Undergraduate Program in Central European Studies

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Environmental Policy in the Central European Context

Time: Thursday 3pm
Location: at CERGE-EI, Room # 9

Professor: Jana Krajcova (JK), email: jana.krajcova@cerge-ei.cz
Guest Professor: Andreas Ortmann (AO), email: aortmann@yahoo.com
See also: http://home.cerge-ei.cz/richmanova/TeachingUPCES.html
(and http://home.cerge-ei.cz/ortmann/UpcesCourse/UpcesCourse.html for Spring 2009 course)

Lecture 2 - Market failures: externalities, tragedy of the commons, enforcement as public good

Endowment effect
(From Wikipedia, the free encyclopedia)

In behavioral economics, the **endowment effect** (also known as **divestiture aversion**) is a hypothesis that **people value a good or service more once their property right to it has been established**. In other words, people place a higher value on objects they own than objects that they do not. In one experiment, people demanded a higher price for a coffee mug that had been given to them but put a lower price on one they did not yet own. The endowment effect was described as inconsistent with standard economic theory which asserts that a person's willingness to pay (WTP) for a good should be equal to their willingness to accept (WTA) compensation to be deprived of the good.

The effect was first theorized by Richard Thaler. It is a specific form, linked to ownership, of status quo bias [people preferring that things remain the same]. Although it differs from loss aversion, a prospect theory concept, those two biases reinforce each other in cases when e.g. the asset price has fallen compared to the owner's buying price. This bias has also a few similarities with commitment and attachment.

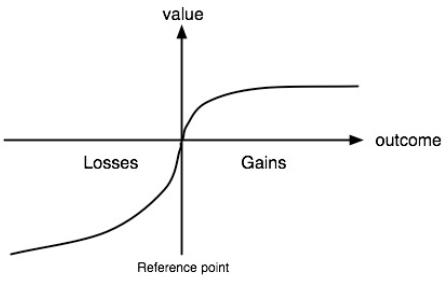
Prospect Theory
(From Wikipedia, the free encyclopedia)

Prospect theory is a theory that **describes decisions between alternatives that involve risk**, i.e. alternatives with uncertain outcomes, where the probabilities are known. The model is descriptive: it tries to model real-life choices, rather than optimal decisions.

Prospect theory was developed by Daniel Kahneman, professor at Princeton University's Department of Psychology, and Amos Tversky in 1979 **as a psychologically realistic alternative to expected utility theory**. [Expected utility theory is unable to explain why people are often simultaneously attracted to both insurance and gambling] Starting **from empirical evidence**, the theory describes how individuals evaluate potential losses and gains. In the original formulation the term prospect referred to a lottery.

The theory describes such decision processes as consisting of two stages, editing and evaluation. In the first, possible outcomes of the decision are ordered following some heuristic. In particular, people decide which outcomes they see as basically identical and they set a reference point and consider lower outcomes as losses and larger as gains. In the following evaluation phase, people behave as if they would compute a value (utility), based on the potential outcomes and their respective probabilities, and then choose the alternative having a higher utility.

The formula that Kahneman and Tversky assume for the evaluation phase is (in its simplest form) given by $U = w(p_1)v(x_1) + w(p_2)v(x_2) + \ldots$, where $x_1, x_2, \ldots$ are the potential outcomes and $p_1, p_2, \ldots$ their respective probabilities. v is a so-called value function that assigns a value to an outcome. The value function (sketched in the Figure) which passes through the reference point is s-shaped and, as its asymmetry implies, given the same variation in absolute value, there is **a bigger impact of losses than of gains (loss aversion).** In contrast to Expected Utility Theory, it measures losses and gains, but not absolute wealth. The function w is called a probability weighting function and expresses that **people tend to overreact to small probability events, but underreact to medium and large probabilities.**



So,

- value is assigned to gains and losses rather than to final assets;
- the value function is defined on deviations from a reference point and
  - → is generally concave for gains (implying risk aversion),
  - → is commonly convex for losses (risk seeking)
  - → is steeper for losses than for gains (loss aversion)

- probabilities are replaced by decision weights
- decision weights are generally lower than the corresponding probabilities (except in the range of low)
- prospect theory predicts both insurance and gambling for small probabilities or other empirically observed phenomena that are inconsistent with the expected utility theory (e.g. Allais paradox:

