Engineering Systems Analysis for Design

Mid-Semester Quiz **October 26, 2003**

This is a closed book exercise. Computers and other wireless enabled devices for communication with web and outside are not allowed.

You may use old-fashioned, non-communicating calculators (if you have them).

Grade Tables

There are 90 points possible for the regular test, or 1 point per minute. Points associated with each question correspond to the estimated time it might take to answer them. There are also a possible 10 points of extra credit. Final scores will be based on 90 possible points.

Item	Score	
	Max	**Yours**
Your Name (provided we can read it)	1	
Concepts	22	
What's the best design?	15	
Static valuation of projects	13	
Decision Analysis and Value of Information	39	
Garage Example	10	
Total	100	
Percentage grade on basis of 90 maximum:		

I have completed this test fairly, without copying from others, a book, or the web.

Please sign your name legibly _____ **(1 point)**

Feedback voluntary question (no credit):

Suggest a CD or DVD for classroom enjoyment in second half of semester:

Concepts (22 points -- 2 points per part)

Write a short definition or description explaining the following:

Production Function

- technical Efficient (1 pt)
- inputs -> outputs (1 pt)

Technical Efficiency

- Max product/output (1 pt)
- From given set of resources (1 pt)
- -1 if confused with economic efficiency

Economic Efficiency

- most economical way to (1 pt)
- produce any level of technically efficient output (1 pt)

Isoquant

- locus of equal output (1 pt)
- technically efficient (1 pt)

Returns to Scale

- the ratio of the rate of change in output (1 pt)
- due to a proportional change in all inputs simultaneously (1 pt)
- -1 if confused with increasing returns to scale

Economies of Scale

- cheaper to produce more (1 pt)
- as scale of production increases (1 pt)

Expansion Path

- locus of all economically optimal design (1 pt)
- for every level of output (1 pt)

Cost Function

- optimal, least cost of producing (1 pt)
- each level of production (1 pt)
- -1 if confused with input cost function

Discount Rate

- the shadow price, opportunity cost at margin (2 pt)
- -1 if only mentioned time value of money because interest rate can also determine time value of money, and yet it is different from the discount rate

WACC

- average cost of money for a firm (1 pt)
- weighted proportion of stock and bond (1 pt)

CAPM

- determine the proper discount rate (1 pt)
- given the risk of the project (1 pt)

What's the best design? (15 points)

You are given a production function: 4 R(exp 0.45) S (exp 0.9)

And the cost of the resources as: 2 R (exp 0.4) + (4/3)S (exp 1.2).

[Note: a (exp b) means "a" raised to the power of "b"]

Note: In calculating answers, you may leave exponents in fractional form rather than estimating numbers in decimal form. For example, (.4) exp (2/3) would be acceptable.

a) What can you say immediately, by inspection, about the returns to scale? The economies of scale? Explain answer (3 points)

$\Sigma a_i = .45 + 0 .9 > 0$ (1 pt), increasing returns to scale (1 pt)
cannot tell from inspection (1 pt)

b) What is the optimal relationship between the resources R and S? (6 points)

$MP_R / MC_R = MPs / MCs$ (2 pt)

$MP_R = 1.85 S^{0.9} R^{-0.55}$ (0.5 pt)
$MC_R = .8 R^{-0.6}$ (0.5 pt)
$MPs = 3.6 R^{0.45} S^{-0.1}$ (0.5 pt)
$MCs = 1.6 S^{0.2}$ (0.5 pt)

Answer: $S = R^{1/3}$ or $S^3 = R$ (2 pt)

c) What is the associated cost function? (6 points)
3 pts for procedures
3 pts for arithmetic

$C = 10/3 S^{1.2}$
$S = 1.85 Y^{0.44}$
$C = 1.59 Y^{0.533}$

Static Valuation of Projects (13 points)

Consider the project with the following revenues and costs:

	Year				
	0	1	2	3	4
Revenues		633	760	900	1045
Costs	1000	300	400	500	600

Assume a discount rate of 10%.

a) Define Net Present Value and calculate it for this case (6 Points)

- NPV = total benefits - total costs (1 pt); all benefits and costs discounted to present value (1pt)
- Express the revenues and costs formula the table in NPV formula (1 pt)
- NPV = 204.6 (3 pt)
- -2 if no definition was provided

b) Define and Calculate the Pay Back Period (4 points)

