# Growth and Development:

# Environment and Development

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Lecture Notes for PhD Growth and Development (EC8510)

# What is Environmental Economics?

- Environmental **Economics is the study of how to allocate scarce resources** between environmental protection and use.
- Why not have zero pollution? Why not conserve all land?
  - If society has limited resources to meet all its wants, then decisions have to be made to determine what and how much to produce and consume.
  - There are many alternative uses for our resources. We want to know how to make the best use of them.
- Economics helps us to understand:
  - The value of environmental quality,
  - The costs of environmental quality,
  - The welfare consequences of different policies to control environmental quality.

# Why I Spend my Time on Environmental Economics

- It touches on almost every field of economics.
  - economic theory, market design, econometrics, macroeconomics, political economy, international trade, growth and development, industrial organization, labor economics, public finance, agricultural economics, economic geography, urban economics ...
- It engages actively, and draws inspirations from, other disciplines:
  - atmospheric physics
  - biology and ecology
  - engineering
  - law
  - philosophy
- It is critical to engaging with and solving some of the most important policy challenges we face as a society.

# My Research

- How does environmental quality influence economic activity?
  - To what extent does the natural environment affect economic opportunity, poverty, and inequality?
  - How does the underlying economic and policy environment affect the translation of changes in environmental quality into economic damages?
  - Are individuals aware of changes in environmental quality and, if so, how do they respond to it?
- What are the environmental and economic consequences of regulations that seek to control economic activity?
  - To what degree do the actions of regulated agents undermine the efficacy of regulations that seek to control economic activity?

# Environment and Development: Two Major Global Challenges Collide

- Developing countries are where the tension between economic activity and the environment looms largest
  - Close to a billion people remain in extreme poverty and economic growth – including large increases in energy use – will be required to lift them out of poverty.
  - Per capita consumption is currently lowest in developing countries, but growth in energy consumption, forest, and marine degradation will be much higher.
  - Large share of the population depends on agriculture, forests, and fisheries
  - Most exposed to climate change and environmental degradation.
  - Gap between *de facto* and *de jure* institutions are more significant.
- How do we balance the imperative for continued growth with the need to mitigate and adapt to the externalities that growth creates?

# Is Environmental Economics applied to Developing countries any different?

- Sometimes.
  - Magnitudes
  - Topics
  - Institutions and state capacity
- Policy design with context in mind is an important margin

# Core Ideas in Environmental Economics

- Externalities and Public Goods.
  - An understanding of welfare analysis is important here.
  - Theoretical: what is the best way to correct externalities/supply public goods and move closer to the social optimum?
  - Empirical: how do we measure the size of externalities and people's WTP to affect them?
- Corrective Policy

# Types of Economic Research

1) Positive Analysis: Aims to explain why certain things happen.

2) Normative Analysis: Aims to design policies or remove distortions that increase welfare. Requires a value-judgement.

- Welfare analysis requires a formal notion of "should".

# Definitions of Optimality

- **Pareto Optimality:**
  - Pareto improvement makes nobody worse off and at least one person better off.
  - Since nobody is worse off, this seems like an innocent concept.
  - Note that it fixes the status quo:
    - Once somebody is well off, they are set for life.
  - It is, however, an incomplete ordering:
    - In most (interesting) policy cases, at least one person is made worse off.
- **Pareto Compensation Criterion**
  - There exists a set of transfer payments (that sum to zero) such that after the transfer payments are actually paid, no one is made worse off and at least one person is better off.
  - This is a modification of Pareto optimality.
  - Larger subset of choices can be ranked (still not all).

# Definitions of Optimality

- **Kaldor-Hicks Compensation Criterion:**
  - There exists a set of transfer payments (that sum to zero) such that nobody would be worse off and at least one person is better off.
  - Similar to the Pareto compensation criterion:
    - The big difference is that these transfer payments are hypothetical.
    - They are not actually being paid.
  - Scitovsky Reversal Paradox:
    - It is possible that among two outcomes $x$ and $y$, each one is preferred to the other.
    - Income effects.
  - Pretty much all benefit-cost analysis conducted by the government implicitly uses Kaldor-Hicks!