Experiment 1		**Experiment 2**	
Gamble 1A	**Gamble 1B**	**Gamble 2A**	**Gamble 2B**
\$30 in 100%	\$45 in 80% Nothing in 20%	\$30 in 25% Nothing in 75%	\$45 in 20% Nothing in 80%
most people choose **1A**		most people choose **2B**	
Expected payoffs:			
\$30	\$36	\$8.75	\$9

→ the only difference is that the pp of winning is scaled down by ¾ from E1 to E2

Another possible implication for economics is that utility might be reference based, in contrast with additive utility functions underlying much of neo-classical economics. This means people consider not only the value they receive, but also the value received by others.

Numerous contingent valuation and experimental studies have reported **discrepancies between WTP and WTA** measures of value. (These measures are obviously connected to property rights about which more in a couple of weeks – Lecture 4 on Coasian solution to the externality problem.)

Surveying forty-five such studies, John H. Horowitz and Kenneth E. McDonnell (JEEM 2002) find that the median ratio of average WTA an WTP is 2.6 (mean 7.17).

This evidence of, seemingly, a systematic asymmetry between individuals' attitudes to gain and losses relative to some reference point, has until recently been widely accepted.

Relevant references:

Knetsch (AER 1989), The Endowment Effect and Evidence of Nonreversible Indifference Curves.

Kahneman, Knetsch, Thaler (JPE 1990), Experimental Tests of the Endowment Effect and the Coase Theorem.

Plott, Zeiler (AER 2005), The Willingness to Pay-Willingness to Accept Gap, the „Endowment Effect", Subject Misconceptions, and Experimental Procedures for Eliciting Valuations

Plott, Zeiler (AER 2007), Exchange Asymmetries Incorrectly Interpreted as Evidence of Endowment Effect Theory and Prospect Theory?

Isoni, Loomes, Sugden (2009), The Willingness to Pay-Willingness to Accept Gap, the „Endowment Effect", Subject Misconceptions, and Experimental Procedures for Eliciting Valuations: Replication and Reassessment.

List, Neoclassical Theory Versus Prospect Theory: Evidence from the Marketplace (Econometrica 72.2, 615 - 625)

List, Neoclassical Theory Versus Prospect Theory: Evidence from the Marketplace

What's the behavioral pattern called endowment effect?

And why are endowment effect and prospect theory synonyms?
[See fn 2: good's value increases once it becomes a part of individual's endowment]

What would be a typical study showing the endowment effect? (Knetsch 1989)
- Most CU students keep what they were given (mugs, chocolate, etc.)

Some economists believe that endowment effect is merely the result of a mistake made by inexperienced subjects; consumers with market experience behave largely in accordance with neoclassical predictions

a field experiment within a well-functioning marketplace: the sportscard market

What's the experimental design?
- How many treatments are there exactly?
  [12: [Emugs, Ecandy, Eboth, Eniether]x[private&nondealers, private&dealers, public&nondealers]]
- What were the two goods „traded" in each of these treatments?
  [coffee mugs, chocolate bars; in pre-sample seemed of about equal interest to similar subject pool.]
- Where, and how exactly, were the first four treatments run? (p. 617)
  [floor of a sportscard show in a large Southern city, monitor approached individuals asking to fill out questionnaire, then offered a „gift", treatment, exit interview.]
- Where, and how exactly, were the other four treatments run? (p. 618)
  [same as before but ... with different subjects, dealers approached at their booths]
- Where, and how exactly, were the "public" treatments run? (p. 618)
  [same as before but ... with different subjects, collective choice mechanisms, majority vote, in the adjacent room]

Theoretical predictions? (p. 619)
- the proportion of subjects who trade mug for choco should be equal to (1 – proportion of subjects who trade choco for mugs) (Neoclassical)
- choices in Eboth and Eneither should be independent from the initial endowment too.

Prospect theory – initial endowment induces a kin of the value function at the point of endowment, making proportion of subjects who opt to trade the mug for the candybar considerably less than (1-proportion who trades the candybar for the mug)

Results

- See Table I
- See Table II

[Do the results reflect less market experience but the specific experience that sellers bring in? Do the results simply illustrate that a particular kind of person selects in seller roles?]

