Lecture 10: Valuing the Environment

ECON7720: Ecological and Environmental Economics

Dr Juan Soto-Diaz[1,2]

[1]School of Economics
[2]Sustainable Minerals Institute (SMI)
The University of Queensland

Semester 2, 2026 | Required reading: Tietenberg & Lewis, Ch. 4

Recap of Lecture 9

Benefit–cost analysis

- Decision rule: recommend if $B > C$; net benefit maximised where $MB = MC$.
- Benefits = WTP (consumer surplus); costs = opportunity costs.
- Kaldor–Hicks: aggregate gains exceed losses (potential Pareto improvement).
- Discount rate is decisive for long-lived environmental goods; declining rates recommended.

Applying BCA

- Primary vs. secondary effects; accounting stance; tangible vs. intangible benefits.
- Sensitivity analysis tests robustness.

Alternatives to BCA

- Cost-effectiveness analysis: set the target, find the least-cost means ($MC_A = MC_B$).
- Impact analysis: when neither benefits nor costs can be reliably monetised.

Lecture Outline

1. Why value the environment? Types of values, TEV framework, WTP vs WTA
2. Revealed preference methods: hedonic pricing, hedonic wages, VSL, travel cost
3. Stated preference methods: contingent valuation, choice experiments

Part 1: Why Value the Environment?

Why value the environment?

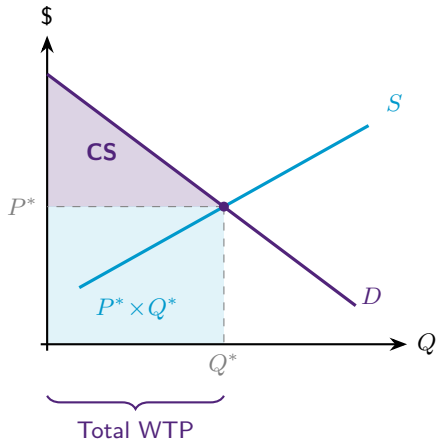
Valuation is a needed input to policy

- Many government agencies depend on benefit–cost analysis for decision-making:
  - Natural resource damage assessments (e.g. oil spills).
  - Designation of critical habitat.
  - Dam relicensing applications.
  - Environmental regulation impact statements.
- Also used in court proceedings: liability for environmental damages requires monetised estimates.
- Without valuation, environmental benefits are effectively assigned a value of zero in the policy process.

Valuing benefits: market goods

- For market goods, benefit = WTP = area under the demand curve.
- Straightforward to estimate from observed prices and quantities.
- The shaded area shows total WTP: consumers pay P^*, but many would have paid more.

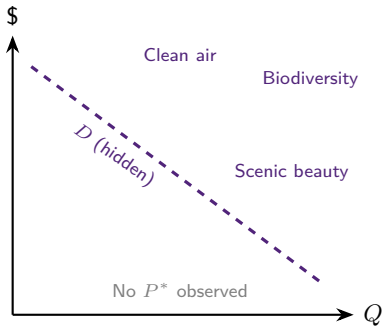
Market data reveal WTP directly, no special method needed.



Valuing benefits: non-market goods

- Non-market goods: no market price exists for clean air, biodiversity, scenic beauty, climate stability.
- But these goods provide real value ⇒ we need methods to infer WTP from other data.
- Without prices, the "demand curve" is hidden, valuation methods try to reveal it.

How do we measure what people are willing and able to pay for goods that are never bought or sold?

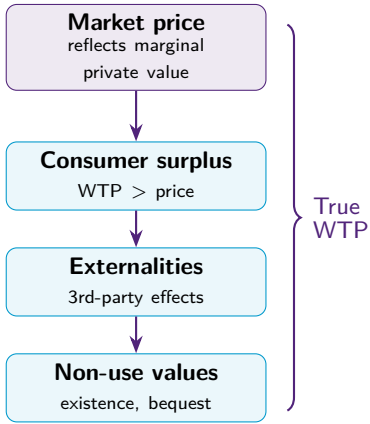


Valuing benefits: what market prices miss

Market prices only reflect marginal private values; they omit:

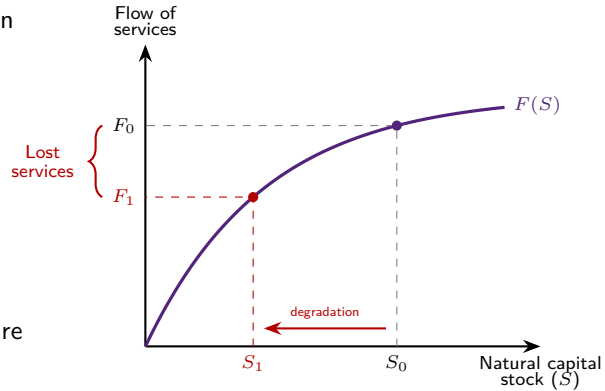
- Consumer surplus: WTP above the market price.
- Externalities: benefits or costs to third parties not captured in the transaction.
- Non-use values: existence, bequest, and altruistic values held by people who never use the good.

The benefit of a good = what people are willing and able to pay for it. The challenge is measuring this WTP when there is no market.

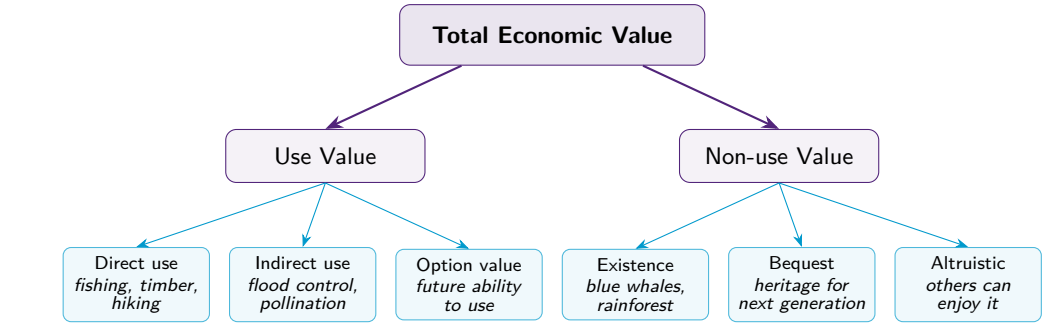


Stocks vs. flows in environmental valuation

- Stock: total quantity at a point in time (e.g. fish population, groundwater volume).
- Flow: services per unit of time (e.g. annual catch, water abstraction).
- Valuation targets flows, but the stock determines the capacity to provide them.
- Degrading the stock reduces future flows $\Rightarrow$ preserving it has option value and bequest value.



Total Economic Value



- Direct use: consumptive (timber, fish) and non-consumptive (hiking, birdwatching).
- Indirect use: ecosystem functions that support economic activity (flood control, water purification, pollination).

Use value

Active (consumptive) use

- Directly consuming the resource: fishing, hunting, timber harvesting, drinking water.
- Relatively straightforward to value via market prices or replacement costs.

Passive (non-consumptive) use

- Enjoying without consuming: birdwatching, hiking, scenic views, swimming.
- Harder to value because there is often no market transaction.
- Requires non-market valuation methods.

