Real Options, Corporate Performance, and Shareholder Value Creation

Cyrus A. Ramezani
Professor of Finance
Orfalea College of Business
California Polytechnic
Contact: cramezan@calpoly.edu

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Overview

Real options (RO):
- Definition
- Basic analytic
- Taxonomy
- Applications and perspectives

Real option and financial characteristics
- Performance metrics and real options

Summary and conclusions
Definitions: What Is Flexibility Worth?

Le Chatlier's principle: unconstrained optimization yields higher optimum than constrained optimization. The difference is the value of removing constraints (flexibility)

Open loop versus feedback control: in stochastic optimization feedback control results in higher optimum value of the objective function. The difference is the value of flexibility

Flexibility is valuable when there are contingencies and one has the freedom to choose

Key point: Managerial or Operational flexibility is akin to valuable options. Managerial flexibility --real options-- can be valued by drawing analogies to financial options
The magic of Black-Merton-Scholes

Economists had worked on valuing flexibility:

The Putty-Clay and valuation of intangibles

Difficult because it required knowledge of risk aversion

Solution of SDP problems

Black-Merton-Scholes showed that the value of the flexibility (option) can be derived by replication and no-arbitrage arguments provided that *certain assumptions* were met.
Real and Financial Options: The Analogy

<table>
<thead>
<tr>
<th>Financial</th>
<th>Feature</th>
<th>Real</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Price</td>
<td>Traded</td>
<td>PV of cash flows</td>
<td>Often Non-traded</td>
</tr>
<tr>
<td>Volatility</td>
<td>unobservable</td>
<td>Volatility</td>
<td>unknown process</td>
</tr>
<tr>
<td>Strike Price</td>
<td>Fixed and observable</td>
<td>Investment costs</td>
<td>Random and born</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>over time</td>
</tr>
<tr>
<td>Option Maturity</td>
<td>Fixed and observable</td>
<td>Investment Horizon</td>
<td>Random</td>
</tr>
<tr>
<td>Dividend</td>
<td>Random or estimated</td>
<td>Cash flow Leakage</td>
<td>Random</td>
</tr>
<tr>
<td>Risk free rate</td>
<td>Short term and observable</td>
<td>Long Term</td>
<td>Term Structure</td>
</tr>
</tbody>
</table>
# Taxonomy of Real Options:
Firms Possess the Following Options or Can Acquire Them As Well (Purchase IP, Form Strategic Alliances, Obtain Platforms).

<table>
<thead>
<tr>
<th>Name</th>
<th>Flexibility</th>
<th>Industry</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defer / Delay</td>
<td>Ability to wait</td>
<td>Mining and Petroleum</td>
<td>American Option: Intrinsic + Time Value</td>
</tr>
<tr>
<td>Stage Investments</td>
<td>Build over time and learn in the process</td>
<td>Biotechnology, drug development</td>
<td>Compound Options</td>
</tr>
<tr>
<td>Scale</td>
<td>Expand, Contract, Shutdown, Restart</td>
<td>Crude oil extraction</td>
<td>Barrier and Compound Options</td>
</tr>
<tr>
<td>Abandon</td>
<td>Shutdown Permanently Optimal Exit / Entry Decisions</td>
<td>All</td>
<td>American Put Option</td>
</tr>
</tbody>
</table>
The Usefulness of the Real Options Theory

A tool for capital budgeting (improves on DCF)
Useful framework for structuring business decisions
How important are real options to the value of your firm?
A method for aligning management's value creation decisions with the market
The appropriate method for valuing IP and new technology (software, IT expenditures)
Difficulties in Implementation:

Application of option pricing theory to real investment decisions are problematic:
- Traded versus non-traded underlying: Replication
- Hedging error: rebalancing and transactions costs
- Parameter uncertainty (Does it make the RO more valuable?)
- Redundancy of real options
- Violations of assumptions underlying Black-Merton-Scholes
  - Impact of exercise on underlying process
  - Influence of exercise on firm's other real options
- Inability to exercise instantaneously
Difficulties in Implementation:

Managers must optimally manage complex portfolio of options:
- Real options interactions (portfolio effects)
- Sequential and strategic exercise is required
- Industry structure matters (competition versus monopoly)
- Game theoretic models are needed
- Multiple sources of risk (input and output prices, quantity, option maturity, size of market, technology) → Ironically added uncertainty enhances the value of real option!

