Economic Evaluation in Sectoral V&A Assessments

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Outline of Presentation

- Use of economics in V&A assessments
- Analytical concepts
- Optimal adaptation framework
- Conceptual framework for understanding adaptation actions
- Steps in Sectoral Assessment
- Methods/models
- Example
- Conclusions

Why Use Economics?

- In sectoral V&A assessments:
  - A common metric for measuring cc ”damages” across sectors without adaptation - actions to adjust to/reduce the impacts of climate change.
  - A common metric for defining/comparing net benefits of adaptation options across sectors.
- In adaptation project assessments:
  - A common metric for comparing project benefits with project costs.
  - A common metric for comparing net benefits across projects (both cc projects and other project investments)

Limitations of Economic Analysis in DCs

- Data limitations and models
- Lack of team expertise in valuing cc impacts
- Limited explanatory power in informal and traditional DC economies
- Valuation of non-market damages and benefits takes more data and expertise and methods are controversial
- Controversies over valuation of some non-market benefits, such as avoided loss of lives
- It is important to integrate regional sector-level economists into these projects to deal with these limitations.

Basic Analytical Concepts - I

- Vulnerability of a region, country, sector, etc. to cc: the magnitude of ”damages” that would occur if the climate changes and decision-makers react to this as if it were existing climate variability and no adaptation to CC takes place.
- Adaptation to cc: the additional actions, directly and indirectly, decision-makers take to adjust to perceived climate change, not existing climate variability

Basic Analytical Concepts - II

- Two types of adaptation:
- Autonomous Adaptation - actions taken to adjust to climate change that will occur because of existing “incentives”.
- Adaptation Strategies - actions that require deliberate policy actions to cause additional actions or provide additional incentives to adapt.

"Optimal" Adaptation

- Economic agents *autonomously* adapt to climate change so as to set their marginal benefits = to their marginal costs (however defined)
- Governments undertake actions to correct "market failures" so that marginal social benefits = marginal social costs
- "Local" CC depends on mitigation, but local mitigation and adaptation actions are poor substitutes when emissions and damages are asymmetric.

Example of Asymmetry

- Country A produces 500 mmtC/yr
- Rest of world produces (ROW) 100 mmtC/yr.
- Country A experiences 10% of global damages
- The marginal cost of mitigation is always higher in A than ROW.
- The marginal cost of adaptation is always lower in A than ROW.
- So, A will always prefer to adapt rather than mitigate.

Problems with Optimal Adaptation Framework

- Existing market failures and distortions influence actions
- Informal economies respond differently and we don't know how to model them
- Free-ridership if government advertises policy (i.e., waiting for compensation)
- Very hard to establish an optimal set of global rules that include both mitigation and adaptation actions.
- A "partial" approach involves:
  - Taking CC (and emissions) as exogenous
  - Focusing on market sectors where avoided damages are easier to estimate.

How do Decision-Makers "Adjust" to CC, Without Information?

- Economic activities are already adjusted to existing climate variability (cv)
- If decision-makers do not have reliable information that cc is taking place
  - The net benefits of many projects to avoid cc damages will be understated, and
  - They will adjust to cc-events as if they were part of the existing cv
- The flexibility of economic activities in the short-run to avoid cc damages will depend on the extent of existing cv (in relation to cc).

How do Decision-Makers ”Adapt” to CC, With Information?

- If they have information that cc is taking place this will open the potential for a new range of decisions, many requiring new investments and new analysis
- The avoided damages of many of these options will now be high enough to justify investment in them
- Once these investments are in place, economic agents will be better able to avoid the damages caused by cc, including changes in cv.

Types of Scenarios and Simulations for Sectoral Assessment

- **Existing climate** - To estimate the sectoral benefits and costs under the current climate (including current cv) and current options for dealing with climate variability
- **Partial Adjustment** - To estimate the sectoral benefits and costs if the climate changes (including changes in cv), but only currently existing options for adjusting to climate variability are in place
- **Adaptation/Full Adjustment** – To estimate the sectoral benefits and costs if the climate changes (including changes in cv) and specific options to adjust to climate change are introduced

Types of Adjustment to CC

Types of Adjustment	Information about CC	Changes in Behaviour	Benefits
No adjustment: all inputs and outputs fixed (deterministic)	no change in weather or climate	no change from base case. Purely reactive behaviour	no benefits; no damages avoided except by flight
Partial Short-run adjustments (stochastic)	CC is perceived as existing CV	flexibility in system allows limited adjustment	avoided damages depend on flexibility built into system
Full Long-run adjustments = adaptation (stochastic)	CC is detected including changes in CV	all inputs and outputs can be varied	max damages avoided. Flexibility to CC and CV added

