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 Helms, Smith, Ready
  - *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,

θ = value of the public good, θ^H or θ^L with probability □ and (1- □),

y = income,

2 periods, uncertainty resolved in first period

State Independent Payment (*Ex Ante* Payment)

How much is a consumer willing to pay **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 **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

$$(1-\pi)U(x_1,\theta^L,y\text{-}c^L)+\pi U(x_1,\theta^H,y\text{-}c^H) \;=\pi U(x_0,\theta^H,y)+(1-\pi)U(x_0,\theta^L,y)$$

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: $(1-\pi)\mathrm{U}(\mathrm{x}_1,\theta^L,\text{y-k})+\pi\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k})$
  - Period 2: $\beta[(1-\pi)\mathrm{U}(\mathrm{x}_1,\theta^L,\text{y-k})+\pi\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k})]$
- Expected utility if do not purchase today
  - Period 1: $\pi\mathrm{U}(\mathrm{x}_0,\theta^H,\mathrm{y})+(1-\pi)\mathrm{U}(\mathrm{x}_0,\theta^L,\mathrm{y})$
  - Period 2: $\beta\{\pi\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k})+(1-\pi)\mathrm{U}(\mathrm{x}_0,\theta^L,\mathrm{y})\}$
- Equate these expected values, solve for k
- k = Dynamic WTP: the most a consumer would be WTP today when learning and delay is possible