TABLE I

SELECTED CHARACTERISTICS OF PARTICIPANTS

	Dealers Mean (Std. Dev.)	Nondealers Mean (Std. Dev.)	Nondealers Mean (Std. Dev.)
Trading intensity	11.81 (10.9)	4.94 (6.58)	6.88 (6.39)
Yrs. of market experience	9.88 (9.79)	7.15 (9.83)	7.21 (8.03)
Income	4.15 (1.75)	4.10 (1.69)	4.18 (1.81)
Age	36.55 (13.1)	34.54 (14.41)	37.04 (14.1)
Gender (% male)	.94 (.24)	.85 (.35)	.82 (.39)
Education	3.54 (1.40)	3.44 (1.33)	3.54 (1.54)
Sample Sizes:			
Private			
Treatment $E_{candybar}$	30	31	—
Treatment E_{both}	32	30	—
Treatment $E_{neither}$	35	33	—
Treatment E_{mug}	32	30	—
Public			
Treatment $E_{candybar}$	—	—	33
Treatment E_{both}	—	—	28
Treatment $E_{neither}$	—	—	29
Treatment E_{mug}	—	—	35

Notes: 1. Trading intensity represents the number of trades made in a typical month. 2. Yrs. of market experience denotes years that the subject has been active in the market. 3. Income denotes categorical variable (1–8): (1) Less than $10,000, (2) $10,000 to $19,999, (3) $20,000 to $29,999, (4) $30,000 to $39,999, (5) $40,000 to $49,999, (6) $50,000 to $74,999, (7) $75,000 to $99,999, (8) $100,000 or over. 4. Age denotes actual age in years. 5. Gender denotes categorical variable: 0 if female, 1 if male. 6. Education denotes categorical variable (1–6): (1) Eighth grade or less, (2) High School, (3) 2-Year College, (4) Other Post-High School, (5) 4-Year College, (6) Graduate School Education. 7. "Private" and "Public" sample sizes denote the number of subjects in Experiments 1A and 1B, respectively.

TABLE II

SUMMARY OF EXPERIMENTAL RAW DATA

	Number of Subjects Choosing Candy Bar	Number of Subjects Choosing Mug	Pearson χ^2
Panel A. Nondealers (Private)			
Treatment $E_{candybar}$	25 (81%)	6 (19%)	19.21 (3 df)
Treatment E_{both}	18 (60%)	12 (40%)	
Treatment $E_{neither}$	15 (45%)	18 (55%)	
Treatment E_{mug}	7 (23%)	23 (77%)	
Panel B. Nondealers (Public)			
Treatment $E_{candybar}$	29 (88%)	4 (12%)	34.79 (3 df)
Treatment E_{both}	16 (57%)	12 (43%)	
Treatment $E_{neither}$	17 (59%)	12 (41%)	
Treatment E_{mug}	6 (17%)	29 (83%)	
Panel C. Dealers (Private)			
Treatment $E_{candybar}$	14 (47%)	16 (53%)	.54 (3 df)
Treatment E_{both}	14 (44%)	18 (56%)	
Treatment $E_{neither}$	18 (51%)	17 (49%)	
Treatment E_{mug}	14 (44%)	18 (56%)	
	Preferred Exchange		*p*-Value for Fisher's Exact Test
Panel D. Trading Rates			
Pooled nondealers ($n = 129$)	.18 (.38)		< .01
Inexperienced consumers (< 6 trades monthly; $n = 74$)	.08 (.27)		< .01
Experienced consumers (≥ 6 trades monthly; $n = 55$)	.31 (.47)		< .01
Intense consumers (≥ 12 trades monthly; $n = 16$)	.56 (.51)		.64
Pooled dealers ($n = 62$)	.48 (.50)		.80

Notes: 1. The Pearson chi-square tests in Panels A–C are distributed with 3 degrees of freedom and each have a null hypothesis of Hicksian preferences. 2. Data in Panel D are pooled from Treatments $E_{candybar}$ and E_{mug}. For nondealers, data from "public" and "private" are pooled. Standard deviations are in parentheses. 3. Experienced consumers are those consumers who trade 6 or more times per month (6 is roughly the mean level of monthly trades). Intense consumers trade 12 or more times per month (12 is roughly the mean plus one standard deviation). 4. Fisher's exact test in Panel D has a null hypothesis of no endowment effect.