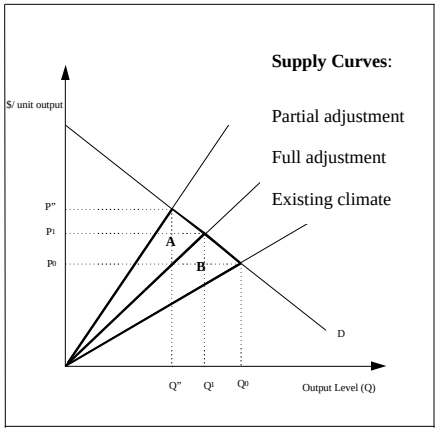
Examples

Sector	No adjustment to CC (unrealistic)	Partial short-run adjustments to CV	Full adjustments to climate change (adaptation)
Crop	Sharp yield reductions Famine & migration	Changing planting and harvest dates Supplemental irrigation	Changing crop mixes, technology & methods. Integration in global food markets
Coastal zone	Land inundation Flight	Build temp dykes Flood-proofing	Build sea walls Planned abandonment
Water supply	Water shortages Famine & migration	Δ reservoir operation Supplemental irrigation	Develop more storage
Wood supply	Famine & migration	Better management forest management	Plant new types of forests Fuel substitution

Adaptation Benefit-Cost Concepts

- *Climate change damages* - the loss in net welfare to society due to climate change (cc), when decision-makers adjust to cc as if it were cv (or don't adjust at all).
- *Imposed costs of climate change* - the net welfare loss to society of cc, after cc is detected and adaptation takes place based on reliable information about cc.
- *Benefits of adaptation* - the reduction in cc damages as a result of adaptation.
- *Adaptation costs* - the change in the opportunity cost of resources society uses to adapt to cc.
- *Net Benefits of adaptation = Benefits of adaptation - Adaptation costs*

Relationship Between Scenario Types and Benefit-Cost Measures



A = Net Adaptation Benefits

B = Imposed Costs of Climate Change

A+B = Climate Change Damages

Examples of Adaptation Benefits and Costs of Options to adjust to CC

Sector	Option	Benefits	Costs
Agriculture	_ crop/management practices	Avoided losses in farm income	Change in production costs
Flooding of major rivers	Periodic dredging of river beds	Avoided losses in net income + clean up recon-struction costs	Additional capital, O&M costs
Water resources supply	Enlarging water storage capacity	Avoided losses in net income of water users	Additional capital, O&M costs
Coastal zone: fresh water estuaries	Diverting water from ag. users to in stream flows	Avoided losses in net income from fishery	Losses in net income of ag. water users

Model/Methods Needs in Sectoral Assessment of Adaptation Options

- Models or Scenarios to translate global GHG emissions stocks into ”local” changes in cc (including changes in cv)
- Model(s) to translate cc (including changes in cv) into bio-physical impacts
- Models to translate physical impacts (as inputs) into changes in:
  - Human behaviour
  - Economic activity
  - Benefits and cost concepts as previously defined
    - ❖ With existing options to adjust to current cv
    - ❖ With options to adjust to cc (including changes in cv)

Steps in Sectoral Assessments: Simulating The Existing Climate Case

- Define the emissions/climate scenario to be used for the current climate with cv included, preferably stochastically
- Define existing activities and options to adapt to current climate, including cv
- Simulate effects of current emissions/climate ⟶ relevant bio-physical receptors = current physical impacts
- Simulate effects of current physical impacts ⟶ human behaviour and economic activity, with existing options
- Estimate benefits and resource costs of existing options:
  - Benefits (existing climate)
  - Resource Costs (existing climate)
- Validate simulations against existing data where possible

Steps in Sectoral Assessments: Simulating The Partial Adjustment Case

- Define the emissions/climate scenario to be used to characterise cc, preferably with changes in cv included
- Use existing activities and options to adjust to current climate, including cv, from the existing climate case
- Simulate effects of cc ⟶ relevant bio-physical receptors
- Simulate effects of these physical impacts ⟶ human behaviour and economic activity with existing options
- Estimate benefits and resource costs of existing options
  - Benefits (partial adjustment)
  - Resource Costs (partial adjustment)
- Simulations may be possible to validate if recent weather conditions seem ”abnormal”