Option and non-use values

Option value

- The value of keeping options open: even if you don't visit a national park this year, you may want to someday.
- Related to quasi-option value: the value of preserving options until more information is available (e.g. potential future medical discoveries from biodiversity).

Non-use (passive-use) values

- Existence value: WTP simply to know a resource exists (blue whales, pristine Antarctic).
- Bequest value: WTP to preserve a resource for future generations (heritage motivation).
- Altruistic value: WTP so that others can enjoy the resource (even if you never will).
- Non-use values can be very large, often exceeding use values for iconic resources.
- Non-use values are hard to measure and most prone to bias.

WTP vs. WTA (1)

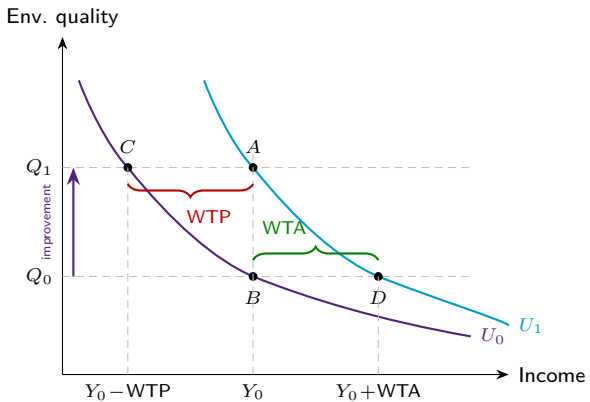
Two ways to measure welfare change

- WTP: "How much would you pay to *gain* this environmental improvement?"
- WTA: "How much compensation would you *accept* to tolerate this environmental loss?"
- In theory (no income effects): WTP $\approx$ WTA.
- In practice: WTA is systematically much larger than WTP.

Why the gap?

- Loss aversion (Kahneman & Tversky): people weight losses more heavily than equivalent gains.
- Income constraint: WTP is bounded by income; WTA is not.
- Endowment effect: once you "own" environmental quality, you demand more to give it up.
- Ando (2022): for biodiversity, WTA may be more appropriate than WTP since WTP is income-constrained and understates true value.

WTP vs. WTA (2)

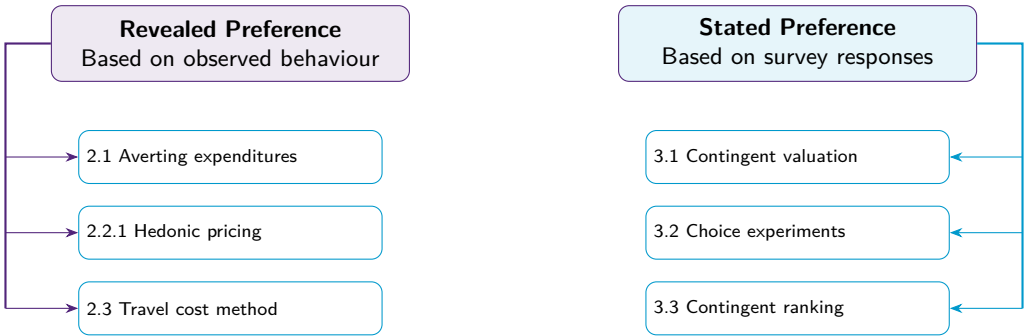


- Quality improves $Q_0 \to Q_1$: move $B \to A$ (same income Y_0, higher utility $U_0 \to U_1$).
- WTP (compensating variation): maximum income sacrifice at Q_1 to stay as well off as at B
  $\Rightarrow$ move $A \to C$ along U_0.
- WTA (equivalent variation): minimum compensation at Q_0 to be as well off as at A
  $\Rightarrow$ move $B \to D$ along U_1.

WTP vs. WTA (3)

- WTP is appropriate when the individual does *not* have a right to the improvement:
  - "How much would you pay for cleaner air?" (no right to clean air).
- WTA is appropriate when the individual *has* a right to the current level of quality:
  - "How much compensation would you accept for dirtier air?" (right to current quality).
- WTP is conservative (income-bounded) and has been the preferred metric in practice.
- But Ando (2022): for biodiversity and irreversible losses, WTA may be more appropriate, WTP understates the true welfare loss because people cannot afford to pay enough to prevent catastrophic loss.
- For damage assessment (oil spills, habitat destruction): WTA is conceptually correct, the loss was imposed without consent.

Classifying valuation methods



1. Direct measurement: use observed damage costs or replacement costs directly.
2. Revealed preference: infer values from actual market behaviour (what people *do*).
3. Stated preference: values from hypothetical scenarios (what people *say* they would do).

Which method captures which value?

Method	Use value	Option value	Non-use value
Averting expenditures	✓		
Hedonic pricing	✓		
Travel cost	✓		
Contingent valuation	✓	✓	✓
Choice experiments	✓	✓	✓
Benefit transfer	Depends on source study		

Only stated preference methods can capture non-use values, because non-use values leave no behavioural trace in markets. This is why stated preference methods are essential despite their limitations.

1. Direct measurement of damage costs

The simplest approach

- Estimate the increased costs imposed by pollution:
  - Agricultural production affected by air pollution (reduced crop yields).
  - Materials damage: increased building maintenance and earlier replacement due to acid rain.
  - Cost of illness: increased medical costs, lost workdays, hospitalisations.
- Benefits of pollution control = reduction in these costs.

Limitations

- Generally incomplete: omits non-market damages (pain and suffering, aesthetic losses).
- Ignores behavioural adjustments people make to reduce exposure.
- Provides only a lower bound on true damages.

1. Direct damage costs: worked example

Agricultural damage from ozone pollution

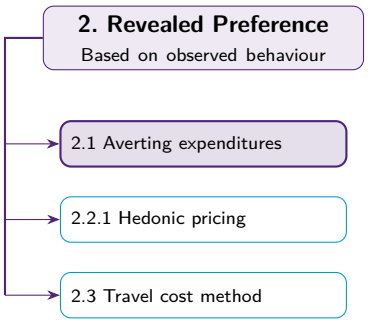
- Elevated ground-level ozone reduces crop yields.
- Estimate the dose-response function: for each ppb (parts per billion) increase in O_3, wheat yields decline by $X\%$.
- Multiply yield loss by market price of wheat $\Rightarrow$ damage cost per hectare.
- Aggregate across affected area $\Rightarrow$ total agricultural damage.
- This gives the approximate benefit of reducing ozone to the target level.

Cost of illness approach

- Benefits of pollution control = reduction in medical costs + lost workdays + productivity losses.
- Lower bound: omits quality-of-life improvements, pain and suffering, and impacts on those outside the labour force (children, retirees).
- Often combined with willingness-to-pay methods to capture the full welfare effect.

