Willingness to Pay Under Uncertainty: Beyond Graham’s Willingness to Pay Locus

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Purpose: Unify and extend concepts of welfare measurement under uncertainty

- **Option Price** (Ex Ante Compensating Variation)
  - Weisbrod, Schmalensee, Bishop, Cichetti and Freeman
  - Ex ante Payments

- **Graham’s WTP Locus** (1981)
  - Ex ante commitments to ex post payments

- **Dynamic WTP**
  - Zhao and Kling
  - Ex ante payments incorporating value of learning and delay opportunities

- **Quasi Option Value**
  - Arrow and Fisher, Henry, Fisher and Hanemann
  - Ex ante adjustment to decision rule
Basics

Notation:  
- $x =$ public good: two levels $x_1$ high, $x_0$ low,
- $\theta =$ value of the public good, $\theta^H$ or $\theta^L$ with probability $\pi$ and $(1-\pi)$,
- $y =$ income,
- 2 periods, uncertainty resolved in first period

State Independent Payment (Ex Ante Payment)
How much is a consumer willing to pay \textbf{today} to obtain a higher level of public good provision?

State Dependent Payments (Ex Ante Commitment to Ex Post Payments)
What state dependent combination of payments is a consumer willing to commit to \textbf{today} to obtain a higher level of public good provision?
Option Price and Graham’s Locus

State Independent Payment: What is most the consumer will pay for $x_1$ to hold her expected utility the same as $x_0$?

$$\{(1 - \pi)U(x_1, \theta^L, y - \text{OP}) + \pi U(x_1, \theta^H, y - \text{OP})\}(1 + \beta)$$

$$= \{\pi U(x_0, \theta^H, y) + (1 - \pi) U(x_0, \theta^L, y)\}(1 + \beta)$$

State Dependent Payments

$$(1 - \pi)U(x_1, \theta^L, y - c^L) + \pi U(x_1, \theta^H, y - c^H) = \pi U(x_0, \theta^H, y) + (1 - \pi) U(x_0, \theta^L, y)$$
Uncertainty and Learning: Dynamic WTP

- Introduce opportunities for learning and delay into formation of WTP and WTA

- National Park can be improved now or can delay, study habitat recovery, and decide later

- State Independent Payment: What is most the consumer will pay for $x_1$ to hold her expected utility equal to going without today?
Uncertainty and Learning: Dynamic WTP

Expected utility if purchase today
- Period 1: \((1 - \pi)U(x_1, \theta^L, y-k) + \pi U(x_1, \theta^H, y-k)\)
- Period 2: \(\beta[(1 - \pi)U(x_1, \theta^L, y-k) + \pi U(x_1, \theta^H, y-k)]\)

Expected utility if do not purchase today
- Period 1: \(\pi U(x_0, \theta^H, y) + (1 - \pi)U(x_0, \theta^L, y)\)
- Period 2: \(\beta\{\pi U(x_1, \theta^H, y-k) + (1 - \pi)U(x_0, \theta^L, y)\}\)

Equate these expected values, solve for \(k\)

\(k = \text{Dynamic WTP: the most a consumer would be willing to pay today when learning and delay is possible}\)
Relationship between Dynamic WTP and Option Price

Dynamic WTP \subseteq OP

Dynamic WTP = k = OP - CC

CC = Commitment cost
    = r \frac{QOV}{E} \mu_y
    = Annualized, monetized QOV
Dynamic WTP Locus

Allowing State Dependent Payments

\[(1 - \pi)[U(x_1, \theta^L, y-k_L) + \beta U(x_1, \theta^L, y-k_L)] \]
\[+ \pi[U(x_1, \theta^H, y-k_H) + \beta U(x_1, \theta^H, y-k_H)] \]

\[= \pi U(x_0, \theta^H, y) + (1-\pi) U(x_0, \theta^L, y) \]
\[+ \beta\{\pi \text{Max}[U(x_1, \theta^H, y-k_H), U(x_0, \theta^H, y)] \]
\[+ (1-\pi) \text{Max}[U(x_1, \theta^L, y-k_L), U(x_0, \theta^L, y)] \}\]

Compensation bundles could also be time dependent
Dynamic WTP Locus

- Dynamic locus
- Graham’s locus

$\pi_1 / \pi_2$

45°
Dynamic WTA and WTP Locus

WTA locus

WTP locus

$WTP$  $OP^c$  $OP^e$  $WTA$

$CC^c$  $CC^e$

$k_L$  $k_H$
Implications for Environmental Economics

From QOV literature: when learning and delay possible, efficient to incorporate this information into decision making.

But, the WTP (e.g. from SP survey) may already include adjustments for information, if so, adjusting decision rule to incorporate QOV will be incorrect – double counting.

If SP respondents are thinking dynamically, do the delay and learning opportunities they perceive match reality?

SP survey design may need to explicitly communicate delay and learning opportunities.
Implications (continued)

From Graham, with heterogeneous individuals (risk) a project can pass a potential pareto test using an aggregate loci when it would fail a state independent test.

- Risk sharing creates an additional benefit.
- Similar benefits with Dynamic WTP loci, but also with regard to differences in time preferences and learning opportunities.
- Use of compensation schemes along the WTP loci can allow efficient distribution of commitment cost.
Illustration: CES Utility

Utility function

\[ U = \frac{\theta x^\rho}{\rho} + (1 - \theta) \frac{y^\rho}{\rho} \]

Parameter values (Corrigan, 2002)

\[ \theta^H = 0.03, \quad \theta^L = 0.01, \quad \rho = 0.277 \]
\[ y = 50,000, \quad x^1 = 1, \quad x^0 = 0 \]
\[ \beta = \frac{1}{1 + r} = 0.952 \quad (r = 0.05) \]
\[ \pi = 0.5 \]
Dynamic WTP, Option Price and Uncertainty
Dynamic WTP, Option Price and the Probability of High Outcome
Dynamic WTP and WTA