# Vulnerability Analysis and Risk Management for Water-Related Hazards

## PART II: "Socio-economic valuation of risk perception"

Rubina Canesi
DICEA
rubina.canesi@unipd.it

Cristiano Franceschinis
TESAF
cristiano.franceschinis@unipd.it

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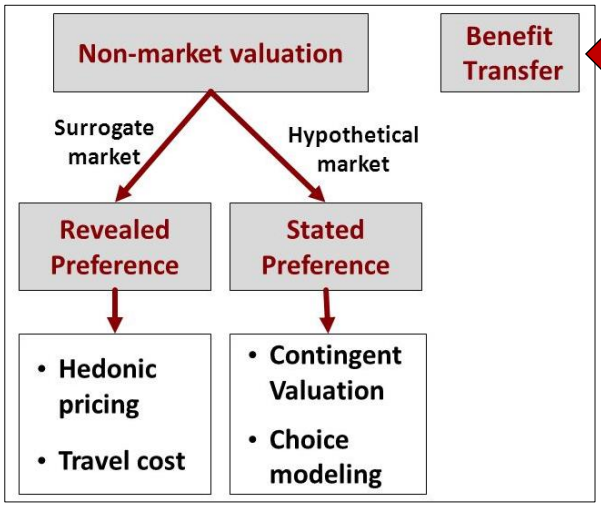
# 1. Overview of economic approaches to risk valuation




Revealed preference
Only use values

Stated preferences
Total Economic Value

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# Benefit transfer

- In the previous lectures we have described how to conduct an original non-market valuation study. However, original research may be **time-consuming and expensive**.
- What might analysts do if a lack of time and/or funding prevents them from conducting an original study? In such case, they must **rely on existing data to compute the costs and benefits of risk mitigation programs**.
- "**Benefit transfer**" is a colloquial term adopted by economists; it is defined as the use of existing data or information on non-market values in **settings other than where they were originally collected**.
- The spirit of benefit transfer is that providing an estimate of the value of non-market resources using existing data may **result in more balanced decision-making** in situations where direct estimation of non-nonmarket benefits is not feasible.

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# Benefit transfer

- BT is the adaptation of information derived from original research in a different context.
- The context of original research is referred to as the study site (*s*).
- The policy site, or the context for which we need information is *p*.
- We derive estimates of **non-market values $V_p$** for policy site *p* from **outcomes of original research** at study site *s* ($V_s$). Study site values ($V_s$) becomes transfer values ($V_T$) when applied to policy site *p*:

$$V_s \Rightarrow V_T$$

- The transfer value allows to transfer information to the specific policy site.

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# Benefit transfer

- Original research provides **context-specific information** regarding the policy site(s). This is because the target of original research is to address a specific need in a specific context.
- The benefit transfer process must discuss the context-relevant information of the study site and policy site in order to have some idea of **how well the study site matches the policy site**.
- In deciding whether the benefit transfer method is applicable, the analyst is trying to **determine whether s is similar to p enough** in context to make a valid inference of $V_p$.
- Criteria:
  - The **non-market resource valued is the same** at the study site and policy site;
  - The characteristics of the **populations affected** by the non-market commodity at the study and policy sites are similar;
  - The **assignment of property rights** is the same at both sites, so that the same theoretically appropriate **value measures** (e.g. WTP a tax) can be used.

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# Modeling and Applying Benefit Transfer

- Several benefit transfer methods have been developed to meet the needs for estimates of $V_p$.
- These approaches are broadly classified as:
  1. **value transfer (single point estimate** and **measure of central tendency)**
  2. **function transfer (demand function transfer** and **meta-regression analysis)**
- **Value transfer** involves the **direct application of summary statistics** from original research to a policy context.
- **Function transfer** involves the application of a **statistical function** that relates the summary statistics of original research to the specifics of the study site.

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# Value transfer – Single point estimate

- Point estimate transfer uses measures of $V_S$ given the context (=characteristics) of study site s ($Q_S$), to estimate the needed measure ($V_P$) for policy site *p,* given the context of the policy site ($Q_P$).

$$V_P | Q_P = V_S | Q_S$$

- The manner by which single measures can be obtained is straight: point estimate transfer typically uses single measures.
- However, when possible, a range of estimates could be transferred to provide bounds on the probable value.
- Confidence intervals constructed around point estimates are recommended. This provides additional information regarding the precision of the study site measures.