# Individual Choice: Powerful Results

- Any continuous rational preferences can be represented by a continuous utility function.
- Rational continuous preferences require the following three conditions to be met:
  - **Completeness:** For all choices $x, y \in X$, we have $x \succeq y$ or $y \succeq x$ (or both).
  - **Transitivity:** For all choices $x, y, z \in X$, we have $x \succeq y$ and $y \succeq z \Rightarrow x \succeq z$.
  - **Continuity:** For a sequence of pairs $\{(x_n, y_n)\}_{n=1}^{\infty} \in X \times X$ with $x_n \succeq y_n$, we have $\lim_{n\to\infty} x_n \succeq \lim_{n\to\infty} y_n$.
- Utility is an index function that ranks alternatives (few restrictions).

# Similar Results for Social Welfare Functions?

- **Samuelson-Bergson Social Welfare Function**
  - Idea: similar to a utility function (of goods).
    - Inputs are individual consumption quantities $x_1, x_2, \ldots, x_n$.
  - Social welfare function has utility of individuals as inputs.

# Can we derive similar results for social welfare functions as we did for individual choice?

- No: Arrow's Impossibility Theorem.
- There is no general rule converting individual choices into social preferences that fulfills all of the following requirements:
  1. Completeness: Ranks all alternatives.
  2. Unanimity: If everyone prefers $x$ to $y$, then so should society.
  3. Nondictatorship: None should always get their way.
  4. Transitivity: If $x \succeq y$ and $y \succeq z$, then $x \succeq z$.
  5. Universality: Individuals can have an arbitrary ranking.
  6. Independence of irrelevant alternatives.
     - Each person ranks alternatives $R_1 : y \succeq x \succeq z$.
     - Social ordering aggregates the $R_1, \ldots, R_n$.
     - IIA implies that as long as all individuals rank $y, z$ the same way, the social ordering has to be the same.
     - $R_1 : y \succeq x \succeq z$ or $R_2 : y \succeq z \succeq x$ rank $y, z$ the same way.

# Why this Matters

- With private goods (utility depends only on goods consumed by person $h$):

$$\frac{\frac{\partial W}{\partial U^h}\frac{\partial U^h}{\partial x_{hi}}}{\frac{\partial W}{\partial U^h}\frac{\partial U^h}{\partial x_{hj}}} = \frac{\frac{\partial U^h}{\partial x_{hi}}}{\frac{\partial U^h}{\partial x_{hj}}} = \frac{F_i}{F_j}$$

- Most general setup (utility depends on goods consumed by all individuals $k = 1, \ldots, H$):

$$\frac{\sum_{k=1}^{H}\frac{\partial W}{\partial U^k}\frac{\partial U^k}{\partial x_{hi}}}{\sum_{k=1}^{H}\frac{\partial W}{\partial U^k}\frac{\partial U^k}{\partial x_{hj}}} = \frac{F_i}{F_j}$$

  - LHS now a weighted average of marginal utilities where weights depend on the SWF.

# With At Least One Private Good

$$\frac{\sum_{k=1}^{H} \frac{\partial W}{\partial U^k} \frac{\partial U^k}{\partial x_{hi}}}{\frac{\partial W}{\partial U^h} \frac{\partial U^h}{\partial x_{h1}}} = \sum_{k=1}^{H} \frac{\frac{\partial W}{\partial U^k} \frac{\partial U^k}{\partial x_{hi}}}{\frac{\partial W}{\partial U^k} \frac{\partial U^k}{\partial x_{k1}}} = \sum_{k=1}^{H} \frac{\frac{\partial U^k}{\partial x_{hi}}}{\frac{\partial U^k}{\partial x_{k1}}} = \frac{F_i}{F_1}$$