- payback period = initial net investment / annual net undiscounted benefits (2 pt)
- Answer: 2.8 yrs (2 pt)
- -1 if "undiscounted" was not mentioned

c) What are the major advantages and disadvantages of the Benefit/Cost ratio as a criterion of evaluation? (3)

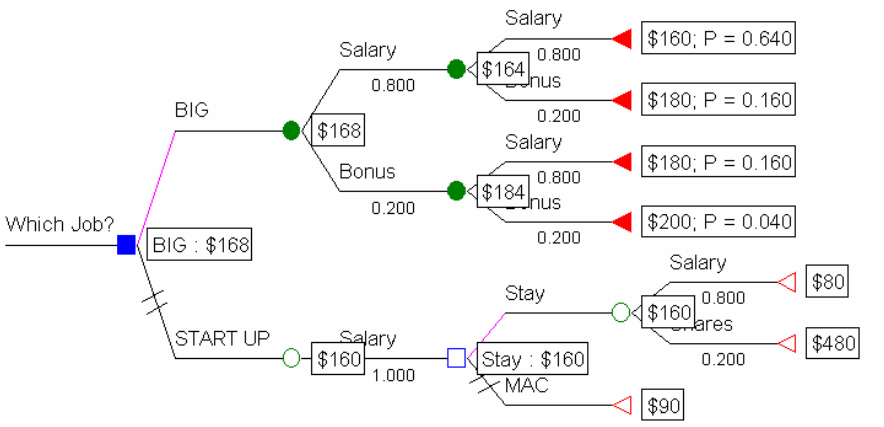
- each advantage and disadvantage = 0.5 pt
- advantages: common scale, easy to rank, easy to interpret, B/C > 1 is a good project, discount the future (-0.5 if B/C > 1 was not specified)
- disadvantages: sensitive to discount rate, biased against recurring cost, hard to assign monetary value to qualitative terms

Decision Analysis (39 points)

It's March and you are trying to choose your post-graduation job. You have two offers:

- BIG company, an established organization that offers a 2-year contract with an annual salary of 80K, which could (Probability = 20%) provide a bonus of 20K at the end of any year.
- START UP that pays only 40K but, at the end of the year 1, gives you shares in the company if you sign up for the year 2. If the product works out well by the end of year 2 (probability = 20%) you could then cash in these shares and receive $400K. If you do not sign up for year 2, you can go to MACJOB and get 50K for that year.

a) Draw the decision tree for this choice, giving all information provided. Which is the choice that maximizes expected value? (7)

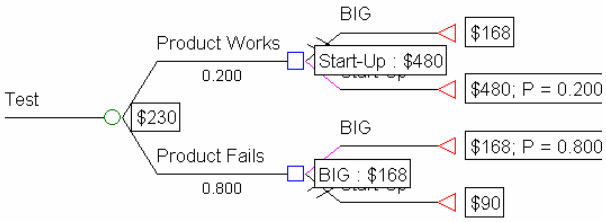


Choice is BIG.

Looking for structure, D→C, correct decisions, outcomes, probabilities, and calculations.

b) You're concerned about the uncertainty associated with START UP, and are thinking about getting some extra information that would help you make your choice. Define the concept of the Expected Value of Perfect Information, and calculate its value for this case. (5)