Prospect theory is found to have strong predictive power for inexperienced subjects, neoclassical theory predicts reasonably well for experienced subjects

Public good
(From Wikipedia, the free encyclopedia)

In economics, a public good is a good that is **non-rivalrous** and **non-excludable**. This means, respectively, that consumption of the good by one individual **does not reduce availability of the good for consumption by others**; and that **no one can be effectively excluded from using the good**. In the real world, there may be no such thing as an absolutely non-rivaled and non-excludable good; but economists think that some goods approximate the concept closely enough for the analysis to be economically useful.

Non-rivalness and non-excludability may cause problems for the production of such goods. Specifically, some economists have argued that they may lead to instances of **market failure**, where uncoordinated markets driven by parties working in their own self interest are **unable to provide these goods in desired quantities**. These issues are known as public goods problems, and there is a good deal of debate and literature on how to measure their significance to an economy, and to identify the best remedies. These debates can become important to political arguments about the role of markets in the economy. More technically, public goods problems are related to the broader issue of externalities.

In economics, a **market failure** exists when the production or use of goods and services by the market is not (pareto) efficient. Market failures are often associated with non-competitive markets, externalities or public goods.

Tragedy of the commons
(From Wikipedia, the free encyclopedia)

"The Tragedy of the Commons" was an influential article written by Garrett Hardin and first published in the journal Science in 1968. The article describes a dilemma in which **multiple individuals acting independently and solely** and rationally consulting their **own self-interest** will **ultimately destroy a shared limited resource** even when it is clear that it is not in anyone's long term interest for this to happen. More usually, the phrase does not refer to the article per se, but to the dilemma itself, typically in application to some circumstance to which it is thought to apply. Many, perhaps most, who use it are not aware of, nor have read, Hardin's essay, but are looking at conceptually parallel situations.

Central to Hardin's article is an example, a hypothetical and simplified situation from medieval land tenure in Europe, of herders sharing a common parcel of land (the commons), on which they are each entitled to let their cows graze. In Hardin's example, it is in each herder's interest to put the next (and succeeding) cows he acquires onto the land, even if the carrying capacity of the commons is exceeded and it is damaged for all as a result. The herder receives all of the benefits from an additional cow, while

the damage to the commons is shared by the entire group. If all herders make this individually rational economic decision, the commons will be destroyed to the detriment of all.

Cotten, Ferraro, Vossler, Can public goods experiments inform policy? Interpreting results in the presence of confused subjects (Cherry, Chapter 10)

Public policy – how to induce individuals to contribute to public goods when it may be in their private interests to free-ride off the contributions of others

VCM (= voluntary contributions mechanism) is the cornerstone of **experimental investigations** on the **private provision of public goods**

- Standard experimental investigation places individuals in a context-free setting where the public good, which is non-rival and non-excludable in consumption, is simply money
- Specifically, endowed "tokens" have to be divided between a private and a public account (contributions to the public account yield a cash return to all group members)
- Typically, parameterized/designed so that each player has a dominant strategy of not contributing (to the public account) but the social optimum is realized when everyone contributes their entire endowment
- In one-shot (single-round) VCM experiments, subjects contribute – contrary to the theoretical prediction – about 40% - 60 %
- In finitely-repeated VCM experiments, subjects contribute about the same initially but contributions then decline towards zero (but rarely ever zero)
- "Thus, there seem to be motives for contributing that outweigh the incentive to free ride" (CFV 194)
- Possible "motives": "pure altruism", "warm-glow" (also called, "impure altruism"), "conditional cooperation", "confusion"
- "**Confusion**" describes individuals' failure to identify (in the laboratory set-up) the dominant strategy of no contribution (a realistic concern, see Rydval, Ortmann, Ostatnicky, Three Simple Games and How to Solve Them, now forthcoming in Journal of Economic Behavior and Organization: http://www.cerge-ei.cz/pdf/wp/Wp347.pdf