Path dependency arises
Simple decision rules are hard to come by!
The Atom Analogy:

Are real options *real* or mere theoretical abstractions?
How do RO influence corporate performance metrics?
How do RO impact risk adjusted equity returns?

*We need a tool to detect the existence of valuable real options:*

The extant Real Option theory offers logically consistent prescriptions
The theory also offers testable hypothesis
But real options are hard to observe in practice
This is much like the early 20th century theory describing the structure of the atom and its family of subatomic particles. Without the creation of particle detectors, the theory could not move forward.
Where Is the Beef?

Real options are:

Easy to conceptualise: multitude of managerial flexibility has been identified and valued by risk neutral valuation techniques.

Hard to detect: do equity prices reflect the value of firm’s real options? how is value realized?

Performance metrics: how does real option value affect observable performance metrics (e.g. ROI, ROE, EVA, MVA, and Tobin’s Q)?
Two Key Ingredients to Identifying Valuable Real Options:

Shareholder value creation requires active managerial control (optimal exercise of real options). Managerial flexibility should enhance the value of a firm’s real options. Uncertainty about the cash flows (revenue) generated by investment projects enhances the value of a firm’s real options. Added volatility enhances real option values!
Managerial Flexibility and Uncertainty

<table>
<thead>
<tr>
<th>Managerial Flexibility</th>
<th>Underlying Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

**Low value for real options:** Lack of volatility and managerial flexibility reduces value of real options.

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**Moderate (ambiguous):** High option value but lack of discretion to optimally exercise real options.

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**Ambiguous:** Low option value despite managerial flexibility.

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**High Value for real options:** High degree of uncertainty and managerial flexibility enhance value of real options.
Separating the Wheat From the Chaff

Use the uncertainty-flexibility matrix to identify firms with valuable options:

- How is managerial flexibility measured?
- How is underlying volatility measured?

Compare performance measures across groups:

- What performance indicators should be used?
- How to interpret the results?
Measuring Managerial Flexibility

Expenditures on investment activities from the firm’s statement of cash flows deflated by:
- Sales
- Book value of total assets
- Market value of total assets (net of cash)

Monopolization creates managerial flexibility

Research and development creates options
- R&D deflated by sales or other measures

Non-reporting problem
Measuring Uncertainty

*What is the underlying risk:* Revenue Drivers

Volatility of quarterly sales growth
Calculated from 20 or more quarters of data

Volatility of the growth rate of cash flows
Calculated from 20 or more quarters of data

Cash flow: income (after all expenses and taxes except dividends) plus depreciation (non-cash charges for obsolescence)
Measuring Uncertainty (Cont.)

What is the underlying risk?

Equity as an option on the assets of the firm
Volatility of monthly returns (total risk)
Calculated from 60 or more months of data
Returns volatility is decomposed into:
Market volatility (CAPM and S&P 500 returns)
Idiosyncratic volatility (remove market risk)
Industry decomposition is also possible
Performance Measures:

Economic value added (EVA)
EVA = return on capital minus cost of capital
Calculated by methods described in the literature

Market value added (MVA)
MVA = market value (debt + equity) minus value of total capital
"Measure of the wealth a company has created"
Calculated by methods described in the literature
Performance Measures (Cont.):

Tobin’s Q

\[ Q = \frac{\text{market value of equity} + \text{debt}}{\text{total assets}} \]

Similar to market to book

Return on investment (ROI)

\[ \text{Income (before extraordinary items) / total capital} \]

Return on equity (ROE)

\[ \text{Income (before extraordinary) / common equity} \]

Other basic ratios:

P/E, leverage, turnover, liquidity, etc.
Data Source: COMPUSTAT and CRSP (1990 to 2002)

Sample of consists of over 3000 firms with clean data

Available data for measures of volatility and managerial flexibility

Outliers (1% tail of distribution) replaced by the value of mean (includes outlier) for that SIC code

Missing data also replaced with means

EVA and MVA were calculated

Other measures (ROI, ROA, etc.) from COMPUSTAT
Searching for Real Option Value:

Four measures of managerial flexibility:
- Investment cash flow / sales
- Investment cash flow / book value
- Investment cash flow / market value
- R & D / sale

Five measures of risk (volatility):
- Volatility of quarterly sales growth
- Volatility of quarterly cash flows
- Volatility of monthly returns
- Risk as measured by beta (CAPM)
- Idiosyncratic risk (residual of CAPM)
Sorting Firms into Quadrants:

Twenty combinations to consider:

(Volatility of Sales Growth) *Versus* (Investment Cash Flow / Sales)
(Volatility of Monthly Returns) *Versus* (Investment Cash Flow / Sales)

Others

Nearly identical results from the 20 combinations

Data sorted by the median of variables:

(Volatility of Monthly Returns) *Versus* (Investment Cash Flow / Sales)

HH: Above median for both volatility of monthly returns and investment cash flow to sales
HL, LH, and HH defined in the same manner

Reported results are for **Beta, Idiosyncratic, and total risk** *versus*

Investment Cash Flow / Sales
Managerial Flexibility *Versus* Uncertainty

<table>
<thead>
<tr>
<th>Flexibility: Investment Cash Flow / Sales</th>
<th>Risk: Monthly Returns, Beta, Idiosyncratic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (below Median)</td>
<td>High (below Median)</td>
</tr>
<tr>
<td>Low value for real options:</td>
<td>Moderate (ambiguous):</td>
</tr>
<tr>
<td>LL</td>
<td>HL</td>
</tr>
<tr>
<td>Ambiguous:</td>
<td>High Value for real options:</td>
</tr>
<tr>
<td>LH</td>
<td>HH</td>
</tr>
</tbody>
</table>

How to deal with the Core (the normal case)?
Main Industries in HH:

**Mining, oil and gas extraction:** Alta Gold, Harken Energy, Marine Drilling

**Chemicals: Pharmaceutical Preparations:** Genentech, Human Genome Sciences

**Semiconductor Equipment:** Applied Materials, Novellus

**Electronic Computers:** Apple Computer, Dell Computers, 3 Com, Tellabbs

**Semiconductors:** JDS Uniphase, LSI Logic, National Semiconductor

**Communications:** Metrocall, Skytel Communications, Children’s Broadcasting, USA Networks

**Software:** AOL, BARRA, Macromedia
Main Industries in LL:

**Construction:** Engle Homes, US Home Corporation

**Food:** Tyson Foods, Best Foods, Heinz, General Mills, Kellogg, Nabisco

**Newspaper and Periodicals:** Knight Ridder, New York Times, Times

**Plastics Materials, Synthetic Resins:** Du Pont, Dow Chemical, AHP

**Pharmaceutical Preparations:** Eli Lilly, Merck, Pfizer, Warner-Lambert

**Primary Metals:** USX Steel, Kaiser Aluminum, Olin Corporation

**Electronic Computers:** Hewlett Packard, Xerox Corporation

**Transportation Equipment:** Northrop Grumman, General Dynamics, Lockheed Martin

**General Merchandise Stores:** Neiman Marcus Group, Nordstrom JC Penny, Sears Roebuck, K Mart, Wal-Mart Stores
Main Industries in HL and LH:

**HL:** Chemicals: Genome Therapcts, Gilead Sciences  
Communications Equipment: Digital Microwave, Qualcomm  
Semiconductor equipment: Micron Technology  
Apparel: Ann Taylor Stores, Talbots  
Miscellaneous Retail: Office depot, Sharper Image  
Direct Mail Advertising: CMGI  
Software: 3DO Company, Adobe Systems  

**LH:** Oil Extraction / Refining: Enron, Occidental, Chevron, Exxon, Texaco  
Food: Archer-Daniels-Midland, Coca-Cola, Anheuser-Busch  
Paper: Georgia-Pacific, Weyerhaeuser, Minnesota Mining & Mfg  
Pharmaceutical: Alza Corp, Johnson & Johnson, Schering-Plough  
Electronic Computers: Compaq, Sun Microsystems, Cisco Systems  
Semiconductors: Intel, Texas Instruments  
Motor Vehicles: Ford Motor, General Motors  
Air Transportation: American, Delta, United Airlines  
Computer Software: IBM, Microsoft Corporation
### Selected Ratios (Table 1): Means