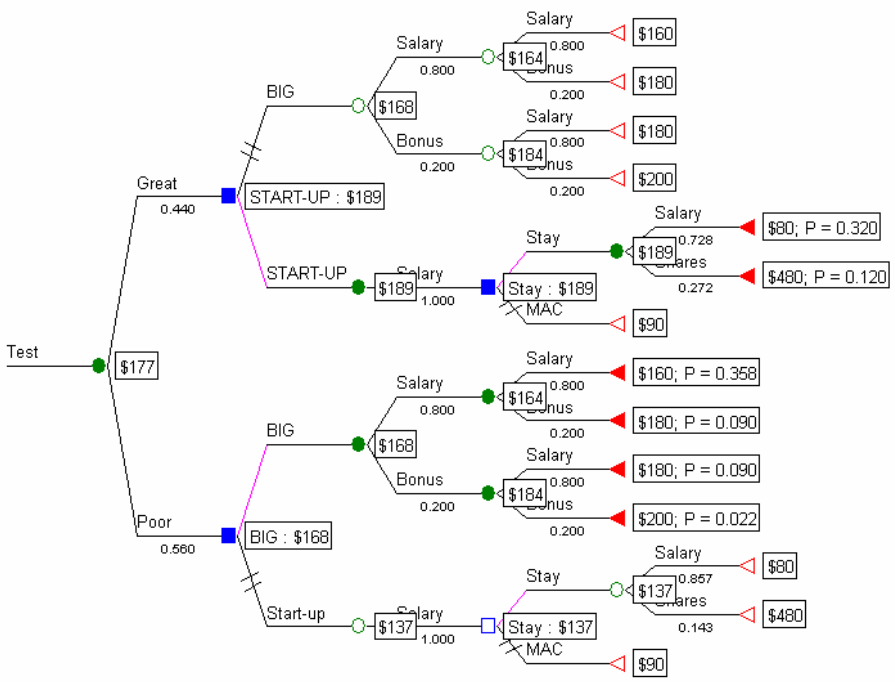
EVPI is the increase in expected value from hypothetically knowing the exact outcome of a chance situation without regarding the cost of obtaining it.



EVPI = 230 – 168 = $62

c) You could organize a market study of START-UP's product before you decide which job to take. You would get a report that would assess it as either "great" or "poor". Graphically indicate how the decision tree in (a) should be altered to include this market test. (5)

The test will be made before making any decision. The probabilities are calculated from later steps. In this step an indication that they change is sufficient. Furthermore, branches could be collapsed for easier representation.



d) Define Bayes' Theorem, explaining the meaning of the terms (4)

Bayes theorem is a formula for revising estimates of probabilities given an observation.

$$P(E/O) = P(E)[\frac{P(O/E)}{P(O)}]$$

Posterior probability = (initial prob.) [(conditional probability) / (probability of observation)]

e) Given your initial assessment that the product has 20% chance of success, what is the probability that the market study will report that the product is “great”. You assess that this study is inaccurate, only giving correct results 60% of the time [i.e, probability (study says ‘great’ if product will be success) = prob (says ‘poor’ if product will fail) = 0.6] (4)

P(Great) = P(Great \ Success) * P(Success) + P (Great \ Failure) * P (Failure) => (2 p)
P(G) = 0.6 * 0.2 + 0.4 * 0.8 = 0.44. (2 p)

f) Calculate how the test results would change your initial assessment of success? (8)

Using Bayes theorem: (2 p)

P(S\G) = P(S) * [P(G\S) / P(G)] = 0.2 * (0.6 / 0.44) = 0.272 (3 p)

P(S\”Poor”) = P(S) * [P(P\S) / P(P)] = 0.2 * (0.4 / 0.56) = 0.143 (3 p)

g) What is the expected value of the sample information? Is it worthwhile to buy the market survey? (6)

EVSI is the increase in expected value from imperfectly knowing the outcome of a chance situation without regarding the cost of obtaining it.

Plugging the results from (f) into the tree of (c) we obtain a revised expected value $177. Therefore

EVSI = $177 - $168 = $9K

If cost of the test is less than $9K (preferably less than $4.5K) one would proceed.

Garage Example (10 points, 2 per question)

Think back to the Garage and Satellite Examples presented in class and your latest assignment.

a) Under what circumstances is the value of a project, when calculated on the basis of the most likely forecasts, the same as its value when calculated for the range of possible scenarios that lead to those most likely forecasts?

Only if functions are linear that is f [EV(x)] = EV [f(x)].

b) Therefore, how likely is it that the valuation based on the most likely forecasts are correct?

This is unlikely since most functions are non-linear and the same is true for the valuation of rare yet highly undesirable events (aka “flaw of averages”).

c) What are the advantages of a staged approach that allows the designer to achieve a capacity through several increments, instead of one?

E staged approach introduces flexibility and ***reduces economic risk*** by (i) deferring expenditures into the future and (ii) allowing for more information to be available for decision-making thus adapting to market changes.

d) What are the disadvantages of the staged approach?

In cases where economies of scale exist their benefits will not be captured to a full extent with a staged approach and usually the undiscounted capital expenditures for incremental capacity increases are higher than those for a large-scale facility.

e) Illustrate how a staged approach could affect the Cumulative Distribution Function of the value of a project.

A staged approach in principle reduces downside risks and increases upside potential returns.