- **Findings:**
  - Palfrey & Prisbey (AER 1997) - find warm-glow but no evidence of pure altruism
  - Goeree et al. (JPublE 2002) - find pure altruism but no warm-glow
  - Fischbacher et al. (EL 2001) – find conditional cooperation but no pure /impure altruism, as do Fischbacher & Gaechter (manuscript 2004)
  - etc. (contradictory gender effects, but see Ortmann & Tichy JEBO 1999)
  - apparent lack of correspondence between contributions behavior in experimental and naturally occurring settings (e.g., Laury & Taylor JEBO 2008)

- **Could it be that these findings are the result of confusion that "confounds" the interpretation of behavior in public good experiments?** (p. 195)
  - One new experiment, two old ones
  - Using the **"virtual-player" method** to sort out pro-social motives such as altruism
  - Virtual players (that are preprogrammed to execute decisions that are made by human players in otherwise identical treatments)
    - Split-sample design (where each participant is randomly assigned to play with humans or (human condition) with virtual players (computer condition)
    - A procedure that ensures that human participants understand how the non-human, virtual players behave.
    - Random assignment of subjects to the human condition or the computer condition – important assumption here that subjects are drawn from the same population.

        - "human twins" in multiple-round public goods games where the group contributions are announced after each round

    → to neutralize other-regarding and strategic motives (contributions in all-human minus contributions in virtual ≈ confusion contributions)

- GHL experiment :

$$\pi_i = 5(25 - x_i) + m_i x_i + m_e \sum_{j \neq i}^{n} x_j$$

    - individual dominant strategy is to contribute nothing
    - full endowment contribution maximizes group earnings
    - varying internal and external rates of return (m's) and group sizes
    - individuals exhibiting pure altruism should increase their contributions when m_e increases
    - considerable contributions uncorrelated with m_e and n point at warm glow

- **Finding:**
    - pure altruism and confusion are important motives whereas warm glow is not
    - "The level of confusion in all experiments is both substantial and troubling." (p. 196) "Assuming that other-regarding preferences and confusion are present in all-human, but only confusion is in virtual treatment, this suggests that an alarming 75% of all-human contributions stem from confusion." (p. 202)
    - "The experiments provide evidence that confusion is a confounding factor in investigations that discriminate among motives for public contributions,… " (p. 196)

More evidence:

- Andreoni (AER 1995) first to argue that (parts of) what looks like kindness in VCM experiments is really confusion. Andreoni finds that other-regarding behavior (kindness, altruism) and confusion are "equally important"
- Houser & Kurzban (AER 2oo2) did the same thing but they used a different setup:
    - o a "human condition" (the standard VCM game)
    - o a "computer condition" (the standard VCM game, played by one human player and three non-human (or, "virtual") players.
    - o Each round, the aggregate computer contribution to the public good is three-quarters of the average contribution observed for that round in the human condition.
    - o Basic idea: confusion and other=regarding behavior present in the human condition but not in the computer condition
    - o Basic result: Confusion accounts for about 54 percent of contributions to all public good contributions.
- Ferraro et al. (JEBO 2003) and Ferraro & Vossler (manuscript 2005), with designs similar to Houser & Kurzban find that 54 and 52 percent contributions come from confused subjects.
- Palfrey & Prisbey (1997) find a similar result in their own experiment (not using virtual players) and estimate with their model that "well over half" of the contributions in the classic VCM experiments by Isaac et al. (Public Choice 1984) are attributable to error.
- Goeree et al. (JPublE 2002) find in their own experiment (not using virtual players) both a positive and significant effect on coefficients that correspond to (pure) altruism and decision error (confusion); no point estimate is given,
- Fischbacher & Gaechter (manuscript 2004) find in their own experiment (not using virtual players) that "at most 17.5% " are contributed by confused subjects; they also argue that none of their subjects exhibits altruism or warm-glow (no subject stated they would contribute if other group members would not). In Fischbacher & Gaechter's view, all non-confused subjects are conditional cooperators"
- **Summary: every study that looks for confusion finds that it plays a significant role in observed contributions**. (at least half of contribution plus confusion does not go away over the course of many repeated rounds)

