ECNS 432
Ch. 8

Option Price and Option Value

- Option Price: The amount individuals are WTP for policies prior to the realization of contingencies
  - Ex ante welfare measure in sense that consumers value policies w/o knowing which contingency will occur
  - Here, we limit focus to uncertainties of direct relevance to individuals
    - Ignore uncertainties arising b/c analysts must make predictions about the future to estimate measures of WTP

Ex Ante WTP (i.e. option price)

- Consider the question: Prior to knowing which contingency will actually occur, what is the max WTP to obtain a policy?
  - Each person's answer is their ***option price***
  - By summing option prices we obtain a measure of agg. benefits (i.e. agg. WTP)
    - Economists generally regard this as the conceptually correct measure of WTP

Illustrations of Option Price

- Example 1: Expected values of net costs of Asteroid Defense Alternatives

	P(exposure to a collision with a large asteroid)	P(exposure to a collision with a small asteroid)	P(No collision with an asteroid)
Probabilities of states of nature	0.001	0.004	0.995

Actions	Payoffs (net costs in billions of dollars)			EV
Forward-based asteroid defense	5,060	1,060	60 (i.e costs of installing program)	69
No asteroid defense	30,000	6,000	0	54

Illustrations of Option Price

- In this case, the expected benefits of forward-based asteroid defense relative to no program are:

  $54 billion - $69 billion = -$15 billion

- Now, consider option price approach
  - Here, we consider the agg. WTP before people know which contingency occurs (i.e. the WTP irrespective of which one actually occurs)
    - Aka "certainty equivalent"
  - Assume the sum of individual option prices is $100 billion.
  - Then, net benefits would simply be $100 billion less the certain program costs of $60 billion

    $100 billion - $60 billion = $40 billion

Illustrations of Option Price

- So, in this example, expected surplus would underestimate net benefits by

  $40 billion – (- $15 billion) = $55 billion

  - This difference between option price and expected surplus is the ***option value*** of forward-based asteroid defense
  - Here, the option value can be thought of as an additional "insurance benefit" of the program
    - It is the amount beyond expected benefits that individuals are WTP to have the defense program available to reduce the risk of the consequences that would result from an undefended asteroid collision
- Q. In general, how does the expected surplus measure compare to option price?
- Ans. Assuming individuals are risk averse, expected surplus can either underestimate or overestimate option price depending on the sources of risk (we will see this in the following example)

Expected surplus vs. option price

- Example: Building a temporary dam that provides a farmer with water for irrigation

	Policy		
Contingency	Dam	No Dam	P(contingency)
Wet	110	100	0.5
Dry	100	50	0.5
Expected value	105	75	
Variance	25	625	

- In expected value terms, the surplus equals $30 (i.e. $105 - $75)
  - Measure of benefits used in CBA when option price is not estimated
- Dam does more for farmer if in a dry yr.
  - His income depends less on which contingency actually occurs once dam is built than it did without the dam
  - ***Dam reduces income risk faced by farmer by decreasing variation in his income***

Expected surplus vs. option price

- To determine benefits from dam, we first calc. expected utility (EU) without dam.
- Then, we find his option price, which is the max he would be WTP for dam (or equivalently) or the amount that gives him the same EU as he would have without the dam.
  - Q. What do we need to know to do this? What is one reason expected surplus (rather than option price) is used in practice?
  - Ans. Need to know farmer's utility function
  - For our example, lets assume his utility is given by the natural log of his income (from the table above)
    - Q. Why use the natural log?
    - Ans. Utility of income increases at a decreasing rate.

[show utility function on board]

Expected surplus vs. option price

- B/c the prob. of wet and dry are each 0.5, the EU w/o dam is midpoint b/w the utilities of these no-dam incomes
  - This point is EU = 4.26 and is A units of utility away from each of the contingent utilities

    [show this on graph]
- If dam is built, we know farmer receives either $100 (dry) or $110 (wet)
- The ***option price*** is the max he would be willing to give up to have the dam
  - i.e. the amount that would allow him to obtain the same EU with dam as he would obtain w/o the dam
- We can write this as

  $$.5U(110 - OP) + .5U(100 - OP) = EU$$

  where EU = 4.26

  $$\Rightarrow \quad .5\ln(110 - OP) + .5\ln(100 - OP) = 4.26$$

  Solving for OP, we obtain

  $$OP = \$34.2$$

  [show on graph and show algebra if class wants to see it]

Expected surplus vs. option price

- So, either no dam or a dam with a certain payment (i.e. a payment the farmer makes) of $34.20 gives the farmer the same EU
- ***We see that the farmer's option price for the dam of $34.20 exceeds his expected surplus of $30***
  - If the opportunity cost of the project were $32, then the common practice of using the expected surplus measure would result in rejecting the dam.

Determining Bias in Expected Surplus

- The key to formulating a definition of ***option value*** lies in the recognition that option price fully measures a person's ex ante WTP for a policy in the presence of uncertainty about the benefits that will accrue ex post.
- Standard is to define option value as

$$OV \equiv OP - E[S]$$

$\Rightarrow OP = OV + E[S]$ (i.e. option price includes option value)

Where

- OP is the certain amount a person is WTP
- E[S] is what is typically measured
- OV is the amount that would have to be added to E[S] to make it equal to the option price

  -Think of this as the bias in estimated benefits resulting from measurement by expected surplus rather than option price

Determining the Sign of Option Value

- OV may be positive or negative
  - Thus, determining whether OP over- or under-estimates E[S]
  - Depends on a variety of things
    - Source of risk
    - Characteristics of policy being analyzed
    - Underlying structure of the individual utility function
  - For a summary of the research on signing OV, see Appendix 8A in your text