- Having at least one private good gives a private denominator
- Not only the MRS of good $i$ for good 1 of person $h$ that matters though.
- All individuals $k = 1, \ldots, H$ matter
- A utility maximizing individual will set,

$$MRS^h_{x_{hi}, x_{h1}} = MRT_{i,1}$$

- This is suboptimal
- Solution: Pigouvian tax
  - Require individual $k$ to pay person $h$ a price $p^k_{h,i}$
  - Price equals the MRS, $p^k_{h,i} = MRS^k_{x_{hi}, x_{k1}}$
  - Price positive for beneficial spillover/negative for disutility

# Aggregate Externalities

- Good that creates an aggregate externality is $N$, e.g., energy use.
- The aggregate externality is good $N+1$, e.g., carbon emissions.

$$\underbrace{\frac{\frac{\partial U^h}{\partial x_{hN}}}{\frac{\partial U^h}{\partial x_{h1}}}}_{\text{MRS}_{x_{hN},x_{h1}}} + \underbrace{\sum_{k=1}^{H} \frac{\frac{\partial U^k}{\partial x_{(N+1)}}}{\frac{\partial U^k}{\partial x_{k1}}}}_{\sum_{k=1}^{H} \text{MRS}_{x_{(N+1)},x_{k1}}} = \underbrace{\frac{F_N}{F_1}}_{\text{MRT}_{N,1}}$$

- If a person does not take into account their effect on the aggregate externality, the optimal tax will be,

$$\tau_N = -\sum_{k=1}^{H} MRS^k_{x_{k(N+1)},x_{k1}}$$

# Aggregate Externalities

- Standard rationale for cap-and-trade
- Only aggregate emissions matter
- For local pollutants (non-uniformly mixing), cap-and-trade might be sub-optimal (Mendelsohn and Muller, 2009)
- Fowlie (2011) shows that pollution may shift to areas where it is more harmful.

# Public Goods

- Public goods = large scale production externalities
- Two types:
  - Pure: non-excludable and non-rival, e.g., national defense.
  - Impure: non-excludable and rival, e.g., roads
- Public good, $N$, provided by the government (person 1) who has no preference over the good $\frac{\partial U^1}{\partial x_{1N}}$

$$\underbrace{\sum_{k=2}^{H} \frac{\frac{\partial U^k}{\partial x_{1N}}}{\frac{\partial U^k}{\partial x_{k1}}}}_{\sum_{k=2}^{H} \mathrm{MRS}_{x_{1N}, x_{k1}}} = \underbrace{\frac{F_N}{F_1}}_{\mathrm{MRT}_{N,1}}$$

- Sum of MU over all individuals = MC of producing it $\rightarrow$ free riding!

# Provision of Public Goods

- Decentralized private provision is suboptimal.
  - Possible through lindahl pricing, clarkes-groves, etc. but requires strong assumptions
- Second best provision:
  - Have to consider interaction with private provision of public goods (crowding out, Bergstrom, Blume, and Varian, (1986))
  - Account for unavailability of lump-sum transfers

# Empirical Evidence on Crowd-Out

- Lab and field experiments.
  - lab experiments have been more influential traditionally, but miss important motives for giving (warm glow, prestige).
- Identification Challenges:
  - Public provision changes because of changes in need.
  - Public provision changes because private provision changes.
- See Hungerman (2005), Andreoni and Payne (2003, 2008), Marwell and Aimes, (1981), Andreoni (1988), Dawes and Thaler (1988), Benabou and Tirole (2006, 2011, etc.), Gneezy and Rustichini (2000), Fehr and List (2004), Ariely et al., (2009), Cialdini (2003), Gerber et al., (2008), Perez-Truglia and Cruces (2013), Chetty, Saez and Sandor (2014), Deryugina and Marx (2020), etc.

# Theory of the Second Best

- First best outcome: all first-order conditions are met. Problem is well behaved.
- Theory of the Second Best (Lipsey and Lancaster (1956)):
  - If one first-order condition isn't met might no longer be optimal to meet the other first-order conditions for second-best solution.
  - Addressing one distortion without considering others may make things worse.
  - May be complex trade-offs between efficiency and equity.
- First question: Can first-best be restored?
- If not, recognize limitations and think through intended/unintended consequences of different interventions.

