# Dynamic Strategic Planning

## Real Options II



# Introduction

- Developed an introduction to real options
  - Relation to financial options
  - Generic forms
  - Comparison of valuation in practice
- Now,
  - Value of flexibility (examining projects with compound real options)
  - A final look at the real options and decision analysis debate
  - Pointers to other course and materials

## Flexibility

- Flexible systems
  - Allow owner to adapt operating conditions
  - Trigger for action is some internal or external stimulus
- Example, flexible manufacturing systems sometimes
  - Allow fast product change-overs
  - Accept a variety of raw materials
  - Can efficiently process a wide range of batch sizes



## Flexibility (cont')

- Flexibility often costs extra to acquire
  - Equipment might require special configurations
  - Production management systems more complex
- But, flexibility can reduce total operating costs
  - Costs less to adapt to variability and change
  - Allows advantageous use of inputs or production of outputs

## An Options Perspective of Flexibility

- Flexible systems enable advantageous actions
  - Resembles a series of options
  - Can continually respond to changing conditions
- Demonstrate value using case of a flexible burner
  - Based on Kulatilaka and Marcus paper



## An Options Perspective of Flexibility (cont')

- Turbines for electric power generation can be powered by
  - Gas burners
  - Oil burner
  - Flexible burner (accepts either oil or gas)
- Fixed technologies (gas or oil) cost less to acquire
- Under what conditions might flexible systems be valuable?

## Starting Assumptions for Dual-Fuel Burner Example

- Examine 10 years of operation
- Discount cash flows at 10%
- Price of gas remains fixed at $1 per energy unit
- Price of oil increases over time
  - At present oil costs $0.75 per energy unit
  - Price increases by 5% per year
- Installation occurs in Year 0

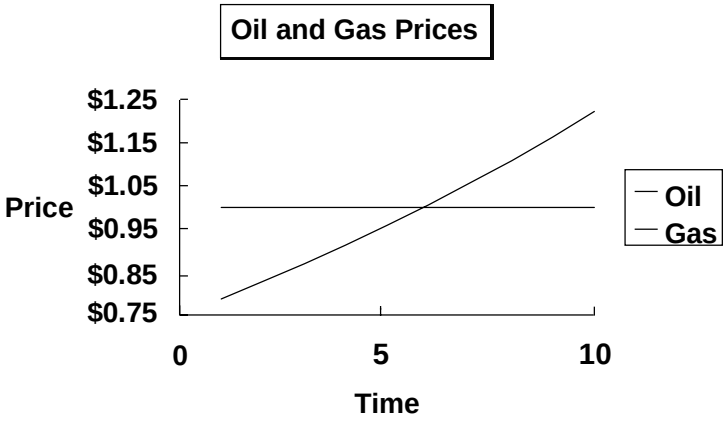


## Starting Assumptions for Dual-Fuel Burner Example (cont')

- Operations start in Year 1
- Revenues are independent of technology
- What is the NPV for each burner?

# Case 1: Oil and Gas Prices are Known with Certainty

- Oil burner cheaper to operate until Year 6






# Cash Flows Under Certainty

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas Plant | | | | | | | | | | | |
| Revenue | | 1.16 | 1.21 | 1.27 | 1.34 | 1.40 | 1.47 | 1.55 | 1.63 | 1.71 | 1.79 |
| Cost | 2.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| PV Net Cash Flow | -2.50 | 0.15 | 0.17 | 0.20 | 0.23 | 0.25 | 0.27 | 0.28 | 0.29 | 0.30 | 0.30 |
| NPV | -0.05 | | | | | | | | | | |
| Oil Plant | | | | | | | | | | | |
| Revenue | | 1.16 | 1.21 | 1.27 | 1.34 | 1.40 | 1.47 | 1.55 | 1.63 | 1.71 | 1.79 |
| Cost | 2.50 | 0.79 | 0.83 | 0.87 | 0.91 | 0.96 | 1.01 | 1.06 | 1.11 | 1.16 | 1.22 |
| PV Net Cash Flow | -2.50 | 0.34 | 0.32 | 0.30 | 0.29 | 0.27 | 0.26 | 0.25 | 0.24 | 0.23 | 0.22 |
| NPV | 0.24 | | | | | | | | | | |
| Flexible Plant | | | | | | | | | | | |
| Revenue | | 1.16 | 1.21 | 1.27 | 1.34 | 1.40 | 1.47 | 1.55 | 1.63 | 1.71 | 1.79 |
| Cost | 3.00 | 0.79 | 0.83 | 0.87 | 0.91 | 0.96 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| PV Net Cash Flow | -3.00 | 0.34 | 0.32 | 0.30 | 0.29 | 0.27 | 0.27 | 0.28 | 0.29 | 0.30 | 0.30 |
| NPV | -0.03 | | | | | | | | | | |