Part 2: Revealed Preference

Part 2: Revealed preference methods



2.1 Averting (defensive) expenditures

What people spend to protect themselves

- Actions taken to reduce exposure to pollution or mitigate its adverse effects.
- Examples:
  - Purchasing bottled water or water filters to avoid contaminated tap water.
  - Installing double glazing or insulation to reduce traffic noise.
  - Buying face masks during wildfire smoke events.
  - Air purifiers for indoor air quality.
- A rational person takes defensive action as long as:

$$\text{Benefit (damage avoided)} \geq \text{Cost of action}$$

- $\Rightarrow$ The expenditure provides a lower bound of the actual benefit of pollution reduction.

Limitation: understates true WTP (some damage is accepted rather than defended against). Also imposes disproportionate hardship on poor households who cannot afford defensive actions.

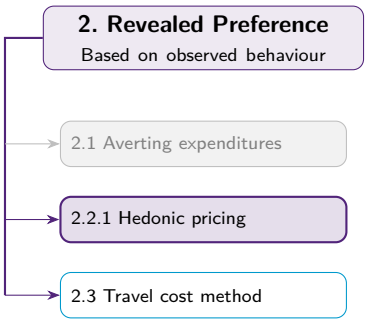
2.1 Averting expenditures: examples and applications

Applications in environmental and health valuation

Pollution	**Averting action**	**WTP proxy**
Water contamination	Bottled water, filters	Cost of substitute
Air pollution	Air purifiers, masks	Equipment cost
Traffic noise	Double glazing, insulation	Installation cost
UV radiation	Sunscreen, shade structures	Product cost
Wildfire smoke	Air filters, relocation	Purchase + moving
Lead paint	Abatement, encapsulation	Remediation cost

- These expenditures reveal a minimum WTP for avoiding the damage.
- Equity concern: poor households may not be able to afford defensive actions $\Rightarrow$ they bear the damage instead $\Rightarrow$ averting expenditures understate *their* WTP and overstate the WTP of the wealthy.
- Mainly applied to health valuation contexts.

Part 2: Revealed preference methods



2.2.1 Hedonic pricing

Extracting environmental values from market prices (Rosen, 1974)

- Many market goods are bundles of characteristics (attributes).
- The price of the bundle reflects the value of each characteristic (including environmental quality).
- If we can statistically isolate the environmental component, we can infer the WTP for environmental improvement.

Two main applications

1. Hedonic property value: house prices as a function of environmental quality (air quality, noise, proximity to parks, water clarity).
2. Hedonic wage: wages as a function of job risk (occupational hazards, exposure to pollution) $\Rightarrow$ the risk premium reveals WTP for safety.

Note: In spatial equilibrium, amenity differences are capitalised into *both* rents and wages (Roback, 1982), hence both applications complement each other for a complete picture.

2.2.1 Hedonic property values (1)

- Collect data on house sale prices and characteristics:
  - House attributes: size, bedrooms, bathrooms, age, heating.
  - Neighbourhood attributes: school quality, crime rate, distance to CBD.
  - Environmental attributes: air quality, noise level, proximity to water, views.
- Estimate a hedonic price function:

$$P = f(\text{house}, \text{neighbourhood}, \text{environment})$$

- The coefficient on the environmental variable gives the marginal WTP for a unit improvement in that attribute.

Key assumption

The housing market is in equilibrium: buyers can choose houses with different environmental quality levels, and prices fully reflect these differences.

2.2.1 Hedonic property values (2)

From the price function to marginal WTP

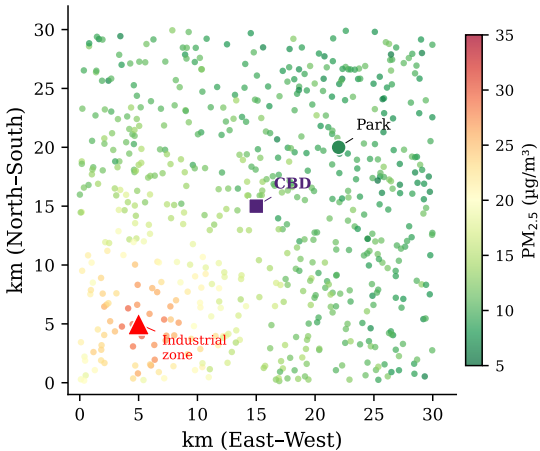
- The hedonic price function $P = f(X_1, X_2, \ldots, X_k)$ shows how price varies with characteristics.
- The partial derivative $\partial P / \partial X_j$ gives the implicit price of characteristic j, the marginal WTP for a small increase.
- For a linear model: $P = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k$, the implicit price of X_j is simply β_j.

Note: The hedonic regression is the first stage, it tells us how much more buyers *currently* pay for cleaner air (the implicit price). But this is one point on the demand curve, not the whole curve. A second stage uses variation across buyers or policy changes to trace out how WTP changes as environmental quality changes, i.e. the demand function itself.

2.2.1 Application: hedonic pricing and air quality

Simulated housing data

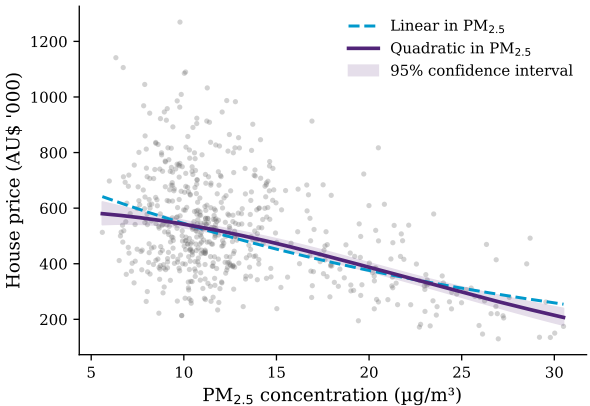
- 600 houses in a simulated city.
- An industrial zone generates $PM_{2.5}$ pollution that decays with distance.
- Houses differ in size, bedrooms, age, distance to CBD, park proximity, school quality.
- Question: how much less are people willing to pay for houses exposed to higher $PM_{2.5}$?



Each dot = one house. Colour shows $PM_{2.5}$ exposure (red = high, green = low).

2.2.1 Application: the hedonic price function

- A simple regression of $\ln P$ on $PM_{2.5}$ overstates the effect, it conflates pollution with distance to CBD and other neighbourhood traits.
- Adding structural controls (size, bedrooms, age, garage) absorbs house-level variation.
- The full model adds neighbourhood controls (CBD distance, park, school quality), the $PM_{2.5}$ coefficient falls towards the true value.



2.2.1 From hedonic estimates to marginal damage

- Linear $PM_{2.5}$:

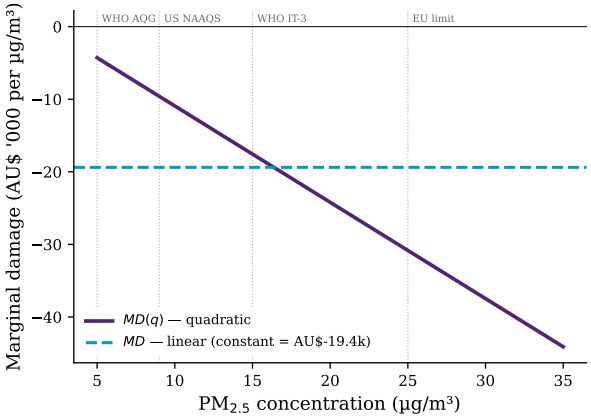
$$MD(q) = \hat{\beta}_{\text{pm}} \times \bar{P}$$

where $\bar{P}$ is the mean house price. Marginal damage is constant, every $\mu g/m^3$ causes the same harm.