Steps in Sectoral Assessments: Simulating The Full Adjustment Case

- Use the emissions/climate scenario from the partial adjustment case, reflecting cc and changes in cv.
- ADD new activities and options to adjust to changes climate and climate variability
- Simulate effects of cc ⟶ relevant bio-physical receptors
- Simulate effects of these physical impacts ⟶ human behaviour and economic activity
- Estimate benefits and resource costs of old + additional options:
  - Benefits (full adjustment)
  - Resource Costs (full adjustment)
- Simulations are impossible to validate, since this case has not happened yet

Pulling the Benefit-Cost Calculations Together

- *Imposed Costs of Climate Change* = [Benefits (full adjustment) – Resource Costs (full adjustment)] – [Benefits (existing climate) – Resource Costs (existing climate)] ≤ 0
- *Climate Change Damages* = [Benefits (partial adjustment) – Resource Costs (partial adjustment)] – [Benefits (existing climate) – Resource Costs (existing climate)] ≤ 0
- *Net Benefits of Adaptation* = [Benefits (full adjustment) – Resource Costs (full adjustment)] – [Benefits (partial adjustment) – Resource Costs (partial adjustment)] ≥ 0

Example

- Price endogenous agricultural sector model – 5 crops for domestic and export demand , 4 quasi-fixed resources – investment. Maximization of expected net benefits over different "states of nature".
- Existing climate cases (2):
  - Two sets of yield distributions with different coefficients of variation
  - Optimal solution determined investment in quasi-fixed resource capacity
- Partial adjustment cases (2):
  - Used same set of yield distributions in both cases to reflect cc
  - Quasi-fixed yields determined in previous cases were held fixed
- Full adjustment case (1):
  - Used same yield distributions as in previous case to reflect cc
  - Allowed unconstrained investment in new resource capacity

Sector Model Used in Example

Maximise $Z = \Sigma_s \mathbf{p_s} * \Sigma_i (\Theta_{\mathbf{i}}^{\mathbf{D}} * Q_{is}^{D} - .5 * \Sigma_{ij} \Theta_{\mathbf{ij}}^{\mathbf{D}} * Q_{is}^{D} * Q_{js}^{D} + \Theta_{\mathbf{i}}^{\mathbf{E}} Q_{is}^{E}$
$- .5 * \Sigma_{ij} \Theta_{\mathbf{ij}}^{\mathbf{E}} * Q_{is}^{E} * Q_{js}^{E}) - \Sigma i \Sigma_k (\mathbf{h_{lk}} * R_{lk} + \delta_{\mathbf{lk}} * R^{+}_{lk} +$
$+ .5 * \varphi_{\mathbf{lk}} * R^{+}_{lk}{}^{**2})$

- Subject to:

$\Sigma_i \mathbf{a_{il}} * X_{ils} - R_{lk} - R^{+}_{lk} \leq 0$	for all s, l and k
$R_{lk} \leq \mathbf{CAP_{lk}}$	for all s, l and k
$- \Sigma_l \mathbf{y_{ils}} * X_{ils} + Q_{is}^{D} + Q_{is}^{E} = 0$	for all s, i and l

- Where (**Parameters/Coefficients in bold print):**

i,j	= crop type	Θ	= Demand function coefficients
s	= climate state of nature	**h**	= Resource prices
l	= region	δ, φ	= Investment supply function
k	= resources (land, labour, machinery, water, etc)	**y**	= Product yield/land unit
Q^D	= Domestic Product Demand	**a**	= Resource use/land unit
Q^E	= Export Product demand	**CAP**	= current resource capacity
X	= Land input	$\mathbf{p_s}$	= the probability of occurrence of climate state of nature s.
R	= Resource input		
R^+	= Investment in capacity		

Value of the Climate Change Damages, Net Adaptation Benefits, and Imposed Costs of Climate Change for Illustrative Example

- **First Set of Cases (Low Existing Climate Variability)**

E[Climate Change Damages]	-1,812,005.0
E[Net Adaptation Benefits]	739,508.2
E[Imposed Cost of Climate Change]	-1,072,496.8

- **Second Set of Cases (High Existing Climate Variability)**

E[Climate Change Damages]	-588,308.7
E[Net Adaptation Benefits]	225,224.5
E[Imposed Cost of Climate Change]	-363,084.2