<table>
<thead>
<tr>
<th>Means</th>
<th>BETA Risk</th>
<th>Idiosyncratic Risk</th>
<th>Total Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
<td>LL</td>
<td>HH</td>
</tr>
<tr>
<td>Alpha</td>
<td>0.001</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Beta</td>
<td>1.31</td>
<td>0.46</td>
<td>1.06</td>
</tr>
<tr>
<td>InvstmtCF/Sales</td>
<td>0.25</td>
<td>-0.01</td>
<td>0.29</td>
</tr>
<tr>
<td>R&amp;D/Sales</td>
<td>0.09</td>
<td>0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>Gross Profit Margin</td>
<td>35.05</td>
<td>29.16</td>
<td>33.95</td>
</tr>
<tr>
<td>Return on Equity</td>
<td>-7.06</td>
<td>-7.74</td>
<td>-18.73</td>
</tr>
<tr>
<td>Price/Earnings</td>
<td>7.50</td>
<td>10.61</td>
<td>8.02</td>
</tr>
<tr>
<td>Market/Book</td>
<td>2.07</td>
<td>1.53</td>
<td>2.00</td>
</tr>
<tr>
<td>EVA / Total Assets (average)</td>
<td>-0.01</td>
<td>0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td>MVA / Total Assets (average)</td>
<td>0.07</td>
<td>-0.05</td>
<td>0.32</td>
</tr>
<tr>
<td>Tobin's Q</td>
<td>2.17</td>
<td>1.62</td>
<td>2.11</td>
</tr>
<tr>
<td>PP&amp;E / Total Assets</td>
<td>0.33</td>
<td>0.34</td>
<td>0.38</td>
</tr>
<tr>
<td>Growth Rate Book Value</td>
<td>23.73</td>
<td>8.28</td>
<td>25.36</td>
</tr>
<tr>
<td>Growth Rate-Sales</td>
<td>25.37</td>
<td>10.61</td>
<td>30.00</td>
</tr>
</tbody>
</table>

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Comparison of Selected Ratios

Mean ratios by quadrant (Table 1):
Significant differences between HH and LL
HH group: High growth rate of Book Value and Sales
HH group: High Market/Book and Low P/E
All volatility measures lead to similar sorting
Distribution of variables is highly skewed
Outliers significantly effect the means
### Selected Ratios (Table 2): Medians

<table>
<thead>
<tr>
<th>Median</th>
<th>BETA Risk</th>
<th>Idiosyncratic Risk</th>
<th>Total Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
<td>LL</td>
<td>HH</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>0.001</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>1.20</td>
<td>0.48</td>
<td>0.96</td>
</tr>
<tr>
<td><strong>InvstmntCF/Sales</strong></td>
<td>0.16</td>
<td>0.02</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>R&amp;D/Sales</strong></td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Gross Profit Margin</strong></td>
<td>36.93</td>
<td>27.94</td>
<td>36.84</td>
</tr>
<tr>
<td><strong>Return on Equity</strong></td>
<td>8.17</td>
<td>7.77</td>
<td>2.62</td>
</tr>
<tr>
<td><strong>Price/Earnings</strong></td>
<td>13.37</td>
<td>11.25</td>
<td>7.84</td>
</tr>
<tr>
<td><strong>Market/Book</strong></td>
<td>1.55</td>
<td>1.24</td>
<td>1.40</td>
</tr>
<tr>
<td><strong>Dividend Yield (Fiscal Year)</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>WACC</strong></td>
<td>0.13</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>EVA / Total Assets (aver)</strong></td>
<td>-0.02</td>
<td>0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td><strong>MVA / Total Assets (aver)</strong></td>
<td>0.27</td>
<td>-0.13</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Tobin's Q</strong></td>
<td>1.72</td>
<td>1.35</td>
<td>1.62</td>
</tr>
<tr>
<td><strong>PP&amp;E / Total Assets</strong></td>
<td>0.30</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Growth Rate-Book Value</strong></td>
<td>18.39</td>
<td>5.93</td>
<td>19.83</td>
</tr>
<tr>
<td><strong>Growth Rate-Sales</strong></td>
<td>16.94</td>
<td>6.55</td>
<td>20.50</td>
</tr>
</tbody>
</table>
Comparison of Selected Ratios

Median ratios by quadrant (Table 2):

More significant differences: HH versus LL

High growth rate of Book Value and Sales: HH

HH group: High Market/Book and High P/E

Volatility measures lead to different sorting

Performance measures reflect Real Options

Expanded comparisons are provided in the appendix (Tables 1A and 2A)
Comparison Based on Regression:

Conditional versus Unconditional means

Cross-Sectional Regression Model:

Performance Measure  =  \alpha + \sum B_i X_i + \epsilon_i

Where:

PM: Tobin's Q, EVA, MVA, ROE, ROI

Conditional Mean: \alpha

Control Variables: X_i

Coefficient: B_i

Residual (heteroskedastic): \epsilon_i
Regression Analysis: EVA/Assets and Tobin's Q

<table>
<thead>
<tr>
<th>Variable</th>
<th>EVA</th>
<th>EVA</th>
<th>TQ</th>
<th>TQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
<td>LL</td>
<td>HH</td>
<td>LL</td>
</tr>
<tr>
<td><strong>CONSTANT</strong></td>
<td>-1.179 *</td>
<td>0.004</td>
<td>0.706 *</td>
<td>0.443 *</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>-0.547 *</td>
<td>-0.490 *</td>
<td>0.169 *</td>
<td>0.072</td>
</tr>
<tr>
<td><strong>Investment C/F/Sales</strong></td>
<td>0.789 *</td>
<td>0.235</td>
<td>0.181</td>
<td>-0.117</td>
</tr>
<tr>
<td><strong>R &amp; D/Sales</strong></td>
<td>0.204</td>
<td>-0.229</td>
<td>2.021 *</td>
<td>2.549 *</td>
</tr>
<tr>
<td><strong>CapExp/Capital/NetAssets</strong></td>
<td>3.003 *</td>
<td>-1.007</td>
<td>0.298</td>
<td>3.490 *</td>
</tr>
<tr>
<td><strong>Acquisitions/NetAssets</strong></td>
<td>1.184</td>
<td>-0.775</td>
<td>-1.569 *</td>
<td>-0.125</td>
</tr>
<tr>
<td><strong>Volatility of Cash Flows</strong></td>
<td>0.005 *</td>
<td>0.001 *</td>
<td>0.000</td>
<td>0.003 *</td>
</tr>
<tr>
<td><strong>Total Asset Turnover</strong></td>
<td>0.367 *</td>
<td>0.084 *</td>
<td>0.444 *</td>
<td>0.140 *</td>
</tr>
<tr>
<td><strong>Total Debt/Total Equity</strong></td>
<td>0.001 *</td>
<td>0.000</td>
<td>-0.001 *</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Dividend Yield (Fiscal Year)</strong></td>
<td>0.031</td>
<td>0.025</td>
<td>0.030</td>
<td>-0.017</td>
</tr>
<tr>
<td><strong>Gross Profit Margin</strong></td>
<td>0.009 *</td>
<td>0.001</td>
<td>0.006 *</td>
<td>0.018 *</td>
</tr>
<tr>
<td><strong>Growth Rate-Sales</strong></td>
<td>0.000</td>
<td>0.006 *</td>
<td>0.007 *</td>
<td>0.012 *</td>
</tr>
<tr>
<td><strong>Price/Earnings</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.003 *</td>
<td>-0.001 *</td>
</tr>
<tr>
<td><strong>Quick Ratio</strong></td>
<td>-0.077 *</td>
<td>-0.075 *</td>
<td>0.112 *</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Return on Equity</strong></td>
<td>0.003</td>
<td>-0.006 *</td>
<td>-0.003 *</td>
<td>-0.002</td>
</tr>
<tr>
<td><strong>Return on Investment</strong></td>
<td>0.027 *</td>
<td>0.035 *</td>
<td>0.004</td>
<td>0.023 *</td>
</tr>
<tr>
<td><strong>PP&amp;E/Total Assets</strong></td>
<td>0.025</td>
<td>-0.012</td>
<td>-0.016</td>
<td>-0.143</td>
</tr>
<tr>
<td><strong>Adjusted R-Squared</strong></td>
<td>0.3</td>
<td>0.27</td>
<td>0.25</td>
<td>0.34</td>
</tr>
</tbody>
</table>

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Regression Summary:

Regression Results Show that:

- The Conditional mean of the Performance Measures are significantly different for each quadrant
- The coefficient of control variables are also very different
- Statistical tests indicate that a different model is needed for each quadrant
- Adjusted R-squared range: 0.20 to 0.67
Further Enhancements:

The regression model will be improved:
- Pool time series-cross section data
- Make correction for heteroskedasticity
- Expand the list of explanatory variables
- Remove the normal core
- Assess the influence of outliers
- Test the robustness of results
Summary and Conclusions

We considered how the existence of Real Options affect financial measures of firms’ performance. We find that performance measures for firms with valuable real options are significantly higher. Financial Ratios seem to reflect the value of firms’ real options.