- Quadratic $PM_{2.5}$:

$$MD(q) = (\hat{\beta}_1 + 2\hat{\beta}_2 q) \times \bar{P}$$

Marginal damage rises with pollution, implying larger gains from cleanup in polluted areas (Chay & Greenstone, 2005).



- The hedonic coefficient $\hat{\beta}_{\text{pm}}$ recovers the marginal damage of pollution.

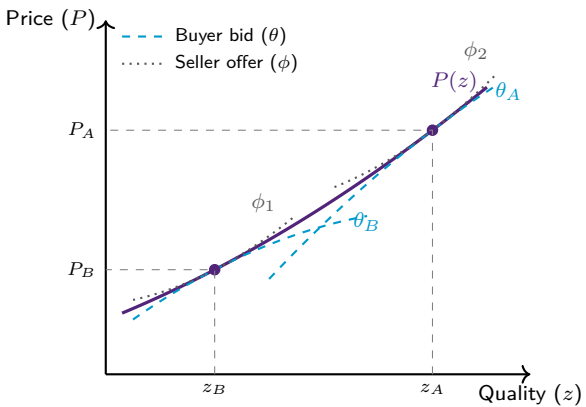
2.2.1 Hedonic property values: Australian applications

Examples from Australian research

- Airport noise: meta-analysis of 33 studies finds properties in high-noise zones sell for 0.5–1% less per decibel increase (Nelson, 2004).
- Urban greenspace (Brisbane): proximity to parks increases property values by 3–7%, depending on park type and distance (Engström & Gren, 2017).
- Coastal erosion risk (Gold Coast): properties in high-erosion zones sell at a discount reflecting perceived risk (Rambaldi et al., 2013).
- Water quality (SE Queensland): properties near high-quality waterways attract 3–9% premiums (Thomy et al., 2024).
- Mining proximity (Kalgoorlie): properties within 2 km of the Super Pit open-cut mine trade at a 20–30% discount (Abelson et al., 2020).

2.2.1 What does the hedonic gradient measure?

- The hedonic price function $P(z)$ is also an equilibrium envelope, tangencies between buyers' bid curves and sellers' offer curves.
- The gradient $\partial P/\partial z$ is the equilibrium implicit price, not a pure WTP or WTA parameter.
- For environmental amenities (air quality, noise), the supply of the amenity is exogenous, nature sets z, not sellers.
- When supply is exogenous, the hedonic gradient is driven by demand alone $\Rightarrow$ closer to pure WTP.



2.2.2 Hedonic wages: the risk premium

How much extra do workers require for risky jobs?

- Estimate a hedonic wage equation:

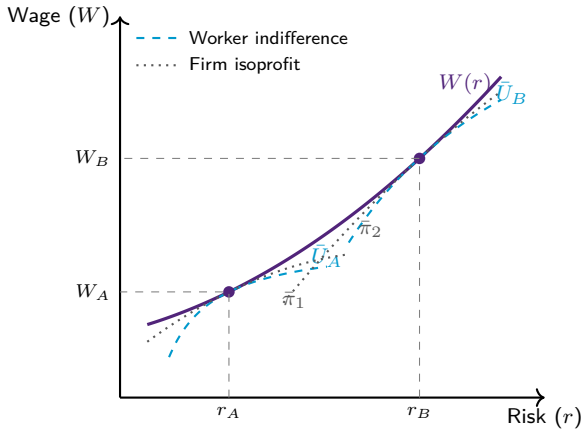
$$W = h(\text{education}, \text{experience}, \text{industry}, \text{risk}, \ldots)$$

- The coefficient on risk is the compensating wage differential: the equilibrium price of risk, not a structural WTA or WTP parameter.
- To recover the structural WTA (worker preferences), Rosen's second step requires an instrument that shifts firms' isoprofit curves without affecting worker preferences (e.g. industry-level safety regulation, technology shocks to the cost of safety).
- Limitations:
  - Workers may not be fully informed about risks.
  - Self-selection: risk-tolerant people choose risky jobs $\Rightarrow$ underestimates WTP for safety.
  - Union bargaining may distort wage premiums.
  - Risk data (fatality and injury rates) are imperfect.

2.2.2 Hedonic wage method

Inferring the value of safety from labour markets

- Workers in riskier occupations receive higher wages (compensating differential).
- The hedonic regression estimates the equilibrium wage–risk gradient $W(r)$ (Rosen, 1974).
- $W(r)$ is the envelope of tangencies between workers' indifference curves and firms' isoprofit curves, not purely WTA or WTP.
- Separately identifying WTA and WTP requires a second step with additional instruments.



The Value of Statistical Life approach

Not valuing "life itself" but reductions in mortality risk

- The Value of Statistical Life (VSL) or *value of reduced mortality risk* (VRMR):
- Measures the aggregate WTP for a small reduction in the probability of death across a population.
- Calculated as:

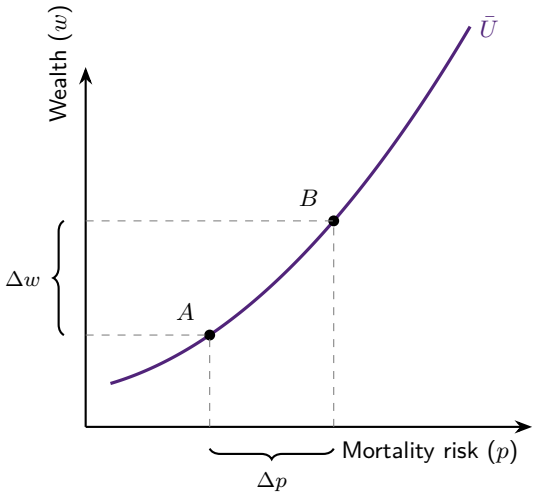
$$VSL = \frac{\text{Individual WTP for risk reduction}}{\text{Size of risk reduction}}$$

- Example: if each of 100,000 people pays \$80 for a policy that reduces each person's annual mortality risk by 1-in-100,000:

$$VSL = \frac{\$80}{1/100{,}000} = \$8 \text{ million}$$

- This is not the value of preventing certain death, it is the marginal rate of substitution between mortality risk and money.

