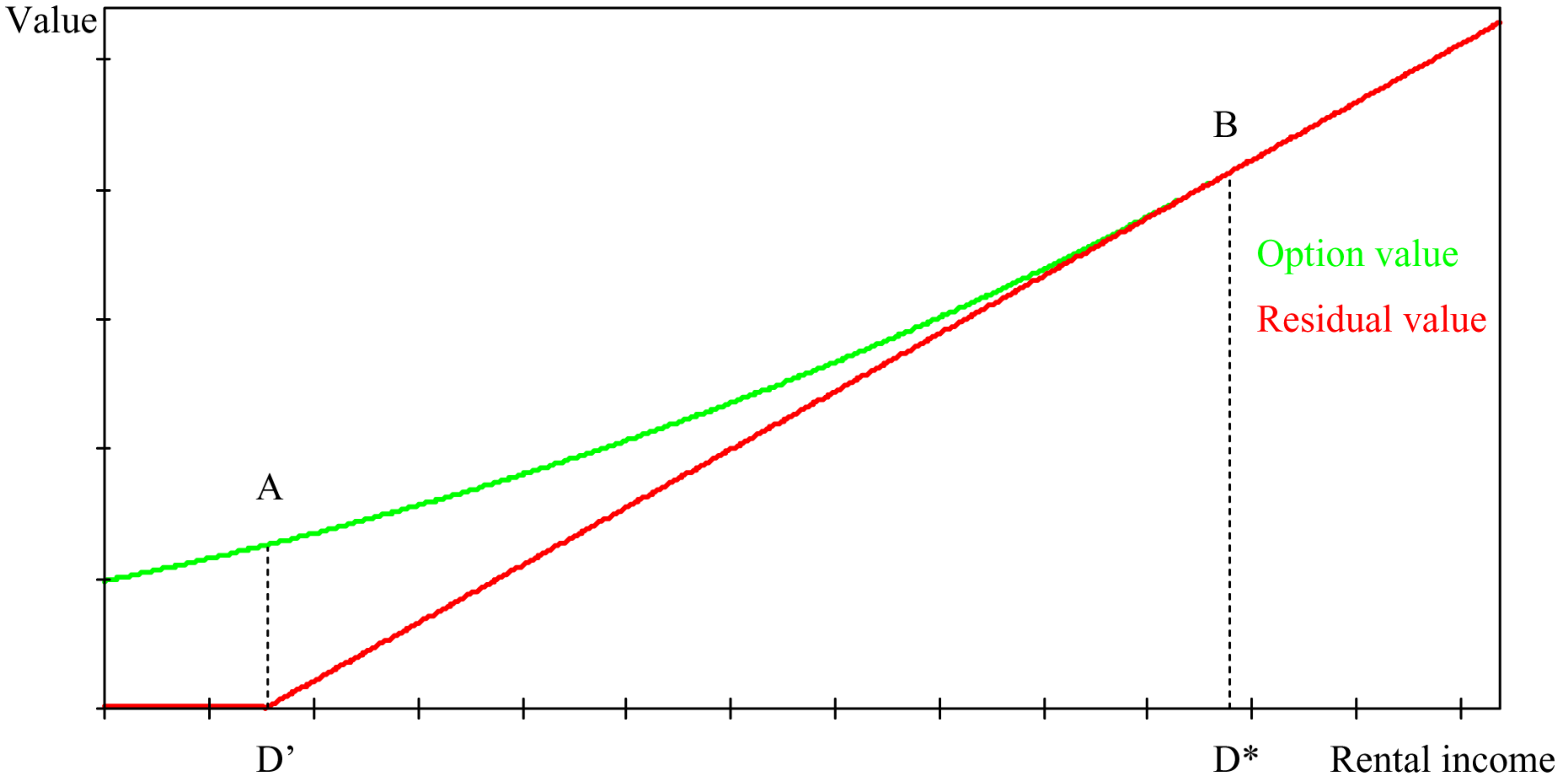


Figure 1: Residual and real option land values

The real option valuation formula

$$L_O(t) = \begin{cases} \left(\dfrac{D^*}{\theta} - I\right) \times \left\{\dfrac{D(t)}{D^*}\right\}^{\alpha} & \text{, if } D(t) < D^*, \\ \dfrac{D(t)}{\theta} - I & \text{, if } D(t) \geqslant D^* \end{cases}$$

with

$$D^* = \frac{\alpha}{\alpha - 1} \times \theta \times I$$

$$\alpha = \frac{1}{\sigma^2}\left[0.5 \times \sigma^2 - (R_f - \theta) + \sqrt{\{0.5 \times \sigma^2 - (R_f - \theta)\}^2 + 2 \times R_f \times \sigma^2}\right]$$

R_f is the riskfree interest rate, set to 4.2%

Tables 2 and 3: Volatility σ and development criteria

For every transaction, four different valuations are observed

- real option value
- residual value
- simple comparison value
- adjusted comparison value

Results

Table 1: Statistics for the valuation ratios of the different techniques

	Mean	Median	Std. Dev.	Min	Max	MSE
Q_E	114.7	85.7	86.9	41.7	355.9	77.6
Q_A	86.8	80.3	28.8	50.3	131.2	10.1
Q_R	84.0	76.3	69.4	0.0	198.0	50.7
Q_O	94.5	76.3	57.8	22.7	198.6	33.8

Notes: Figures in percent. MSE is the Mean Squared Error.

Real option values react very sensitive to θ and σ

Using homogenous cap rate $\theta = 6.4\%$

- recall: $\theta = R - G$
- WertV: $\theta \in [5.0\%, 6.5\%]$

improves real option values (mean error reduces to -4%, MQF 26.7%).

Other options can be modelled with higher volatilities.

Reverse the question: What are the implied volatilities?

Table 5: Implied volatilities

Summary and outlook

Property development comes with much flexibility.

Real options approach considers flexibility explicitly and values it.

Empirical micro study shows that

- real option values are better than residual values
- do not consider all options
- implied volas can be calculated with historical transactions

⇒ task for the future: more data...