Relationship between Dynamic WTP and Option Price

- Dynamic WTP $\odot$ OP
- Dynamic WTP = k = OP - CC
- CC = Commitment cost

  $= r\ QOV/E_{\square}Mu_y$

  = Annualized, monetized QOV

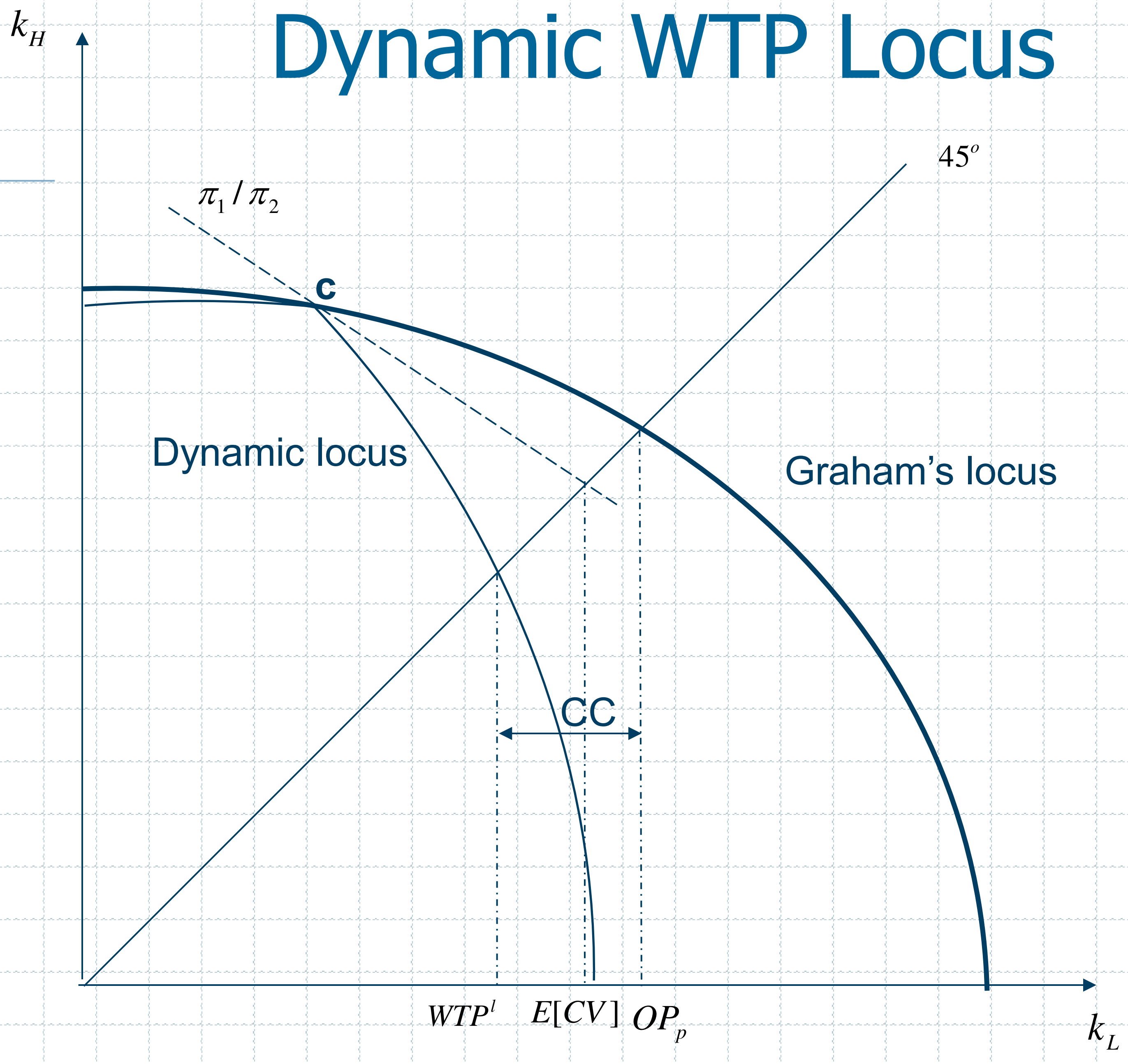
Dynamic WTP Locus

- Allowing State Dependent Payments

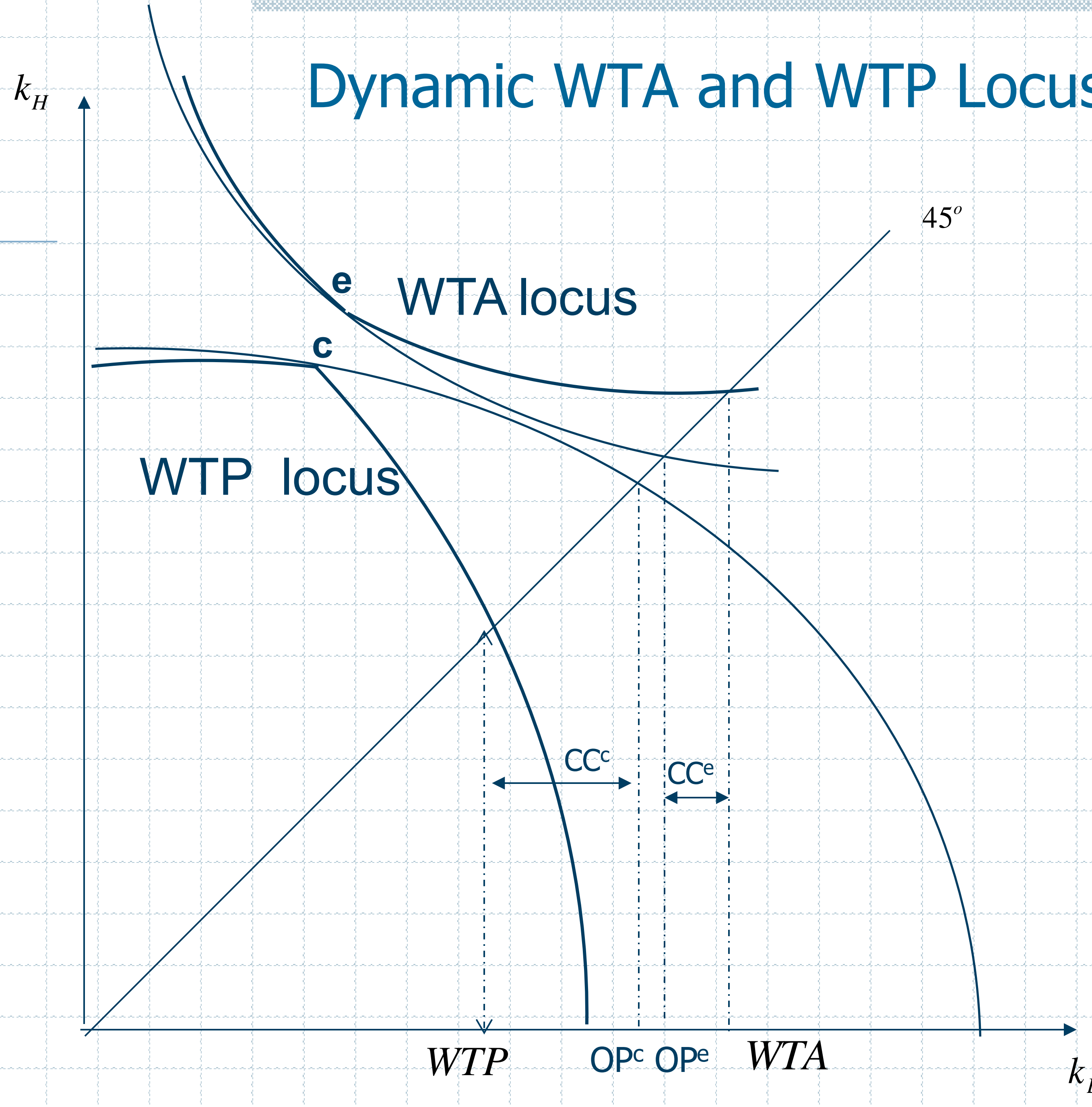
$$
\begin{aligned}
&(1-\pi)[\mathrm{U}(\mathrm{x}_1,\theta^L,\text{y-k}_\mathrm{L}) + \beta\mathrm{U}(\mathrm{x}_1,\theta^L,\text{y-k}_\mathrm{L})] \\
&\qquad + \pi[\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k}_\mathrm{H}) + \beta\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k}_\mathrm{H})] \\
&= \pi\mathrm{U}(\mathrm{x}_0,\theta^H,\mathrm{y}) + (1-\pi)\mathrm{U}(\mathrm{x}_0,\theta^L,\mathrm{y}) \\
&\qquad + \beta\{\pi Max[\mathrm{U}(\mathrm{x}_1,\theta^H,\text{y-k}_\mathrm{H}), \mathrm{U}(\mathrm{x}_0,\theta^H,\mathrm{y})] \\
&\qquad + (1-\pi)Max[\mathrm{U}(\mathrm{x}_1,\theta^L,\text{y-k}_{\mathrm{L2}}), \mathrm{U}(\mathrm{x}_0,\theta^L,\mathrm{y}]\}
\end{aligned}
$$