The VSL



- A worker is indifferent between A and B along $\bar{U}$.
- Moving from A to B: accepts higher mortality risk Δp in exchange for higher wealth Δw.
- The slope of the indifference curve is:

$$VSL = \frac{\Delta w}{\Delta p} = \left.\frac{dw}{dp}\right|_{\bar{U}}$$

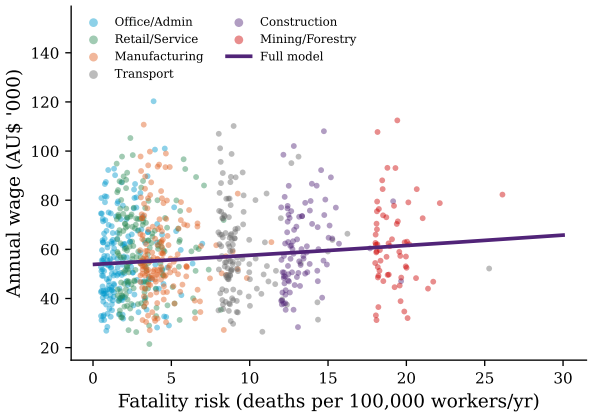
- This is the marginal rate of substitution between wealth and mortality risk.

2.2.2 Application: hedonic wages and occupational risk

- 800 simulated workers, six industries, fatality risk <1–26 per 100,000/year.
- Full model controls for education, experience, gender, union status.
- The upward-sloping line is the compensating wage differential: riskier jobs pay more.
- Without controls, the gradient is hidden, high-risk industries have lower-education workers.

$$w_i = \beta_0 + \beta_{\text{fatal}} \cdot \text{risk}_i + \beta' \mathbf{X}_i + \varepsilon_i$$

where $\mathbf{X}_i$ = education, experience, gender, union.



2.2.2 Application: the Value of a Statistical Life

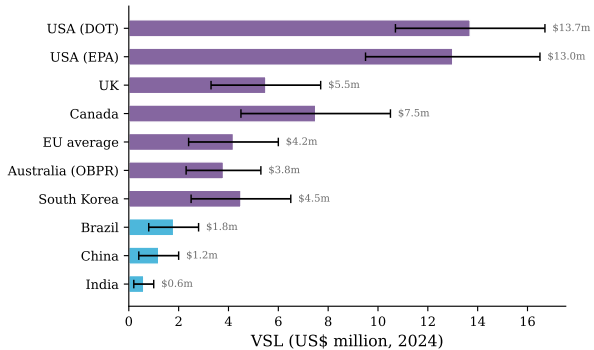
From $\hat{\beta}_{\text{risk}}$ to VSL

In the semi-log model, the wage premium per unit of risk is $\hat{\beta}_{\text{fatal}} \times \bar{W}$ (mean wage), so:

$$\text{VSL} = \hat{\beta}_{\text{fatal}} \times \bar{W} \times N$$

where $N = 100{,}000$ is the number of workers per statistical death (matching the risk units).

- $\hat{\beta}_{\text{fatal}} = 0.007$, $\bar{W} = \text{AU\$56k} \Rightarrow$ VSL $\approx$ AU\$39m.
- VSL scales with income: a 1% higher GDP per capita is associated with a 0.5–1.0% higher VSL.



Source: Viscusi (2008); Banzhaf (2021); US Environmental Protection Agency, Department of Transportation, Australian Office of Best Practice Regulation. Purple = high-income countries; cyan = middle/low-income countries.

2.2 Hedonic methods: strengths and limitations

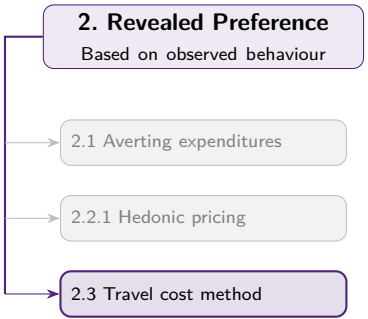
Strengths

- Based on actual market transactions (not hypothetical).
- Large datasets available (property sales, wage data).
- Well-established econometric methodology.

Limitations

- Requires that environmental quality varies across observations (e.g. pollution levels differ across neighbourhoods).
- Assumes markets are in equilibrium and buyers/workers are well-informed about environmental quality.
- Captures only use values (not option or non-use).
- Identification: environmental quality is not randomly assigned, omitted variables correlated with both price and quality bias estimates. Credible designs require exogenous variation (e.g. regulatory changes, natural experiments).

Part 2: Revealed preference methods



2.3 The travel cost method

Valuing recreational sites

- Infers the value of a recreational resource by examining how much visitors spend getting there (time + money).
- Visitors who live further away face higher travel costs $\Rightarrow$ make fewer visits (a "price" for using the site).
- By relating visit frequency to travel cost, we can estimate a demand curve for the site.
- Consumer surplus under the demand curve = total value of the site (or "access value").

Applications

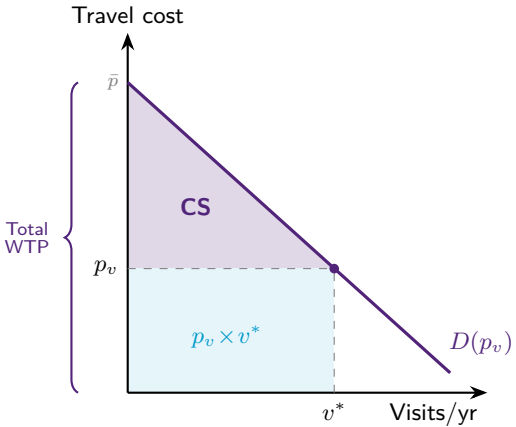
- National parks, beaches, rivers, mountain climbing, fishing sites, marine protected areas.
- Can also value changes in site quality: include a quality variable q in the demand function and estimate the change in consumer surplus.

2.3 Travel cost: the single-site model

Estimating the demand curve

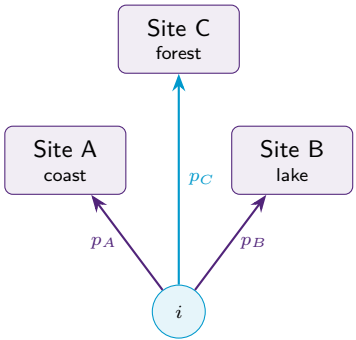
$$v = g(p_v, p_s, y, z)$$

- v = number of visits per year.
- p_v = travel cost to the site (fuel, time, entry fees).
- p_s = travel cost to substitute sites.
- y = income; z = demographic variables.
- Consumer surplus (CS) = area above p_v and below demand = recreational value of the site.
- Total site value = CS + expenditure ($p_v \times v^*$).



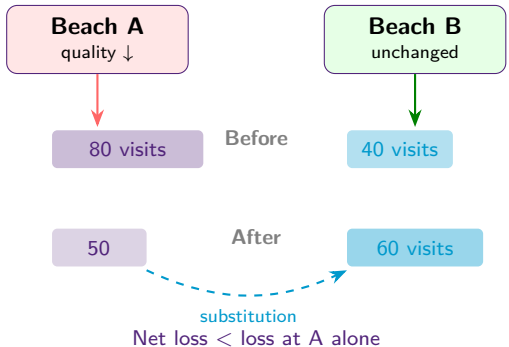
2.3 Travel cost: multi-site models

- Random utility models (RUM): visitor i picks the site with the highest net utility (quality minus travel cost).
- Unlike the single-site model (which adds p_s as a control), the RUM models the joint choice across all sites, substitution emerges from the model structure.
- Can value quality changes at one site while accounting for substitution.