# Market Power

- Negative externality: self-interested firm produces too much and doesn't incorporate negative impact on others.
- Monopolist: produces too little, drives up the price of the good.
- What's the optimal tax?

**Two Wrongs Can Sometimes Make a Right: The Environmental Benefits of Market Power in Oil**

John Asker, Allan Collard-Wexler, Charlotte De Canniere, Jan De Loecker & Christopher R. Knittel

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Market power reduces equilibrium quantities and distorts production, typically causing welfare losses. However, as Buchanan (1969) noted, market power may mitigate overproduction from negative externalities. This paper examines this in the global oil market, where OPEC's market power affects oil production and carbon intensity. We estimate that from 1970 to 2021, OPEC's market power reduced emissions by over 67 GtCO2, equating to $4,073 billion in climate damages and 17.8% of the carbon budget needed for the 1.5○ C Paris Agreement target. This environmental benefit outweighs the welfare loss from distorted production allocation.

# Measuring Externalities

- How do we measure the costs of an externality?
- No markets for environmental goods and services so can't rely on prices and revealed value.
  - Two approaches:
    - **Stated Preferences:** Contingent valuation and Choice Modeling $\Rightarrow$ issues are quite clear, but only option for evaluating non-use values (Krutilla, 1967).
    - **Revealed Preferences:** Hedonic/capitalization (Rosen, 1974 and travel cost approaches $\Rightarrow$ precise, but incomplete.
  - Is some number better than no number?
    - Eventually, someone will come up with a number.
    - That number ought to be generated as thoughtfully as possible.

# Willingness-to-Pay

- Consider a single-period static model with $n$ identical agents.

- Agents choose consumption $c$, improvements in environmental quality $\Delta e$ and self protection $s$ to maximize utility:

$$u(e, h(s, e), c)$$

subject to the budget constraint,

$$y \geq c_e(\Delta e) + c_s(s) + c$$

# Willingness-to-Pay

- total wealth and the agent's experienced environmental quality are defined by,

$$\begin{aligned} y &= y_0 + \Delta y(e, h(s, e)) \\ e &= e_0 + \Delta e + a(c, s) \end{aligned}$$

where the function $a(c, s)$ captures the impact of consumption and self protection on environmental quality as experienced by the agent, and $h(s, e)$, reflects the agent's health.

# Willingness-to-Pay

- The agent chooses $c$, $\Delta e$, and $s$ to equalize the MU of investments.

$$\begin{aligned} MWTP_e &\equiv \frac{\lambda_e}{\lambda_y} \\ &\equiv \frac{1}{\lambda_y}\left(\frac{\partial u}{\partial e}+\frac{\partial u}{\partial h}\frac{\partial h}{\partial e}\right)+\frac{\partial \Delta y}{\partial e}+\frac{\partial \Delta y}{\partial h}\frac{\partial h}{\partial e} \end{aligned}$$

- $\lambda_e$ captures the MU of environmental quality improvements
- $\lambda_y$ captures the MU of consumption.
- If utility is concave in consumption, low levels of income will correspond to high MU of income and low $MTWP_e$

# Willingness-to-Pay

$$MWTP_s \equiv \frac{1}{\lambda_y}\left(\frac{\partial u}{\partial e}\frac{\partial a}{\partial s} + \frac{\partial u}{\partial h}\left(\frac{\partial h}{\partial s} + \frac{\partial h}{\partial e}\frac{\partial a}{\partial s}\right)\right) + \frac{\partial \Delta y}{\partial e}\frac{\delta a}{\delta s} + \frac{\partial \Delta y}{\partial h}\left(\frac{\partial h}{\partial s} + \frac{\partial h}{\partial s}\frac{\partial a}{\partial s}\right)$$

- If the MU of consumption is decreasing then $MWTP_s$ is higher at higher levels of consumption as long as any negative effects of self-protection on $e$ can be offset by compensatory investments in self-protection.