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# Steps for a single point estimate value transfer

| | |
|---|---|
| **Step 1** | Define the policy context ($Q_P$). This definition should include various characteristics of the policy site, what information is needed, and in what units |
| **Step 2** | Locate and gather original research outcomes ($V_S$). Conduct a thorough literature review and obtain copies of potentially relevant publications |
| **Step 3** | Screen the original research studies for relevance ($Q_S = Q_P$). How well does the original research context correspond to the policy context? Are the point estimates ($V_S$) in the right units or can they be adjusted to the right units? What is the quality of the original research? |
| **Step 4** | Select a point estimate or range of point estimates ($V_S$). This point estimate or range of point estimates should be selected on the best match between $Q_P$ and $Q_S$ |
| **Step 5** | Transfer the point estimate or range of point estimates ($V_T$). Aggregate the point estimate to the policy site context by multiplying it by the total number of units, which provides a total value estimate for the good or service at the policy site |

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# Value transfer – Measure of central tendency

- A measure of central tendency transfer entails using a mean, median, or other measure of central tendency based on all or a subset of primary research point measures:

$$V_P \mid Q_P = \overline{V}_S \mid \overline{Q}_S$$

- This measure provides an indication of the center of the data, potentially being more defensible than relying on a single point measure.
- However, you should recognize that your measure of central tendency is dependent upon the single point measures underlying it.

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# Steps for a measure of central tendency value transfer

| | |
|---|---|
| Step 1 | Define the policy context. This definition should include various characteristics of the policy site, what information is needed, and in what units. |
| Step 2 | Locate and gather original research outcomes. Conduct a thorough literature review, and obtain copies of potentially relevant publications. |
| Step 3 | Screen the original research studies for relevance. How well does the original research context correspond to the policy context? Are the point estimates in the right units, or can they be adjusted to the right units? What is the quality of the original research? |
| Step 4 | Calculate the average value or other measure of central tendency for the point estimates. This average value should be based on those estimates that have the best fit out of the candidate estimates. |
| Step 5 | Transfer the average value estimate. Aggregate the average value to the policy site context by multiplying it by the total number of units, providing a total value estimate for the good or service at the policy site. |

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# Example of central tendency value transfer

Whitewater rafting/kayaking studies, United States (2013 $), 20% trimmed mean

| Region | No. of studies | No. of estimates | Mean ($); (s.e.) | Range ($) |
|---|---|---|---|---|
| Mountain Region | 6 | 17 | 140.15 (20.39) | 39-294 |
| Pacific Region | 2 | 3 | 82.53 (28.06) | 32-128 |
| West Region | 8 | 20 | 131.51 (18.23) | 32-294 |
| **Total** | **10** | **32** | **$142.63 (15.42)** | **$31-294** |

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# Function transfer

- Function transfers are more technically-oriented than value transfers. They entail the transfer of functions, or models that define statistical relationship in study site data.
- Two category of functions may be transferred:
  1. demand (or benefit or WTP) functions
  2. meta-regression analysis functions
- Function transfers are generally considered to perform better than value transfers. This is because function transfers may be tailored to fit some of the characteristics of the policy site. Value transfers on the other hand are invariant to differences between the study site and the policy site.

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# 1. Demand functions

- Demand or benefit function transfer are based on the premise that the study site estimate for site s ($V_S$) is a function of characteristics of the study site context ($Q_S$) (location, physical features, characteristics of the population, etc.)

$$V_s = f(Q_S) = \alpha + \beta_1 Q_{s1} + \beta_2 Q_{s2} + \cdots + \beta_n Q_{sn}$$

- A value transfer requires a strong similarity between study sites and policy sites, which may not be always there. Therefore, we should be able to increase the precision of benefit transfer if we can tailor a function to fit the specifics of a policy site.
- Model the statistical relationship between the summary measures of interest and characteristics of the original research.
- Adjust this function to specific characteristics of the study site.

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# Demand function transfer example (from VandenBerg et al., 2001)

| Variable | Regression coefficient | Policy site measure | Partial WTP |
|---|---|---|---|
| Constant | −29.68 | 1 | −29.68 |
| Perception of contamination (0, 1 = no experience) | −23.48 | 1 | −23.48 |
| Perception of contamination (0, 1 = don't know) | −26.96 | 0.24 | −6.47 |
| Likelihood of future contamination (0, 1 = likely or very likely) | 17.51 | 0.5 | 8.76 |
| Likelihood of future contamination (0, 1 = not sure) | 9.41 | 0.5 | 4.70 |
| Interest in community water issues (0, 1 = mild to no interest) | −20.66 | 0.5 | −10.33 |
| Interest in community water issues (0, 1 = interested) | −11.15 | 0.5 | −5.58 |
| Perceived water quality (0, 1 = unsafe or somewhat safe) | 29.92 | 0.5 | 14.96 |
| Perceived water quality (0, 1 = safe) | 21.07 | 0.5 | 10.54 |
| College degree (0, 1 = has college degree) | −17.51 | 0.24 | −4.20 |
| Some college (0, 1 = has some college but no degree) | −15.72 | 0.24 | −3.77 |
| Average risk perception (3-question composite; 1 = safe to 5 = unsafe) | 9.91 | 4 | 39.64 |
| Number of perceived potential contamination sources | 2.56 | 3.17 | 8.12 |
| Trust in government and organizations (9-question composite; 1 = do not trust to 3 = trust) | 15.67 | 1.91 | 29.93 |
| Household income ($/year) | 0.0008 | 45,500 | 36.40 |
| **Total mean WTP = ∑(column 2 × column 3) =** | | | **$69.54** |