2.3 Travel cost: why substitution matters

- If water quality at Beach A declines, some visitors switch to Beach B.
- The loss at A is partially offset by gains at B.
- Adding p_s as a control gives an unbiased demand for A, but still measures loss at A in isolation.
- The RUM predicts the net welfare change across all sites, loss at A minus gains at B.



2.3 Discrete choice modelling: the econometrics

- Based on random utility theory (McFadden, 1974): individuals choose the option that maximises their utility.
- Utility of option j for individual i:

$$U_{ij} = \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_k X_{kj} + \beta_p \text{Cost}_j + \varepsilon_{ij}$$

- The probability of choosing j depends on utility *relative to all alternatives*.
- Marginal WTP for attribute k:

$$MWTP_k = -\frac{\beta_k}{\beta_p}$$

- Models: conditional logit (basic), mixed logit (allows preference heterogeneity), latent class (identifies distinct preference groups).
- This framework also underpins choice experiments, the same econometrics applies to both revealed and stated preference discrete choice data.

2.3 Random utility models: setup

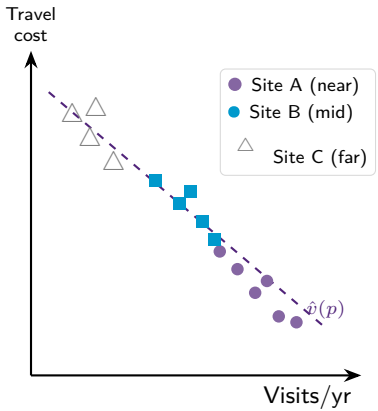
Visitor i picks site j with the highest utility:

$$U_{ij} = \underbrace{V_{ij}}_{\text{observable}} + \underbrace{\varepsilon_{ij}}_{\text{unobservable}}$$

The systematic component:

$$V_{ij} = \beta_p \, p_{ij} + \boldsymbol{\beta}_q' \, \mathbf{q}_j + \boldsymbol{\beta}_z' \, \mathbf{z}_i$$

- p_{ij} = travel cost (home i to site j)
- $\mathbf{q}_j$ = site attributes (quality, facilities)
- $\mathbf{z}_i$ = individual characteristics (income, experience)
- ε_{ij} = random taste variation (Type I EV $\Rightarrow$ logit)

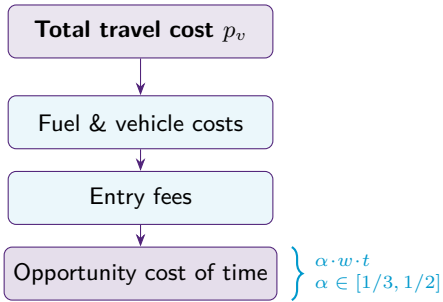


2.3 Travel cost: valuing travel time

The cost of travel time is a major component of total travel cost:

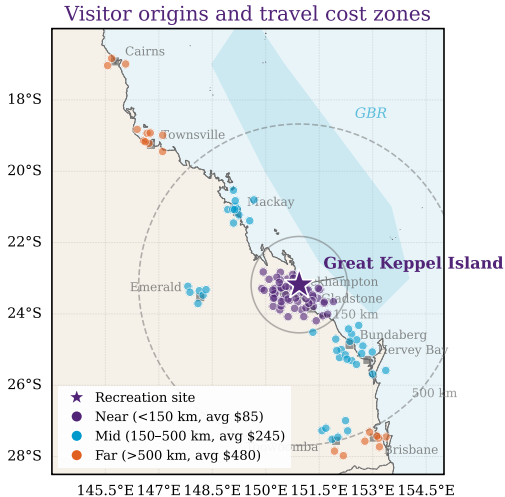
$$p_v = \underbrace{\text{fuel} + \text{fees}}_{\text{out-of-pocket}} + \underbrace{\alpha \cdot w \cdot t}_{\text{time cost}}$$

- w = wage rate; t = travel time (hours).
- α = fraction of wage used to value time.
- Common assumption: $\alpha = 1/3$ to $1/2$ (T&L, Ch 4).
- But leisure time may be valued differently from work time, making this a significant source of estimation uncertainty.



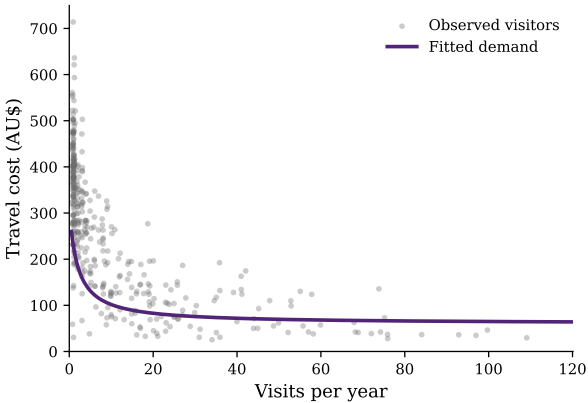
2.3 Application

- Consider valuing recreational visits to Great Keppel Island (Capricorn Coast, Qld).
- Visitors come from across Queensland; those further away face higher travel costs.
- The map shows simulated visitor origins colour-coded by distance zone.
- Key insight: variation in travel cost across origins traces out the demand curve, visitors further away make fewer trips.



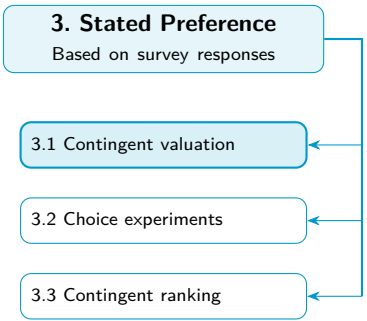
2.3 Application: estimating the demand curve

- 400 simulated visitors to a coastal recreation site.
- Travel cost = out-of-pocket + $\alpha \cdot w \cdot t$.
- Controls: substitute-site cost, log income.
- The fitted demand curve traces out how visits decline with travel cost, holding controls at sample means.
- CS per trip = area above p_v and below the demand curve (as in the single-site model).



Part 3: Stated Preference Methods

Part 3: Stated preference methods



3.1 Contingent valuation

Directly asking people their WTP

- Respondents are presented with a hypothetical scenario describing a change in environmental quality.
- They are asked: "What is the maximum you would be willing to pay for this change?"
- The scenario specifies:
  - What the respondent would get (e.g. improved water quality, species protection).
  - How it would be provided (e.g. government programme).
  - That they would have to pay for it (e.g. via taxes, donations, utility bills).
- The only method that can capture all types of value (use + option + non-use).
- But: subject to a number of potential biases.

3.1 Potential biases in contingent valuation

Bias	Description
Strategic bias	Respondent intentionally overstates or understates WTP to influence the outcome. Related: social desirability bias.
Information bias	Respondent must value something with which they have little experience. Providing adequate information reduces this.
Starting-point bias	The initial amount suggested anchors responses.
Hypothetical bias	Hypothetical WTP $\neq$ actual WTP; tendency to overstate in hypothetical settings.
Payment vehicle bias	Respondent reacts to the payment mechanism (e.g. "I refuse to pay more taxes") rather than valuing the good.