- **Some graphs:**

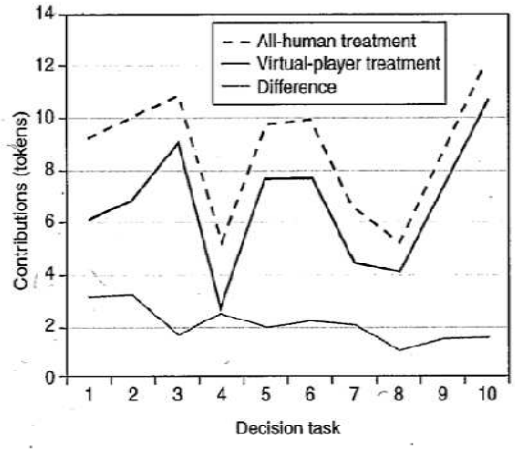


Figure 10.1 GHL application, comparison of all-human and virtual-player contributions.

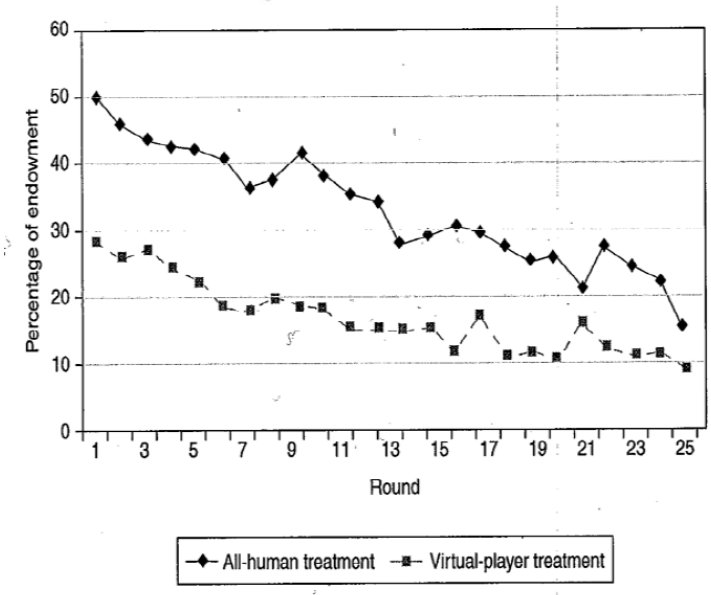


Figure 10.2 Ferraro and Vossler (2005) experiment, mean contributions.

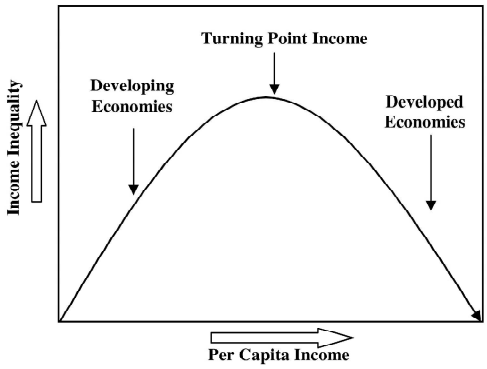
- **Solutions:**
  - Increase monetary rewards in VCM experiments! (inadequate monetary rewards having been identified as potential cause of contributions provided out of confusion)
  - Make sure instructions are understandable! (poorly prepared instructions having been identified as possible source of confusion)
  - Make sure, more generally, that subjects manage to identify the dominant strategy! (the inability of subjects to decipher the dominant strategy having been identified as a possible source of confusion)
  - "Our results call into question the standard, "context-free" instructions used in public good games." (p. 208) "Subjects may seem like zero intelligence agents when they are placed in the unfamiliar and abstract context of the experiment, even if they function quite adequately in familiar settings." (Loewenstein, 1999)