# Willingness-to-Pay

- The marginal cost of improving environmental quality is $\frac{\partial c_e}{\partial \Delta e}$.
- The marginal cost of self protection is $\frac{\partial c_s}{\partial \Delta s}$.
- The representative agent will therefore set the MC of environmental quality improvements and self-protection equal to their respective MWTP, such that the ratios are equal to each other,

$$\frac{MWTP_e}{MWTP_s} = \frac{\frac{\partial c_e}{\partial \Delta e}}{\frac{\partial c_s}{\partial \Delta s}}$$

- With this set-up, individuals' decisions about $c$, $\Delta e$, and $s$ will produce the first-best outcomes.

# The Economic Consequences of Environmental Change

- An emerging literature has examined the relationship between pollution and health in developing countries ($\frac{\partial h}{\partial e}$).
- Evidence suggests that poor environmental quality leads to sicker and shorter lives.
  - Chen et al. (2017)
  - Field, Glennerster, and Hussan (2011)

# The Effects of Environmental Quality on Income

- There is very limited evidence on the effects of environmental quality on income in developing countries ($\frac{\partial y}{\partial e}$).
  - Aragón and Rud (2013) show that the pollution associated with gold mining in Ghana had a negative impact on income from agriculture.
  - They estimate an agricultural production function and analyze the effect of mining on the residuals of productivity, which is shown to correspond to an 18% increase in rural poverty.
  - Aragón et al. (2017) look at the effects of pollution on labor supply, finding that it reduces hours worked and that the effects are increasing in exposure.
  - At low levels the effects are driven by caregiving
  - At higher levels the effects are driven by health consequences ($\frac{\partial \Delta y}{\partial h} \frac{\partial h}{\partial e}$).

# Willingness to Pay for Environmental Quality

- A high health burden from environmental quality in developing countries does not directly imply a high $MWTP_e$.
- The papers in the previous section descibed $\frac{\partial h}{\partial e}$ or $\frac{\partial \Delta y}{\partial h}\frac{\partial h}{\partial e}$.
- However, the MWTP$_e$ associated with these changes is required to determine optimal policy.

# Willingness to Pay for Environmental Quality

- Few studies have attempted to develop revealed preference estimates of $\text{MWTP}_e$.
- Kremer et al. (2011) use an RCT to generate exogenous variation in water quality across springs in Kenya.
- They find that the investment reduced fecal contamination by 66 percent, which led to a reduction in diarrhea of 25 percent.
- However, households are only willing to pay \$11 per year for clean water, where $\text{MWTP}_e$ is calculated from rural wage rates and revealed willingness to walk to clean water.
- This translates into a revealed preference VSL of \$860, four times lower than accepted VSL numbers for the US.
- Revealed $\text{MWTP}_e$ is substantially lower than the valuations given in a contingent valuation survey.

# Willingness to Pay for Environmental Quality

- The little evidence we have suggests that observed levels of $\text{MWTP}_e$ are low.
- It is an open question as to whether low measured $\text{MWTP}_e$ would be low in well-functioning markets or if market failures reduce measured $\text{MWTP}_e$.
- What could explain this puzzle? Greenstone and Jack (2015) suggest:
  1. Individuals value increase in income more than marginal improvements in environmental quality
  2. The marginal costs of environmental quality improvements are high
  3. Political economy factors undermine efficient policymaking
  4. Market failures such as weak property rights and missing capital markets distort MWTP
- Big picture question: Is the current level of environmental quality in developing countries optimal?

# Explanation 1: If $u'(c) > \text{MWTP}_e$, you'd rather eat

- Proposition: $MWTP_e$ is low because people in developing countries are poor.
- MU of consumption is high relative to the MU of environmental quality.
- This is captured in the comparative statics of the framework.
  - The agent trades off consumption and environmental quality
  - If the MU of consumption is decreasing then the agent will forego investments in environmental quality at low levels of consumption.
  - As the budget constraint is relaxed the value of an additional unit of consumption falls and the trade-off becomes less extreme.