## Results of Certainty Case

- Rank of technologies
  - Oil
  - Flexible
  - Gas
- Oil burner captures early cost advantages over gas
  - Time value of money means early gains more significant than later losses

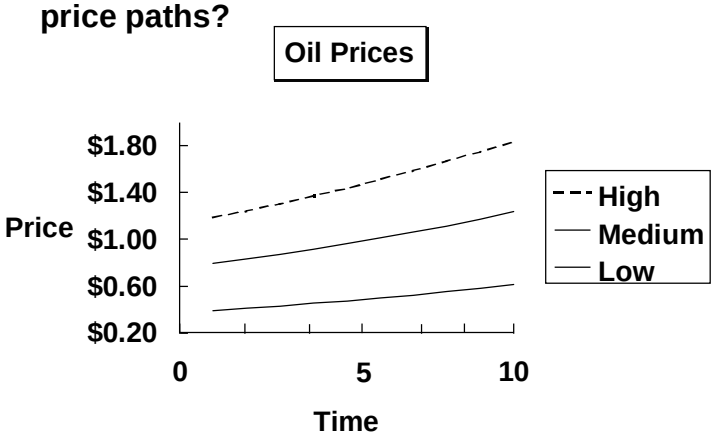


## Results of Certainty Case (cont')

- Oil burner also better than flexible
  - Both capture cost advantages early-on
  - Flexible advantageously switches to gas in Year 6
  - Additional costs of acquiring flexible overshadow later gains
- Critical assumption is that input prices are predictable

## Case 2: Uncertainty in Oil Prices

- **What if oil could follow one of three price paths?**






## Cash Flows with Uncertainty

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oil Plant | | | | | | | | | | | |
| Revenue | | 1.16 | 1.21 | 1.27 | 1.34 | 1.40 | 1.47 | 1.55 | 1.63 | 1.71 | 1.79 |
| Cost (High) p=0.3 | 2.50 | 1.18 | 1.24 | 1.30 | 1.37 | 1.43 | 1.51 | 1.58 | 1.66 | 1.74 | 1.83 |
| Cost (Medium) p=0.4 | 2.50 | 0.79 | 0.83 | 0.87 | 0.91 | 0.96 | 1.01 | 1.06 | 1.11 | 1.17 | 1.23 |
| Cost (Low) p=0.3 | 2.50 | 0.39 | 0.41 | 0.43 | 0.45 | 0.47 | 0.50 | 0.52 | 0.55 | 0.58 | 0.61 |
| Cost (Avg.) | 2.50 | 0.79 | 0.83 | 0.87 | 0.91 | 0.96 | 1.00 | 1.05 | 1.11 | 1.16 | 1.22 |
| PV Net Cash Flow | -2.50 | 0.34 | 0.32 | 0.30 | 0.29 | 0.28 | 0.26 | 0.25 | 0.24 | 0.23 | 0.22 |
| NPV | **0.24** | | | | | | | | | | |
| Flexible Plant | | | | | | | | | | | |
| Revenue | | 1.16 | 1.21 | 1.27 | 1.34 | 1.40 | 1.47 | 1.55 | 1.63 | 1.71 | 1.79 |
| Cost (High) p=0.3 | 3.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Cost (Medium) p=0.4 | 3.00 | 0.79 | 0.83 | 0.87 | 0.91 | 0.96 | **1.00** | 1.00 | 1.00 | 1.00 | 1.00 |
| Cost (Low) p=0.3 | 3.00 | 0.39 | 0.41 | 0.43 | 0.45 | 0.47 | | 0.52 | 0.55 | 0.58 | 0.61 |
| Cost (Avg.) | 3.00 | 0.73 | 0.75 | 0.78 | 0.80 | 0.83 | 0.85 | 0.86 | 0.86 | 0.87 | 0.88 |
| PV Net Cash Flow | -3.00 | 0.39 | 0.38 | 0.37 | 0.37 | 0.36 | 0.35 | 0.36 | 0.36 | 0.36 | 0.35 |
| NPV | 0.63 | | | | | | | | | | |