Benefit-Cost Estimation Methods

- Damage/Cost Accounting - used at project level, but hard to estimate "optimal" adaptation in all cases
- Market/Sector models - used for assessment and policy, can estimate "optimal" adaptation and baseline in partial equilibrium
- CGE Models - used for assessment and policy, includes full market effects, but sectoral details are lost
- Global Integrated Assessment Models - used for global assessment, but damage functions are crude and there is little sectoral detail

Adaptation Actions

- Detection/learning, dissemination of information
- Input and output substitution
  - Type and quantity
  - timing
  - location
- R&D/new technology
- Elimination of current "market failures"
- ECONOMIC DEVELOPMENT

Concluding Comments

- Previous adaptation studies have limited value for
  - policy
  - cost estimates
- Need consistent framework
  - to cover all adaptation actions
  - make investment/policy decisions
  - compare adaptation and mitigation actions

Conclusions

- Future studies should distinguish between various costs
  - Climate change damages
  - Imposed costs of climate change
  - Adaptation benefits
  - Adaptation costs
  - Net benefits of adaptation
- Focus should be on long-run measures to adapt to cc (i.e., involving investment), not to be confused with short-run resource management to adjust to existing climate variability

Inputs for Illustrative Example Linking Adaptation to Climate Variability to Climate Change					
	Existing Climate (Low CV) Case 1	Existing Climate (High CV) Case 2	Partial Adaptation Case 1	Partial Adaptation Case 2	Climate Change Case
Inputs					
land	1000	1000	1470.9	1005.5	1000
machinery	1000	1000	3473.2	2506.9	1000
fertiliser	3000	3000	1218.8	1052.6	3000
water	0	0	146.5	1234.0	0
Ave. Yld					
dryland Corn	94	94	54	54	54
dryland Wheat	80.5	80.5	53	53	53
dryland Vegis	96	96	51	51	51
irrig. Corn	136	136	126	126	126
irrig. Vegis	147	147.2	132	132	132
CV Yieilds					
dryland Corn	3.447	40.574	32.667	32.667	32.667
dryland Wheat	1.146	24.976	15.113	15.113	15.113
dryland Vegis	0.875	32.25	53.118	53.118	53.118
irrig. Corn	1.794	3.706	0.667	0.667	0.667
irrig. Vegis	2.633	3.015	1.636	1.636	1.636

Partial Results for the Illustrative Example				
Existing Climate Case 1 - Low CV: E[CS+PS] = $2,235,788				
	Land	Fertiliser	Machinery	Water
Investment (units)	1470.9	3473.2	1218.8	146.5
Marginal Cost ($/unit)	98.55	79.46	173.75	129.31
Climate State	Resource Use			
1	2426.1	6473.2	2194.3	146.5
2	2470.9	6473.2	2218.8	146.5
3	2470.9	6275.8	2148.6	146.5
Existing Climate Case 2-High CV: E[CS+PS] = $1,526,375				
Investment (units)	1005.5	2506.9	1052.6	1234.0
Marginal Cost ($/unit)	75.27	60.14	167.10	346.79
Climate State	Resource Use			
1	2005.5	5506.9	2052.6	1234.0
2	2005.5	5506.9	1856.0	1234.0
3	1830.1	4685.2	1609.1	0000.0
Low CV Partial Adaptation Case 1: E[CS+PS] = $ 423,783				
	Land	Fertiliser	Machinery	Water
Quasi-fixed factors (units)	**1470.9**	**3473.2**	**1218.8**	**146.5**
Climate State	Resource Use			
1	2470.9	6473.2	1854.1	146.5
2	2470.9	6473.2	2218.8	146.5
3	2321.0	5737.3	1925.2	000.0
High CV Partial Adaptation Case 2: E[CS+PS] = $938,066				
Quasi-fixed factors (units)	**1005.5**	**2506.9**	**1052.6**	**1234.0**
Climate State	Resource Use			
1	2005.5	4945.6	1462.4	1234.0
2	2005.5	5506.9	1964.3	1234.0
3	2005.5	5089.0	1714.8	0000.0
Full Adjustment Case: E[CS+PS] = $1,163,291				
Investment (units)	1404.0	2812.5	898.6	1920.7
Marginal Cost ($/unit)	95.20	66.25	160.94	484.13
Climate State	Resource Use			
1	2404.0	5812.5	1898.6	1920.7
2	2164.8	5812.5	1866.6	1920.7
3	2288.5	5662.8	1898.6	1920.7