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# Steps for a demand function transfer

| | |
|---|---|
| **Step 1** | Define the policy context ($V_P$). This definition should include various characteristics of the policy site ($Z_P$), what information is needed, and in what units |
| **Step 2** | Locate and gather original research demand or benefit functions ($Vf$). Conduct a thorough literature review and obtain copies of potentially relevant publications |
| **Step 3** | Screen the original research studies for relevance ($Q_S = Q_P$). How well does the original research context correspond to the policy context? What is the quality of the original research? And most importantly, is a demand or benefit function ($Vf_S$) provided? |
| **Step 4** | The demand or benefit function ($Vf_S$) provided by original research has several independent or explanatory variables associated with it. Gather summary data on the policy site ($Z_P$) for as many of the variables in the model as possible |
| **Step 5** | Predict the policy site benefit estimate ($V_T$) by multiplying the summary statistics reflecting the policy site by the regression coefficients in the transfer function ($Q_{S\|P}$ and $Z_{S\|P}$). This results in a tailored estimate for the policy site |
| **Step 6** | Aggregate the tailored estimate to the policy site context by multiplying it by the total number of units, providing a total value estimate for the good or service at the policy site |

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# Demand function transfer example – ES at Adamello Park (Lombardy)

Study framework

Households survey (**Choice Experiment**)

↓

WTP estimation (**Choice Models**)

↓

WTP maps (sampled municipalities)

↓

Benefit transfer

↓

WTP maps (whole region)

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## Data Collection

| Attributes (ES) | Levels |
|---|---|
| Slope stability | *10 km safe roads*<br>20 km safe roads (+10)<br>35 km safe roads (+25)<br>45 km safe roads (+35) |
| Biodiversity (flora conservation) | *0 ha managed meadows*<br>200 ha managed meadows (+200)<br>250 ha managed meadows (+250)<br>300 ha managed meadows (+300) |
| Fauna | *2 fauna sighting sites*<br>5 fauna sighting sites (+3)<br>7 fauna sighting sites (+5)<br>10 fauna sighting sites (+8) |
| Recreation | *1 floristic trails*<br>2 floristic trails (+1)<br>4 floristic trails (+3)<br>6 floristic trails (+5) |
| Aesthetic value (landscape) | *450 ha dry-stone walls in good state*<br>453 ha dry-stone walls in good state (+3)<br>455 ha dry-stone walls in good state (+5) |
| Regional Tax | Regional Tax (0, 2,5,10,15,20€) |

We sampled households in 562 out of the 1523 municipalities of Lombardy

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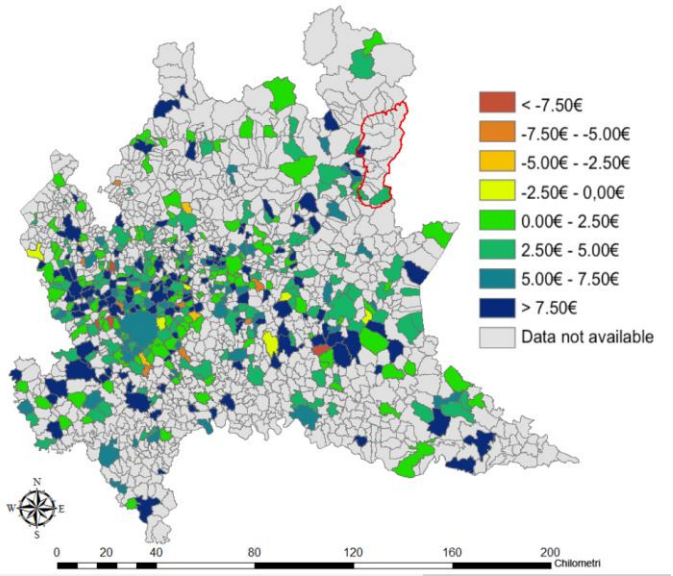
## WTP values for «Slope stability (45km)»

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# Benefit transfer function

| Variable | Estimate | \|t\| | Pr(> \|t\|) |
|---|---|---|---|
| Intercept | 6.79 | 2.64 | 0.008281 |
| edu | 0.7 | 1.53 | 0.127536 |
| age | −0.1 | 3.42 | 0.000644 |
| ln(pop_tot) | 0.01 | 1.53 | 0.12615 |
| s_sparse | 3.44 | 1.57 | 0.117078 |
| ln_dist | −0.83 | 1.75 | 0.079082 |
| edu x ln(pop_tot) | 0.02 | −2.01 | 0.04547 |

Adjusted R-squared: 0.2232 Multiple R-squared: 0.2304F-statistic: 18.24 on 7 and 1460 DF p-value: < 0.001.