## Results of Uncertainty Case

- Rank of technologies
  - Flexible
  - Oil
  - Gas (same NPV as before since gas price remains fixed)
- Flexible technology enabled advantageous switching
  - For high oil price case, do better than oil burner
  - For high gas prices, do better than gas burner
  - Benefits accrue early on when uncertainty in prices is considered
  - Operating cost savings outweigh additional acquisition costs

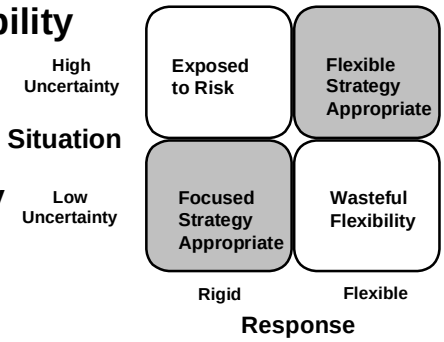


## Results of Uncertainty Case (cont')

- Input price uncertainty increased value of flexibility
  - Option value driven by cost of inputs
  - Uncertainty in prices represents volatility

## General Point of Flexibility Case

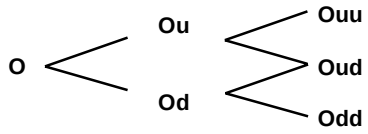
- Pursue flexible strategies when uncertainty is high
- Focus when uncertainty is low
- Mis-match of flexibility to uncertainty environment leads to
  - Waste of flexibility
  - Exposure to risk






## Extending the Flexibility Case

- Uncertainty in oil prices treated by three price paths
- Flexible technology switched modes only once, if at all




- In reality, oil price continually moves up and down

## Estimating the Value of Flexibility in Practice

- **Because problem involves a series of options**
  - **Can be difficult to evaluate using simple tables or decision trees**
  - **Black-Scholes does not apply either (multiple, dependent options)**
- **Typically requires computerized simulation**
  - **Based on binomial technique**
  - **— Structurally similar to decision trees**
  - **— Draws upon dynamic programming discipline**



## Estimating the Value of Flexibility in Practice (cont')

- **Dual-fuel case was later extended using simulation**

## A Few Final Remarks on Real Option Valuation

- **Conditions under which financial models work well**
  - One or a few uncertainty variables (underlyings)
  - Underlyings have an established market price history



## A Few Final Remarks on Real Option Valuation (cont')

- **Conditions under which decision analysis works well**
  - Likelihood and timing of critical uncertainties and decisions understood
  - Information sources more focused on individual project
  - Variables without an established price history are of importance

## A Few Final Remarks on Real Option Valuation (cont')

- Real options approaches are sometimes more compact
  - Decision trees rapidly become bushy
  - Simulation techniques are rooted in operations research techniques anyway
- Significant value in the mind-set
  - Approximate values can be a vast improvement



## Points to Keep in Mind When Selecting a Framework

- Options theory concerned with pricing based on risk & return
- Decision analysis concerned with strategy development
- Must decide on needs
  - Valuation according to strict finance perspective
  - Setting guidelines for strategic planning

## Points to Keep in Mind When Selecting a Framework (cont')

- Should consider level of required effort and ease of use
- Beware of false sense of precision



## If You Want to Pursue this Topic Further...

- Courses
  - Basic finance theory: 15.415 or 15.412
  - Options: 15.437
  - Corporate finance: 15.434
  - Decision analysis: 15.065
  - Others in operations research and at Sloan related to simulation

## If You Want to Pursue this Topic Further...

- **Additional resources**
  - **Real Options, Lenos Trigeorgis, MIT Press 1996 (ISBN 0-262-20102-X)**
  - **Real Options in Capital Investment, Ed. L. Trigeorgis, Praeger, 1995 (ISBN 0-275-94616-9)**
  - **Investment Under Uncertainty, A. Dixit and R. Pindyck, Princeton Press, 1994 (ISBN 0- 691-03410-9)**
  - **Journal of the Financial Management Association, Vol. 22, No. 3, Autumn 1993 (Special Section on Topics in Real Options and Applications)**



## Conclusions: What We Hope You Learned

- **Project options can be major sources of value**
- **Value of options depends on several factors**
- **Finance models and decision analysis are valuation bases**

## Conclusions: What We Hope You Learned (cont')

- It is useful to be aware of merits and limitations of each
- Most practical valuation framework depends on situation



## Conclusions

**You Can Add Value To Projects By:**

- Recognizing the value of options
- Looking for opportunities to build options into project when appropriate
- Doing the valuation (do not blindly justify efforts as "strategic")