- Compensation bundles could also be time dependent

Dynamic WTP Locus



Dynamic WTA and WTP Locus



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)

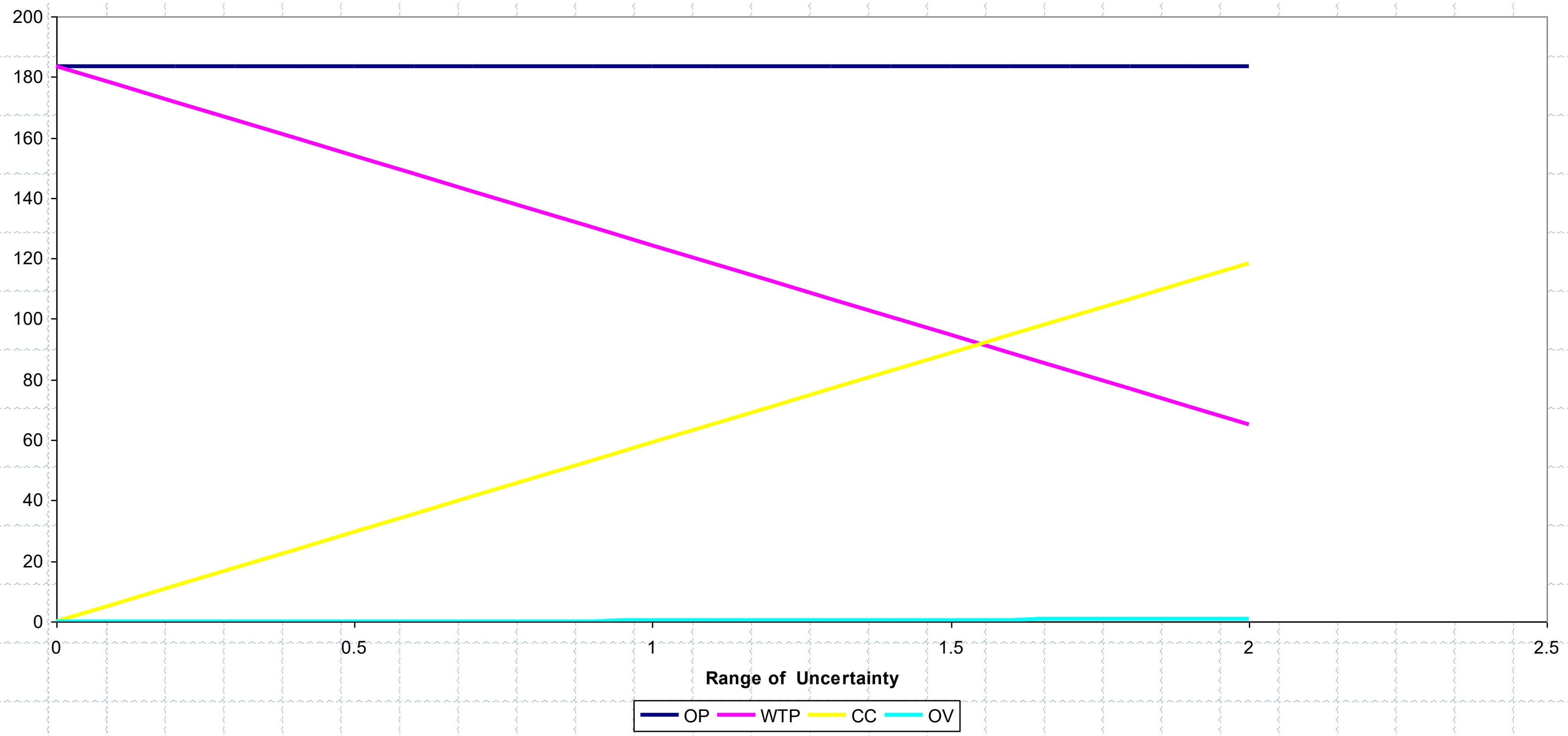
$$\theta^{H} = 0.03,\ \ \theta^{L} = 0.01,\ \ \rho = 0.277$$