# Explanation 1: High MU of consumption

- Richer models provide related explanations:
  - If in a two-period model the probability of living to the second period is affected by $e$ then $MWTP_e$ increases in income (Hall and Jones, 2007).
  - For poor households that face myriad risks the MU of immediate consumption may be much higher

# Explanation 1: High MU of consumption

- An ideal experiment would measure how $\text{MWTP}_e$ changes with an exogenous change to income.
- However, most experiments generate only short-run changes in income and it may be difficult to find a quasi-experimental design that credibly identifies permanent changes to income.
- There is very little evidence on the individual-level income $\text{MWTP}_e$ relationship.

# Explanation 1: High MU of consumption

- Hanna and Oliva (2014) examine the fuel choices of households in India following the randomized roll out of a transfer program that had measurable effects on income and assets.
  - Energy use increases substantially, but does not become much cleaner.
- Ito and Zhang (2018) find that *MWTP* is increasing in income (correlational)
- Berry et al. (2018) find no correlation between MWTP and income.

# Explanation 1: High MU of consumption

- Higher incomes might be associated with both higher $\text{MWTP}_e$ and also larger environmental impacts (if $\frac{\partial a}{\partial c} > 0$)

- Several recent papers provide evidence to suggest that as incomes in developing countries increase, there is a negative effect on environmental quality.

- These findings suggest that externalities from consumption and self-protection may increase more quickly with income than investments in environmental quality.

# Explanation 2: If environmental quality is expensive, you'll buy less of it

- Proposition: High MC explain the observed levels of environmental quality in developing countries.
- Intuition suggests that increasing MAC would imply lower marginal costs of environmental quality in settings with few existing regulations and high levels of pollution.
- However MC of environmental quality improvement may not only be driven by abatement costs.

# Explanation 2: High Marginal Costs

- High MC may reflect local capacity for policy design and implementation.
  - In settings where capacity is weak, the MC of environmental quality improvements may be high even if MAC are relatively low.
  - Weak capacity in other policy domains may also increase the cost of environmental quality improvements.
  - Alternatively, low MC of self-protection may lead individuals or policy makers to prefer investments in self-protection.

# Explanation 2: High Marginal Costs

- Empirical evidence on the magnitude of the marginal cost of environmental quality improvements $\frac{\partial c_e}{\partial \Delta e}$ is important for solving the social planner's problem.
- High MC is a sufficient explanation for why environmental quality is so poor in developing countries.
- Many countries have tough environmental regulations, yet have trouble achieving their environmental goals, potentially because of the high costs of doing so.
- Poor policy design and implementation doesn't imply high MAC.

# Explanation 2: High Marginal Costs

- Many environmental quality improvements are most cheaply achieved through aggregate investments.
- Taxation offers the practical means for aggregating individual contributions to environmental quality.
- However, a growing number of studies highlight the challenges of collecting taxes in developing countries (Besley and Persson, 2013)
- The social cost of investing in public goods is higher when raising revenues is difficult.
- Weak capacity for taxation will also interfere with efforts to implement market-based pollution regulations.

# Explanation 2: High Marginal Costs

- A lack of scientific expertise, poor policy guidance, or low levels of accountability may result in poorly chosen policy objectives.

- Field, Glennerster, and Hussam (2011) demonstrate a striking example of this.

  - The paper also highlights the challenges of multiple environmental risks, and an inability of households or policymakers to accurately rank them.

# Explanation 2: High Marginal Costs

- Unanticipated effects of environmental regulation also arise through agents' responses to policies:
  - Davis (2008)
    - Mexico City policy to restrict driving according to license plate number had no effect on pollution levels and increased the number of registered cars.
    - Cost to households are estimated at $300 million with no improvements in environmental quality.

