Binomial Model in Real Options Analysis

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Problems with traditional capital budgeting methods motivate ROA

Net present value

The binomial model

Real options analysis (ROA)
I investigate the application of the binomial model in valuing real options.
I investigate the application of the binomial model in valuing real options
A real option is the right (not obligation) to undertake some business decision

• Types of real options include
  – Option to invest
  – Option to wait
  – Option to expand
  – Option to contract
A real option is the right (not obligation) to undertake some business decision

*GM’s plant development project*

GM wants to build a factory that produces fuel efficient cars. The project costs $60 million immediately for permits, which take a year. At the end of the year, GM could invest $400 million to complete the design phase. Once the design phase is over, GM has a two-year window during which it can invest the $800 million needed to build the plant.

*Question*

Which types of real options can you identify?
A real option is the right (not obligation) to undertake some business decision

*GM’s plant development project*

GM wants to build a factory that produces fuel efficient cars. The project costs $60 million immediately for permits, which take a year. At the end of the year, GM *could invest $400 million* to complete the design phase. Once the design phase is over, GM has a two-year window during which it *can invest the $800 million* needed to build the plant.

We can identify the following real options in this project

- GM has an option to invest $400 million in Year 1
- GM has the option to wait in Year 2.
- GM has the option to invest $800 million in Year 3
I investigate the application of the binomial model in valuing real options
Recall the three step process of the binomial model

**Step 1**

Construct a tree describing all possible states
Recall the three step process of the binomial model

**Step 2**
Make decisions at the end nodes of the tree

*Decision rule*

\[ $100(\#H - \#T) > 0 \rightarrow \text{Accept} \]

Otherwise \(\rightarrow\) Decline
Recall the three step process of the binomial model

**Step 3**
Calculate value of game at each earlier node

$182 = \frac{\text{expectation}}{1 + \text{interest rate}}$

$= \frac{(0.5)(300) + (0.5)(100)}{1.10}$
I will apply a similar three step process to evaluate GM’s plant development project

GM’s plant development project
GM wants to build a factory that produces fuel efficient cars. The project costs $60 million immediately for permits, which take a year. At the end of the year, the GM could invest $400 million to complete the design phase. Once the design phase is over, GM has a two-year window during which it can invest the $800 million needed to build the plant.

Question
What is a possible source of uncertainty?
I will apply a similar three step process to evaluate GM’s plant development project

**GM’s plant development project**

GM wants to build a factory that produces fuel efficient cars. The project costs $60 million immediately for permits, which take a year. At the end of the year, GM could invest $400 million to complete the design phase. Once the design phase is over, GM has a two-year window during which it can invest the $800 million needed to build the plant.

One source of uncertainty is the possible future values of the plant under plausible market scenarios.
Assume plant is worth $1 billion if it existed today and moves +20% or -16.7%

**Step 1**
Construct a tree describing all possible plant values.

Plant values (in $millions):

Yr 0: 1000
Yr 1: 833
Yr 2: 694
Yr 3: 579

Yr 0: 1200
Yr 1: 1000
Yr 2: 833
Yr 3: 694

Yr 0: 1440
Yr 1: 1200
Yr 2: 1000
Yr 3: 833

Yr 0: 1728
Yr 1: 1440
Yr 2: 1200
Yr 3: 1000
In year 3, GM has an option to invest $800 million to construct the plant

**Step 2**

Make decisions at the end nodes of the tree

*Decision rule*

If value of plant > 800 → invest
Otherwise → abandon
In year 2, GM has the option to wait (or invest $800 million)

Step 2.5
Calculate value of project at each earlier node and make decisions
In year 2, GM has the option to wait (or invest $800 million)

Step 2.5
Calculate value of project at each earlier node and make decisions

Decision rule
Value of project from waiting >
(value of plant – 800) → wait
Otherwise → invest $800 million in Yr 2
In year 2, GM has the option to wait (or invest $800 million)

**Step 2.5**

Calculate value of project at each earlier node and make decisions

*Decision rule*

Value of project from waiting >

(value of plant – 800) → wait

Otherwise → invest $800 million in Yr 2
In year 1, GM has the option to invest $400 million to complete the design phase

Step 2.5

Calculate value of project at each earlier node and make decisions
In year 1, GM has the option to invest $400 million to complete the design phase.

**Step 2.5**

Calculate value of project at each earlier node and make decisions.

*Decision rule*

- Value of project > 400
  - → invest 400
- Otherwise → abandon
In year 1, GM has the option to invest $400 million to complete the design phase.

**Step 2.5**
Calculate value of project at each earlier node and make decisions.

*Decision rule*
- Value of project > 400 → invest 400
- Otherwise → abandon
In year 0, GM has the option to invest $60 million for permits and preparation.

**Step 2.5**
Calculate value of project at each earlier node and make decisions.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Values (in $millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yr 0</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Abandon 71</td>
</tr>
<tr>
<td>Yr 1</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>Invest 400 114</td>
</tr>
<tr>
<td></td>
<td>wait</td>
</tr>
<tr>
<td>Yr 2</td>
<td>833</td>
</tr>
<tr>
<td></td>
<td>wait</td>
</tr>
<tr>
<td></td>
<td>wait</td>
</tr>
<tr>
<td>Yr 3</td>
<td>579</td>
</tr>
<tr>
<td></td>
<td>Abandon 0</td>
</tr>
</tbody>
</table>

Legend:
- Invest 400
- Invest 800
- Abandon

Note: The values in the diagram represent the project values at each node, indicating the decision points and the corresponding outcomes (invest, wait, abandon).
In year 0, GM has the option to invest $60 million for permits and preparation.

**Step 2.5**

Calculate value of project at each earlier node and make decisions.

*Decision rule*

Value of project $> 60 \rightarrow$ invest

Otherwise $\rightarrow$ Abandon
In year 0, GM has the option to invest $60 million for permits and preparation.

**Step 2.5**

Calculate value of project at each earlier node and make decisions.

**Decision rule**

Value of project > 60 → invest

Otherwise → Abandon
I investigate the application of the binomial model in valuing real options

Real Options

Binomial model in ROA example

Assessment of ROA
All models are simplified representations of reality, and all involve assumptions

ROA assumes that

– the source of uncertainty can be modeled as a stochastic process
– managers exercise their option rights in a timely and rational manner
The binomial model is very flexible, which allows it to model complex projects

The binomial model can reflect

– Early decision points
– Multiple decisions
– Changing volatility
Real options analysis not only evaluates a project but also gives you a feasible plan.
Real options analysis typically gives higher return and lower risk than does NPV.
Questions?

Real Options

Binomial model in ROA example

Assessment of ROA
Binomial Model in Real Options Analysis

Thank You!
References

Microsoft PowerPoint 2003 Clip Art web collections