Zelmer, Linear Public Goods Experiments: A Meta-Analysis

- Use meta-analysis techniques [the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings in to a single, generalizable finding] to assess the impact of various factors on the **extent of cooperation in standard linear public goods experiments using the voluntary contributions mechanism.**
- Potentially relevant experiments were identified through searches of EconLit, the Internet Documents in Economics Access Service (IDEAS), and a survey article.
- A total of 349 potentially relevant studies were identified. Of these, 27 (representing a total of 711 groups of participants) met the inclusion criteria. Data were abstracted from these studies using a standardized protocol. Results were analyzed using weighted ordinary least squares. Average group efficiency was the dependent variable.
- The **marginal per capita return**, **communication among subjects** ("cheap talk"), **constant group composition** over the session ("partners"), **positive framing** (as altruism or fairness), and the **use of children** as subjects had a **positive and significant effect** on the average level of contribution to the public good. **Heterogeneous endowments to subjects**, **experienced participants**, and **soliciting subjects' beliefs regarding other participants' behavior prior to the start** of the session/period had **a negative and significant effect.** A number of other factors were not identified as significant (group size, gender, geography, repetition, economic training), perhaps in some cases because there was small variability in the sample.
- *Conclusion*: The meta-analysis results parallel several key findings from previous literature reviews. In addition, they offer parameter estimates and an analysis of significance based on the totality of the available research evidence. More consistent reporting of the results of experiments would greatly improve the ability to conduct this type of research.

Yandle, Vijayaraghavan, Bhattarai, The Environmental Kuznets Curve: A Primer.
[Optional reading: Stern, The Rise and Fall of the Environmental Kuznets Curve not because it is not important but because it is too technical. I suggest you read at least the non-technical parts**]**

Kuznets (AER 1955) hypothesized that income inequality first rises and then falls with economic growth – inverted U shape - hence the name EKC (Environmental Kuznets Curve) for similar pattern in environmental policy



Since 1991 when EKC first reported [Grossman and Krueger's analysis of air quality measures in a cross-section analysis of countries for different years, investigating the claim that economic growth accompanying the NAFTA would foster environmental degradation – they did indeed identify a turning point where higher income started to improve air quality (for two indicators SO2 and dark matter, or smoke)], it has become standard fare in technical conversations about environmental policy. Early estimates showed that some important indicators of environmental quality such as the levels of SO2 and particulates in the air actually improved as income levels and levels of consumption went up

Meadows, Meadows, Randers, & Behrens (1972) – "Club of Rome" study, dire predictions (economic growth is bad, a threat to the environment) (in Stern 2004)

Grossman & Krueger (1991) - impact of NAFTA study, much more optimistic predictions (economic growth may be good); popularized by 1992 World Bank Development Report (IBRD 1992)

the theoretical framework still in early stages (see e.g. Lopez 1994 or Munasinghe 1999, in Yandle et al.)

What the basic issue?

- Can economic growth be the means to *eventual* environmental improvement?
- Can have humankind "have our cake and eat it" – a prospect of achieving sustainability without a significant deviation from business (Rees 1990, p. 435, in Stern)
- Does the following result (of an "inverted U-shaped function of income per capita") generalize to other emissions?

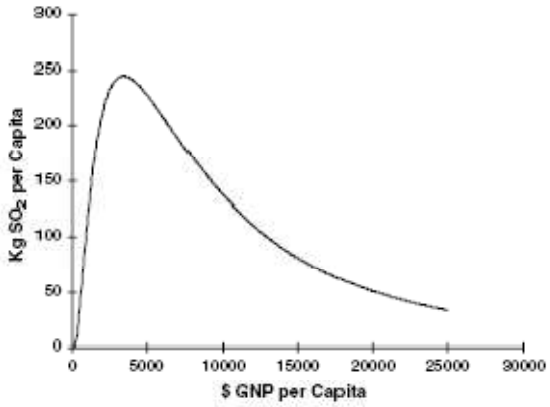


Figure 1. *Environmental Kuznets curve for sulfur emissions. Source: Panayotou (1993) and Stern, Common, and Barbier (1996).*

Sulfur
(From Wikipedia, the free encyclopedia)

Sulfur or **sulphur** (pronounced /ˈsʌlfər/ *SUL-fər*, *see spelling below*) is the chemical element that has the atomic number 16. It is denoted with the symbol **S**. It is an abundant, multivalent non-metal. Sulfur, in its native form, is a yellow crystalline solid. In nature, it can be found as the pure element and as sulfide and sulfate minerals. It is an essential element for life and is found in two amino acids, cysteine and methionine. Its commercial uses are primarily in fertilizers, but it is also widely used in black gunpowder, matches, insecticides and fungicides. Elemental sulfur crystals are commonly sought after by mineral collectors for their brightly colored polyhedron shapes. In nonscientific contexts, it can also be referred to as *brimstone*.