- Additional concern: bots and inattentive respondents in online surveys (a growing problem).
- Careful survey design can reduce (but not eliminate) these biases.

3.1 The "warm glow" problem

Are respondents valuing the good or purchasing moral satisfaction?

- Scope insensitivity: WTP does not scale with the quantity of the environmental good being valued.
- Desvousges et al. (1993): WTP to save 2,000 / 20,000 / 200,000 migratory birds from oil waste ponds was nearly identical ($80, $78, $88), suggesting respondents are purchasing "moral satisfaction" rather than valuing the specific resource.
- Kahneman & Knetsch (1992): argued this "warm glow" invalidates CV estimates as measures of economic value.
- Related but distinct: the embedding effect (part–whole bias), where WTP for a good changes depending on whether it is valued alone or as part of a larger package.
- Counter-arguments:
  - Better survey design (adequate information, scope reminders) reduces scope insensitivity.
  - Some insensitivity may reflect real preferences, though a $100\times$ increase in scope with near-zero change in WTP is difficult to rationalise with diminishing MU alone.
  - Choice experiments (next slides) are less susceptible to this problem.

3.1 The Exxon Valdez oil spill: a landmark CV study

Background

- 24 March 1989: the tanker *Exxon Valdez* ran aground in Prince William Sound, Alaska.
- 11 million gallons of crude oil released, the largest tanker spill in US waters at that time.
- Massive ecological damage: seabirds, sea otters, fish, coastal habitats.
- The State of Alaska commissioned a CV study to measure lost passive-use values for litigation.

Why CV was needed

- Most of the damage was to non-use values: Americans who would never visit Prince William Sound still valued its pristine condition.
- No revealed-preference method could capture these values.
- The Ohio v. US Department of the Interior (1989) court ruling affirmed that passive-use values are compensable.

3.1 Exxon Valdez: CV in practice (Carson et al., 2003)

Design

- Goal: measure lost passive-use values from the 1989 oil spill.
- Referendum format (dichotomous choice): "Would you vote for an escort ship programme if it cost your household $X?"
- Face-to-face interviews; national random sample; 75% response rate.

Results

- Median WTP $\times$ population = \$2.8 billion (1990 dollars), a lower bound (median $<$ mean; WTA would exceed WTP for a loss).
- Legal settlement: \$1 billion (\$900M civil + \$100M criminal); Exxon spent an additional $\sim$\$2.5 billion on cleanup.

Demonstrated that non-use values can be enormous and that CV can inform real-world damage assessment, but triggered intense debate about the reliability of CV, leading to the NOAA Panel.

Benefit transfer and meta-analysis

Using existing estimates for new contexts

- Original valuation studies are expensive and time-consuming. Can we transfer estimates?
- Benefit transfer: use values estimated at one site/time to approximate values at another site/time.
- Three forms:
  1. Value transfer: directly apply estimates from another study.
  2. Benefit function transfer: apply the estimated *function* (adjusting for site characteristics).
  3. Meta-analysis: statistically synthesise estimates from many studies, relating them to study characteristics.

Transfer is a pragmatic compromise: better than no estimate, but must be used with caution.

3.1 Meta-analysis in environmental valuation

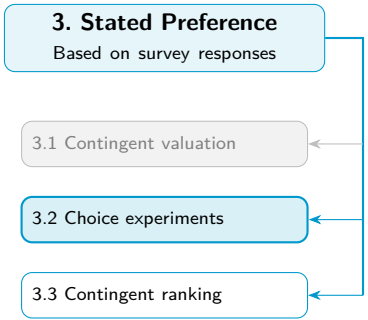
Synthesising evidence across studies

- Meta-analysis: statistical analysis of results from multiple valuation studies.
- Estimates a "meta-regression":

$$\text{WTP}_s = \alpha + \beta_1 \text{Method}_s + \beta_2 \text{Income}_s + \beta_3 \text{Good}_s + \varepsilon_s$$

- Reveals how WTP varies with:
  - Method (CV vs. CE vs. travel cost).
  - Population characteristics (income, education).
  - Resource type (water, air, biodiversity, recreation).
  - Study quality (sample size, response rate, format).
- Can identify publication bias (tendency for journals to publish significant or large results).
- Limitation: "garbage in, garbage out"—meta-analysis is only as good as the underlying studies.

Part 3: Stated preference methods



3.2 Choice experiments

An attribute-based alternative to CV

- Instead of asking "How much would you pay?", respondents choose among alternative bundles of attributes.
- Each bundle has several attributes at varying levels; one attribute is always a price/cost.
- Since the price attribute varies, WTP for each attribute can be estimated from the choices.
- Typically includes a status quo option ($0 cost, current conditions).

Advantages over CV

- Mimics real-world choices (we routinely choose among bundles in markets).
- Estimates WTP for individual attributes, not just the whole package.
- Less susceptible to strategic bias (harder to manipulate choices across multiple attributes).
- Gaining popularity in environmental economics, health, and transport policy.

3.2 Choice experiment: example choice set

Water quality improvement (hypothetical)

Attribute	Option A	Option B	Status Quo
Nutrient level	Low	Medium	High
Water clarity	High	Medium	Low
E. coli risk	Absent	Present	Present
Monthly cost	\$15	\$8	\$0

- "Which option do you prefer?"
- By varying attribute levels and costs across many choice sets, the analyst can estimate marginal WTP for each attribute.
- Example result: WTP for "high clarity" vs. "low clarity" = \$12/month; WTP for "absent *E. coli*" = \$5/month.
- These attribute-level values are more useful for policy design than a single total WTP number.

3.2 Choice experiments: applications

Growing rapidly in environmental economics

- Water quality (Walsh et al., 2022): NZ residents' WTP for nutrient reduction, clarity, *E. coli*.
- Marine protected areas: WTP for reef preservation, shipwreck heritage, public education programmes.
- Renewable energy: WTP for wind farms vs. solar (considering visual amenity, noise, employment).
- Forest management: WTP for biodiversity, recreation access, carbon storage, fire risk reduction.
- Urban planning: WTP for greenspace, cycling infrastructure, reduced traffic noise.
- Climate adaptation: WTP for flood protection, heatwave preparedness, coastal retreat options.

Why CE is gaining ground over CV

CE provides more information (attribute-level WTP), is more natural (choosing among options mirrors real decisions), and is less prone to strategic bias and "yea-saying".

3.2 Choice experiments vs. contingent valuation

Feature	CV	Choice experiment
Question type	"Would you pay $X?"	"Choose A, B, or status quo"
Output	Total WTP for a package	WTP per attribute
Strategic bias	Higher risk	Lower risk
Scope sensitivity	Often fails	Generally passes
Embedding/warm glow	Higher risk	Lower risk
Cognitive demand	Lower	Higher (complex choice sets)
Policy flexibility	Less (package only)	More (can model scenarios)
Dominant use	Damage assessment	Policy design

Trend

Choice experiments have become the dominant method in environmental valuation since the 2010s, largely displacing CV for new policy applications. CV remains important for damage assessment (Exxon Valdez, Deepwater Horizon).