$$y = 50,000, \quad x^{1} = 1,\ x^{0} = 0$$

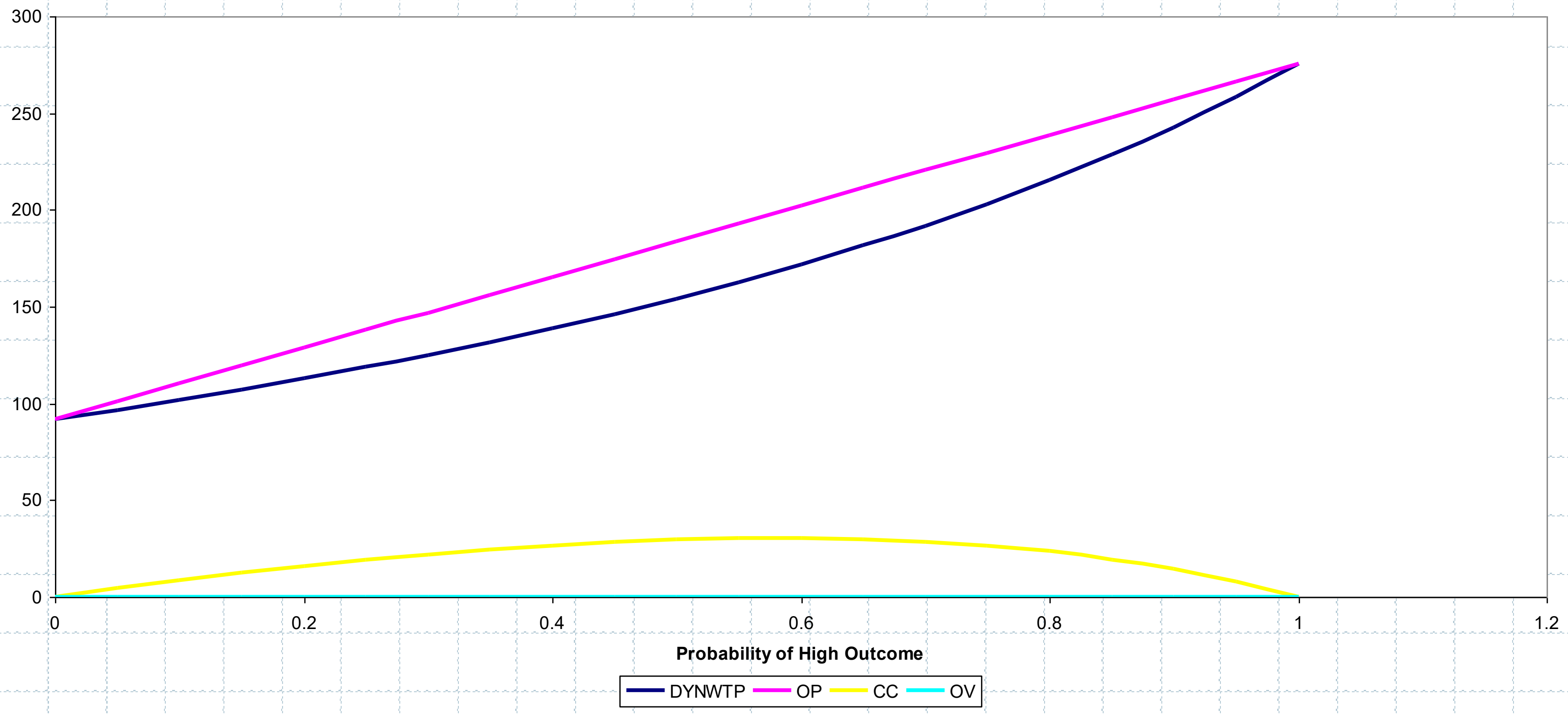
$$\beta = \frac{1}{1+r} = .952 \quad (r = 0.05)$$

