Review of whole course

- A thumbnail outline of major elements
- Intended as a study guide
- Emphasis on key points to be mastered

Major Elements Covered (1st half)

- Modeling of production possibilities
- Valuation Issues
  - over time
  - evaluation criteria
- Optimization of production and cost
  - marginal analysis
  - constrained optimization
  - linear programming
- Sensitivity Analysis
- Use of Excel, LP programs (not on exam)
Modeling of Production Possibilities

- **Basic Concept: Production Function**
  - locus of technical efficiency
  - defined in terms of technology only

- **Characteristics**
  - marginal products, marginal rates of substitution
  - isoquants -- loci of equal production
  - returns to scale (≠ economies of scale!)
  - convexity of feasible region? Know when!

- Generally defined by systems models that define possibilities (e.g., satellite systems)

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Trade Space
Valuation Issues -- over time

- Resources have value over time
  - Discount rate (DR), r%/period
  - Formulas; \( e^{rt} \) for continuous compounding
- Choice of discount rate defined by best alternatives, at the margin
- DR ~ 10% or more -- long term benefits beyond 20 years have little consequence
- Money may change value via inflation
- Make sure you are comparing like with like

Valuation issues-- criteria

- Many types -- none best for all cases
  - Net Present value -- no measure of scale
  - Benefit/ Cost -- sensitive to recurring costs
  - Cost / Effectiveness -- no notion of value
  - Internal Rate of Return -- ambiguity, does not reflect actual time value of money
  - Pay-Back Period -- omits later returns
- Choose according to situation (if allowed)
- In practice, people may use several criteria
Optimization -- Marginal Analysis

- Economic efficiency merges technical opportunities (Prod. Fcn) and Values (Costs)
- For continuous functions, convex feasible region in domain of isoquants
  - Optimum when MP/MC ratios all equal
  - Expansion path is locus of resources that define optimal designs
  - Cost function: Cost = f(Optimum Production)
  - Economies of Scale (≠ increasing returns to scale)
- Good Concepts, often not applicable in detail

Optimization -- Dealing with Constraints

- Equality Constraints:
  - Lagrangean Equation
  - Lagrangean multipliers = shadow prices
- Inequality Constraints
  - Kuhn-Tucker conditions
  - Shadow prices or slack = zero (complementary slackness)
Optimization -- LP

- Standard Form
- Conditions
  - linearity of Objective function
  - additivity; non-negativity
- Formulation issues
  - Activities
  - Non-linearities (approximations valid only for convex feasible regions)
  - “fixed charge” problems
- Solution cost = f(number of constraints)

Sensitivity Analysis

- Key part of analysis -- because parameters never known exactly, need to explore solution
- Two main concepts:
  - Shadow prices = Change in Objective Function per unit change in constraint
  - Opportunity cost = Change in OF per unit use of non-optimal decision variable
- Shadow prices typically given with ranges
  - Notice that SP decrease as constraints relaxed or feasible space increased (floors dropped, roofs raised)
Computer Programs

- Excel -- a basic tool
  - Economic valuations
  - Cost models (as in Exercise 1)
  - Sensitivity analysis (via Data Tables)
  - Basic optimization
- LP Suites
  - What’s Best, etc
  - Sensitivity information

Major Elements Covered (2nd half)

- Recognition of Risk and Uncertainty
- Analysis under Uncertainty
  - Decision Analysis
  - Value of Information
- Valuation issues
  - Value and Utility Functions
  - CAPM adjustment of discount rate for risk
- Options Analysis
  - Theory: Value of waiting for new information
  - Practice: Issues in Evaluation
Recognition of Risk

- Psychologically
  - Resistance to acceptance of this basic fact
- Descriptively: Forecast always wrong
  - Reasons: “surprises”, “trend-breakers”
  - Examples: technical, market, political
- Theoretically: Forecasts => “house of cards”
  - Data range
  - Drivers of phenomenon (independent variables)
  - Form of these variables
  - Equation for model

Analysis under Uncertainty

- Primitive Models
  - sensitivity to irrelevant alternatives, states
  - sensitivity to basis of normalization
- Decision Analysis
  - Organization of Tree
  - Analysis
- Results
  - ≠ those on Average forecasts (flaw of averages)
  - Middle road, that provides flexibility to respond
  - Second best choices, flexibility costs
Value of Information

- Extra information has value
  - Value taken as improvement over base case
  - Is compared to cost of getting information

- Value of Perfect Information
  - Purely hypothetical / Easy to calculate
  - Provides easy upper bound

- Value of Sample information
  - Bayes’ Theorem
  - Repeated calculations
  - Worthwhile in important choices

Valuation Issues: Utility Functions

- Value Functions
  - Diminishing marginal value (sometimes)
  - Threshold effects
  - “sweet spots” (sugar in tea / CG on aircraft)
  - Axiomatic basis: Monotonic / Transitive

- Utility Functions
  - Measured on special cardinal scale
Valuation Issues: CAPM

- Capital Asset Pricing Model Adjusts Discount Rate to reflect “risk aversion”
- Accounts for Unavoidable (market) risks
- Assumes Project risks can be avoided
  - for investors, not so simple for owners
- Discount rate adjusted for relative volatility (by beta)
- \[ r = r \text{ (risk free)} + \beta \text{ [risk (market) - risk (free)]} \]

Options

- Concept:
  - A right … but not an obligation
  - to do something (buy, sell, change design…)
  - at a price

- Financial -- those referring to traded assets
  - Calls, Puts (~ insurance) // American, European

- “Real” -- Applied to physical projects
  - “on” and “in” projects

- The Mantra of the 3 types of options
Valuation of Options: Theory

- For “financial” options there is only one correct approach:

  - “Arbitrage Enforced” pricing
    - Replicating portfolio -- risk free rate
    - Independent of actual probabilities!
    - Black-Scholes formula for European Options

- Know how to replicate example given in lecture !!! (will be on final)

Valuation of Options: Practice

- For Real options finance theory may not work
  - No traded assets, no statistical history

- Alternative approaches often necessary
  - Decision Tree (Merck)
  - Simulation (Antamina)
  - Enumeration (Iridium)
  - Hybrid (Ford)

- Understand Range
Lattice Analysis

- No calculations on Final
- Understand Concept:
  - Like a Decision Tree
  - Binomial approach merges cells, thus makes analysis linear in number of stages
  - Easily reproduces Normal and LogNormal distributions assumed associated with random events
  - Typically assumes path independence, which further reduces calculations needed

Valuation of Real Options: Issues

- What is the “asset” involved modeling?
  - NPV of project?
  - What drives or affects that value?
- What is variability of project?
  - Historical Data may not exist
  - Data may not be random
- How do we develop results?
  - What can engineering team handle?
- How to we explain results?
  - What can client or audience handle?
Research issues in Options

- What method best in practice?
  - Formal real options analysis
  - decision analysis
  - net present value in some form?
- How to apply in specific areas, depending on
  - Economies of Scale
  - Path dependency over time
  - Interactions between design features
- How to present results to owners/managers of major projects?

Some Closing Thoughts

- Follow-on from Last Assignment

- System designers need to
  - Think beyond technical mechanics to behavior of system – for example, price elasticity
  - Recognize rapidity of change, and thus monitor changes constantly – this is key to intelligent use of options – have to know when time is right
  - Maintain flexibility to act – don’t let yourselves get locked into a plan
Best Wishes on exam and for rest of your studies!

The teachers really hope you will do excellently!
(and make us look good!)

We’ve enjoyed being with you and hope that our relationship can grow over time.