3.2 Choice experiments: econometrics

Same discrete choice framework as travel cost RUM

- Choice experiments use the same random utility model (McFadden, 1974) as the multi-site travel cost method.
- The difference: travel cost uses observed choices (revealed preference); CE uses hypothetical choices (stated preference).
- Estimation (conditional logit, mixed logit, latent class) and welfare calculation ($MWTP_k = -\beta_k/\beta_p$) are identical.

Which methods capture which values?

	Use value	Option value	Non-use value
Revealed preference			
Averting expenditures	✓		
Hedonic pricing	✓		
Travel cost	✓		
Stated preference			
Contingent valuation	✓	✓	✓
Choice experiments	✓	✓	✓
Other			
Benefit transfer		Depends on source study	

- Only stated preference methods can reach non-use values (no behavioural trace in markets).
- Comprehensive valuation often requires combining methods.
- Each method uses different data and different expertise.

Aggregation challenges

From individual values to total benefits

- Once WTP is estimated for a sample, it must be aggregated to the relevant population.
- Key question: how large is the relevant population?
  - Local residents only?
  - State/national population?
  - Global population (for globally significant resources)?
- The choice of aggregation scope can dramatically affect total benefit estimates.
- Do benefits decline with distance from the resource? ("distance decay" in WTP, typically yes for use values, less clear for non-use values.)
- Risk of double counting: if multiple methods each capture overlapping value components, summing can overstate total benefits.

Emerging frontiers in environmental valuation

New methods and applications

- Machine learning + big data: using social media, satellite imagery, and mobile phone data to infer recreation values (e.g. Flickr photo density as a proxy for site visits).
- Life satisfaction approach: use large-scale happiness surveys to estimate the contribution of environmental quality to subjective well-being.
- Ecosystem service valuation: frameworks like TEEB (The Economics of Ecosystems and Biodiversity) integrate multiple methods to value natural capital (covered in Lecture 12).
- Digital choice experiments: online and app-based platforms enable larger samples at lower cost, but raise data quality concerns.
- Indigenous and cultural values: growing recognition that Western economic valuation may miss spiritual, cultural, and relational values of land and water.

Appendix

Valuation databases and evidence synthesis

Key databases for benefit transfer and meta-analysis

- EVRI — Environmental Valuation Reference Inventory
- ESVD — Ecosystem Services Valuation Database
- ValueBaseSWE — Swedish EPA database of Nordic valuation studies
- TEEB — The Economics of Ecosystems and Biodiversity
- SEEA — UN System of Environmental-Economic Accounting
- ARIES for SEEA — AI-driven platform for rapid ecosystem accounting

Natural capital accounting: country examples

GIS-based ecosystem accounts in practice

- UK — ONS Natural Capital Accounts
- UK — DEFRA Enabling a Natural Capital Approach guidance
- Australia — ABS National Ecosystem Accounts
- Australia — CSIRO natural capital accounting
- SE Queensland — Crossman et al. (2010), *Environmental Management*

References (1/3)

- Abelson, P., Joyeux, R. & Mahuteau, S. (2020), "Impacts of Mining on Property Values in Kalgoorlie-Boulder, Western Australia," *Resources Policy* 68, 101752.
- Ando, A.W. (2022), "Equity and Cost-Effectiveness in Valuation and Action Planning to Preserve Biodiversity," *Environmental and Resource Economics* 83(4), 999–1015.
- Arrow, K., Solow, R., Portney, P.R., Leamer, E.E., Radner, R. & Schuman, H. (1993), "Report of the NOAA Panel on Contingent Valuation," *Federal Register* 58(10), 4601–4614.
- Banzhaf, H.S. (2021), "The Value of Statistical Life: A Meta-Analysis of Meta-Analyses," *Journal of Benefit-Cost Analysis* 13(2), 182–207.
- Carson, R.T., Mitchell, R.C., Hanemann, M., Kopp, R.J., Presser, S. & Ruud, P.A. (2003), "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill," *Environmental and Resource Economics* 25(3), 257–286.
- Carson, R.T. & Mitchell, R.C. (1995), "Sequencing and Nesting in Contingent Valuation Surveys," *Journal of Environmental Economics and Management* 28(2), 155–173.

References (2/3)

- Chay, K.Y. & Greenstone, M. (2005), "Does Air Quality Matter? Evidence from the Housing Market," *Journal of Political Economy* 113(2), 376–424.
- Deloitte Access Economics (2017), *At What Price? The Economic, Social and Icon Value of the Great Barrier Reef*, Report for the Great Barrier Reef Foundation.
- Desvousges, W.H., Johnson, F.R., Dunford, R.W., Boyle, K.J., Hudson, S.P. & Wilson, K.N. (1993), "Measuring Nonuse Damages Using Contingent Valuation: An Experimental Evaluation of Accuracy," *Research Triangle Institute Monograph* 92-1.
- Engström, G. & Gren, Å. (2017), "Capturing the Value of Green Space in Urban Parks in a Sustainable Development Context," *Ecology and Society* 22(2), 21.
- Johnston, R.J., Boyle, K.J., Adamowicz, W. et al. (2017), "Contemporary Guidance for Stated Preference Studies," *Journal of the Association of Environmental and Resource Economists* 4(2), 319–405.
- Kahneman, D. & Knetsch, J.L. (1992), "Valuing Public Goods: The Purchase of Moral Satisfaction," *Journal of Environmental Economics and Management* 22(1), 57–70.
- Kaul, S., Boyle, K.J., Kuminoff, N.V., Parmeter, C.F. & Pope, J.C. (2013), "What Can We Learn from Benefit Transfer Errors? Evidence from 20 Years of Research on Convergent Validity," *Journal of Environmental Economics and Management* 66(1), 90–104.
- Lewis, L.Y. & Landry, C.E. (2017), "River Restoration and Hedonic Property Value Analyses," *Water Resources Research* 53(7), 5432–5450.

References (3/3)

- Nelson, J.P. (2004), "Meta-Analysis of Airport Noise and Hedonic Property Values: Problems and Prospects," *Journal of Transport Economics and Policy* 38(1), 1–27.
- Rambaldi, A.N., Fletcher, C.S., Collins, K. & McAllister, R.R.J. (2013), "Housing Shadow Prices in an Inundation-Prone Suburb," *Urban Studies* 50(9), 1889–1905.
- Roback, J. (1982), "Wages, Rents, and the Quality of Life," *Journal of Political Economy* 90(6), 1257–1278.
- Rosen, S. (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy* 82(1), 34–55.
- Thomy, B., Greig, J., Crossman, N. & Roberts, M.E. (2024), "Investigating Revealed Preferences for Urban Waterway Conditions: A Hedonic Property Valuation Study," *Australian Journal of Agricultural and Resource Economics* 68(3), 567–590.
- Viscusi, W.K. (2008), "How to Value a Life," *Journal of Economics and Finance* 32(4), 311–323.
- Walsh, P., Banerjee, S., Grilli, G., Murphy, J. & Siderelis, C. (2022), "Valuing Water Quality in New Zealand Using a Choice Experiment Approach," *Water Resources Research* 58(10), e2021WR031551.