$$\pi = 0.5$$

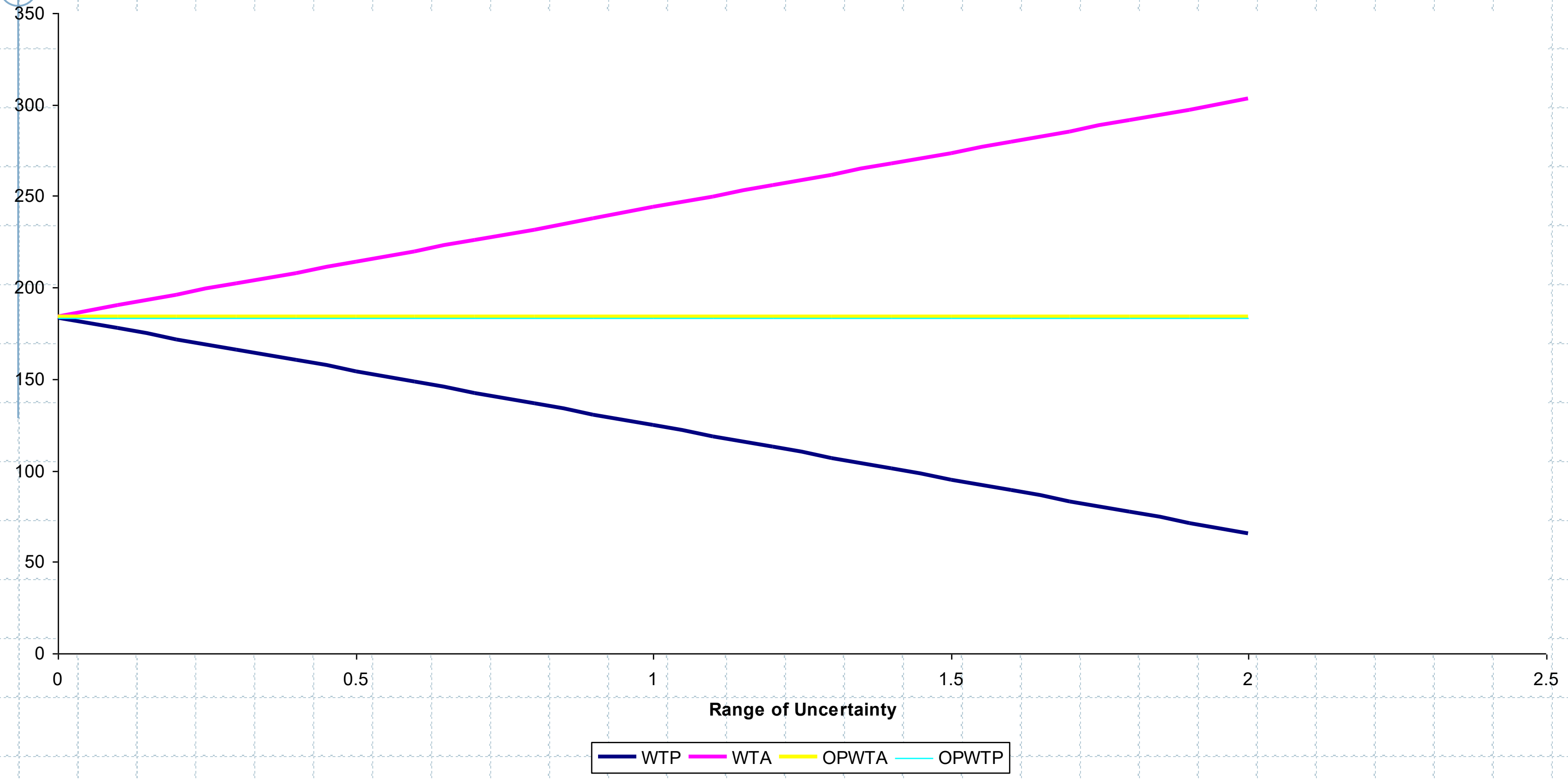
Dynamic WTP, Option Price and Uncertainty



Dynamic WTP, Option Price and the Probability of High



Dynamic WTP and WTA



Dynamic WTP Locus