# Explanation 2: High Marginal Costs

- Poor targeting also increase the MC of environmental quality improvements.
  - Davis, Fuchs, and Gertler (2014)
  - Boomhower and Davis (2014)
  - Calel et al. (2024)

# Explanation 3: Political Economy and Rent-Seeking Behavior (Supply-side failures)

- In a first-best world, poor environmental quality implies low $MWTP_e$ or high $MC_e$.
- However, in a world of political economy constraints, poor environmental quality may stem from a social planner who does not maximize social welfare.
- Political economy factors add an additional element to the SWF – the planner's own payoff or utility weights for their preferred group.
- In many cases, this will result in a downward bias on the optimal level of environmental quality, driving a wedge between aggregate preferences and the payoffs over which the social planner optimizes.

# Explanation 3: Political Economy and Rent-Seeking Behavior

- Empirical studies on the effects of political economy considerations and rent-seeking behavior on environmental quality provide estimates of these distortions.

- An emerging literature has explored the role that rent seeking plays as an explanation for poor environmental quality.

  - Oliva (2015) studies a pollution control policy in Mexico City and finds extensive corruption in the smog emissions testing program for private vehicles.

  - Structural estimates suggest that at least 9.6 percent of old-car owners paid bribes of around $20 to circumvent the regulations.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

- Market failures and behavioral biases and heuristics can cause measured $MWTP_e$ to diverge from true $MWTP_e$.
  - If all markets function well then the transformation of $y$ into environmental quality and self protection is frictionless.
  - However, information, credit, risk, or property rights imperfections may be reflected in measured $MWTP_e$.
  - Whether measured $MWTP_e$ is above or below the perfect-market $MWTP_e$ is theoretically ambiguous.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Information

- Revealed preference measures of $MWTP_e$ rely on individuals knowing the payoffs from investments in environmental quality.
- The barriers associated with quantity and quality of information are likely higher in developing countries.
  - Misinformation may be more persistent because of limited liability rules around the provision of information, or because markets fail to convey incentives for accurate information producers.
  - Governments may fail to provide accurate information about $e$ and $h$.
  - Individuals may be illiterate or lack the education needed to understand the available information.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Information

- Jalan and Somanathan (2008) provide Delhi residents with information about the quality of their tap water and find a significant change in expenditures.
- Pattanayak et al. (2009) show that intensive information designed to generate social pressure as well as awareness increase latrine adoption in Orissa, India.
- Ashraf et al. (2013) offer an unfamiliar water purification solution at randomly varied prices to urban consumers in Zambia and observe that households are more price sensitive when they have more information about the product.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Information

- All of this relates to a large literature on the information and learning challenges associated with technology adoption.
  - A household that has never experienced clean water may not know the benefits of experimenting with technologies or behaviors that improve water quality
  - To the extent that peers and neighbors offer transferable information through their own actions, social learning is more likely to occur (Foster and Rosenzweig, 1995; Conley and Udry, 2010)
  - A trusted government agency may be able to help overcome information failures
    - However, individuals may not trust official information sources – in some cases for good reason.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Credit Markets

- Credit market failures stem from a difficulty in writing and enforcing contracts
  - In settings with credit market frictions individuals may not be able to pay upfront for investments that generate future improvements in environmental quality.
  - If environmental quality investments require upfront payments and future payoffs, the income and other determinants of liquidity will confound measured $MWTP_e$

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Credit Markets

- Guiteras et al. (2014) randomly introduce different types of credit for water purification filters in Bangladesh and document a positive relationship between measured WTP and credit availability.
- Highlights clear distortion to revealed preference measures of $\text{MWTP}_e$ in settings with missing credit markets.
- However, credit constraints may inhibit environmental damage.
- Assuncao et al. (2016) show that a restriction on credit in Brazil lowered deforestation rates, likely by decreasing land-intensive livestock investments.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Insurance Markets

- Missing risk markets can lower individual willingness to invest in environmental quality improvements if the payoffs are uncertain and insurance is not available.
- Missing insurance markets exacerbate exposure and reduce measured $MWTP_e$
- If an agent faces multiple environmental or health risks then measured $MWTP_e$ to improve one dimension may be affected by the endowment of $e$ on another dimension.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Property Rights