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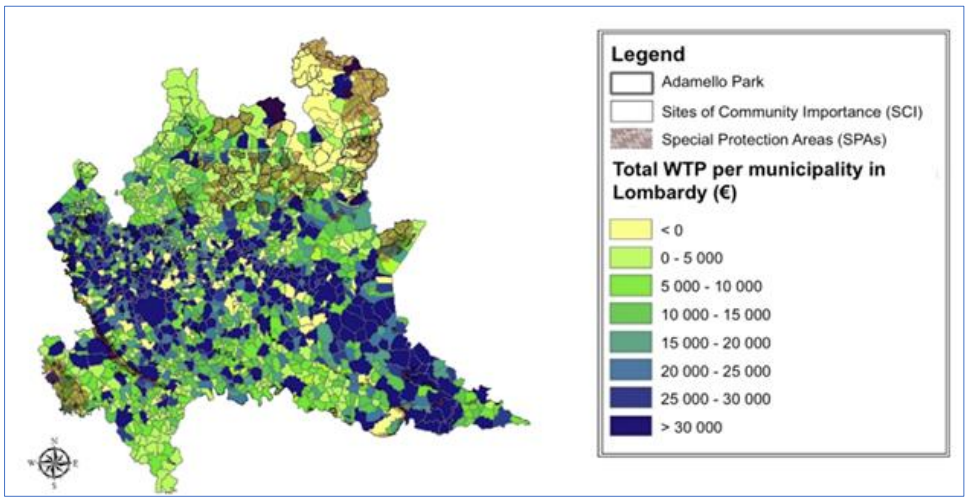
# Aggregate transferred WTPs for «Slope stability (45km)»

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# 2. Meta-Regression Analysis function transfer

- Benefit function transfer rely on statistical relationship defined for certain variables based on a single study.
- Meta-regression analysis, summarizes and synthesizes outcomes from several studies.
- Meta regression analysis is based on a value function in which:
  1. the dependent variable is value estimated in each individual study
  2. the independent explanatory variables are site characteristics and features of the original studies.

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# Meta-Regression Analysis function transfer example – Summary statistics

| Variable | Description | Mean values | |
|---|---|---|---|
| | | Full data | 20% trimmed |
| South | 1 = Southern Census Region; 0 = otherwise[a] | 0.269 | 0.250 |
| West | 1 = Western Census Region; 0 = otherwise[a] | 0.654 | 0.625 |
| Site quality | 1 = site quality is rated high by author; 0 = otherwise | 0.673 | 0.625 |
| Sample frame | 1 = sample is drawn from onsite visitors; 0 = otherwise | 0.519 | 0.594 |
| Valuation method | 1 = travel cost model; 0 = otherwise | 0.519 | 0.406 |
| Trip type | 1 = private trip; 0 = otherwise | 0.558 | 0.500 |
| Average flow | Average river flow in cubic feet per second (cfs) | 14,204 | 13,975 |
| Change in elevation | Elevation change: Source to mouth of river in miles | 6,576 | 6,374 |
| River length | Length of river in miles | 606 | 578 |
| Wild and scenic | 1 = portion of river is designated wild and scenic; 0 = otherwise | 0.500 | 0.438 |
| No. of observations | Number of estimates of recreation value | 52 | 32 |

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# Meta-Regression Analysis function transfer example – Results and predictions

| Variable | Full data MRA[a] | | |
|---|---|---|---|
| | Coefficient | Policy value[c] | Increment[d] |
| Constant | 3.30478* | 1 | 3.30 |
| South | 1.23337* | 0 | 0 |
| West | −1.05715 | 1 | −1.06 |
| Site quality | 0.57336 | 1 | 0.57 |
| Sample frame | 0.77846 | 0.52 | 0.40 |
| Valuation method | −0.86976 | 0.52 | −0.45 |
| Trip type | −0.59010 | 1 | −0.59 |
| Average flow | 0.00003* | 17010 | 0.22 |
| Change in elevation | 0.00057* | 4090 | 3.03 |
| River length | −0.00317* | 263 | −0.68 |
| Wild and scenic | −1.24168 | 1 | −1.24 |
| Root MSE[e] | 0.72056 | | |
| $R^2$ | 0.6504 | | |
| Predicted value[f] | | | $25.94 |
| 95% confidence interval[g] | | | $17-40 |

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