- If there are weak property rights then this may lower investments in environmental quality because agents are uncertain about their ability to retain the benefits.
- Incomplete property rights introduce frictions into the relationship between $e$ and $y$.
- Private bargaining solutions are unlikely to arise (Coase, 1960)
- Revealed preference measures of $MWTP_e$ will be biased downward because of weak property rights, relative to settings with strong property rights.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Property Rights

- There has been limited empirical work on property rights and environmental quality.
- Ali, Deininger, and Goldstein (2014) use a spatial RDD to measure the impacts of a land titling program on a number of outcomes, including investments in soil fertility.
- They show that more secure land titles increased investments in environmental quality

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Behavioral Heuristics and Cognitive Biases

- Numerous behavioral and cognitive biases may affect revealed preference measures of $MWTP_e$
- Behavioral biases are most likely to affect decision making when the decisions are infrequent, outcomes are probabilistic, and consequences are in the future.
- In developing countries, market failures undermine the feedback that helps individuals learn from their previous decisions and exacerbate standard behavioral biases (Bertrand, Mullainathan, and Shafir, 2004)
- Unlike developed countries where air, water, and food are governed by regulations to ensure quality, residents of developing countries must continuously take action to minimize exposure.
  - Repeated decision making can deplete cognitive energy.

# Explanation 4: Measured $MWTP_e \neq$ True $MWTP_e$

## Behavioral Heuristics and Cognitive Biases

- There is a sizable literature in development on MWTP for health investments (Dupas, 2011) that highlights the role of behavioral biases.
- There is little examination within the context of MWTP$_e$
- Behavioral biases and psychological factors offer a promising direction for future research.

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## Externalities and Public Goods

- So far we have ignored spillovers across agents.
- While a useful benchmark this is implausible as decisions that affect the environment involve externalities and public goods.
- To allow for the possibility of externalities, let aggregate environmental quality be given by

$$e = e_0 + \sum_{i=1}^{n} (\Delta e_i + a(c_i, s_i))$$

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## Externalities and Public Goods

- SMWTP for environmental quality accounts for externalities and public goods so it reflects the first-best allocation and is given by,

$$\begin{aligned} SMWTP_e \equiv & \frac{n}{\lambda_y^{SP}}\left(\frac{\partial u}{\partial e}+\frac{\partial u}{\partial h}\frac{\partial h}{\partial e}\right) \\ & +n\frac{\partial \Delta y}{\partial e}+n\frac{\partial \Delta y}{\partial h}\frac{\partial h}{\partial e} \end{aligned}$$

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## Externalities and Public Goods

- $SMWTP_e > MWTP_e$ if environmental quality investments create public goods of positive externalities, or if consumption generates negative externalities.
- $SMWTP_s$ will diverge from $MWTP_s$ if self-protection generates externalities or provides public goods.
- Generally, we don't expect the public good nature of environmental quality to differ across developed and developing countries.
- However, externalities may be exacerbated by, and interact with, other market failures that are more prevalent in developing country settings.

# Environment and Development

- Research is taking off in this area. Why?
  - Growing recognition and understanding of the problem (arbitrage opportunities)
  - Advances in modeling individual and firm behavior open the door to the estimation of parameters with a clear economic interpretation
    - the best empirical work will contribute to the identification of relevant parameters in the social planner's maximization problem.
    - Most work has been on quantifying the effects of environmental quality on health ($\frac{\partial h}{\partial e}$), rather than MWTP.
    - Those that have studied MWTP have focused on health channels, rather than direct effects or other indirect channels.

# Environment and Development

- Research is taking off in this area. Why?
  - Advances in measurement through remote sensing allows researchers to bypass local data collection obstacles.
  - Advances in quasi-experimental and experimental methods
    - Experiments cannot answer many important questions, yet they can serve as a complement to other methods that may be better suited to understanding more aggregate problems.

# Discussion

- The intersection of environmental and development economics offers a wealth of questions that are of interest to economists and policymakers.
- Many of these questions are poorly understood.
- Finding reliable answers to these questions will advance economic understanding and inform policy, with the potential to enormously influence human welfare.