Environmental impact

The burning of coal and/or petroleum by industry and power plants generates sulfur dioxide (SO_2), which reacts with atmospheric water and oxygen to produce sulfuric acid (H_2SO_4). This sulfuric acid is a component of acid rain, which lowers the pH of soil and freshwater bodies, sometimes resulting in substantial damage to the environment and chemical weathering of statues and structures. Fuel standards increasingly require sulfur to be extracted from fossil fuels to prevent the formation of acid rain. This extracted sulfur is then refined and represents a large portion of sulfur production. In coal fired power plants, the flue gases are sometimes purified. In more modern power plants that use syngas the sulfur is extracted before the gas is burned.

Yandle et al

- Where did the name "Environmental Kuznets Curve" come from?
- Why Kuznets?
- What have we learned about the statistical relationships between various measures of environmental quality and income?
- Do all aspects of environmental quality deteriorate or improve systematically with economic development?
- Does the degree of property rights and contract enforcement make a difference?

"At the low levels of per capita income found in pre-industrial and agrarian economies, where most economic activity is subsistence farming, one might expect rather pristine environmental conditions, relatively unaffected by economic activities—at least for those pollutants associated with industrial activity. The EKC statistical relationship suggests that as development and industrialization progress, environmental damage increases due to greater use of natural resources, more emission of pollutants, the operation of less efficient and relatively dirty technologies, the high priority given to increases in material output, and disregard for—or ignorance of—the environmental consequences of growth. However, as economic growth continues and life expectancies increase, cleaner water, improved air quality, and a generally cleaner habitat become more valuable as people make choices at the margin about how to spend their incomes. Much later, in the post-industrial stage, cleaner technologies and a shift to information and service-based activities combine with a growing ability and willingness to enhance environmental quality (Munasinghe, 1999)."

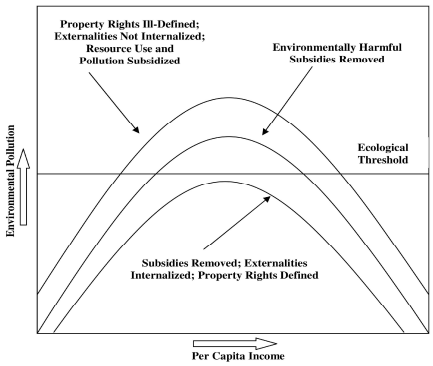
"Saying all this may tempt one to think that higher incomes alone will solve most environmental problems. Unfortunately, life is not that simple. If it were, transfers of income from richer to poorer societies—through foreign aid, for example—would enable the recipients to avoid environmental destruction. The movement along an environmental Kuznets curve is also a movement through a well-known set of property rights stations. In primitive societies managed by tradition or tribal rule, part of the resource base may be treated as a commons. With growing scarcity, however, a time comes when some aspects of the commons become defined as public or private property. As "propertyness" expands—and private property is the most incentive-enriched form—individuals have a greater incentive to manage, to conserve, and to accumulate wealth that can be traded or passed on to future generations. … Eventually, when most aspects of the environment are defined as property, the community moves rapidly in the race to improve environmental life."

"Thus, the Environmental Kuznets Curve is a proxy for a property rights model that begins with a commons and ends with private property rights."

Evidence:

- Grossman and Krueger 1991 – identified the turning point for SO2 and dark matter

- Shafik and Bandopadhay (1992) – for SO2, suspended particulate matter, fecal coliform [a bacteria - its Aerobic decomposition can reduce dissolved oxygen levels if discharged into rivers or waterways]
- Hettige et al 1992 - using a composed production toxicity intensity index – found EKC for toxic intensity per GDP, not for "per manufacturing output"… Manufacturing, which is just one part of GDP, did not become cleaner or dirtier as income changed. Instead, manufacturing became smaller relative to services and trade in expanding economies. … This could mean that dirty production shifts elsewhere… They find that "toxic intensity in manufacturing has grown much more rapidly in economies that are relatively closed to international trade"
- Gokany 2001 – "Open economies improve their environments
- Suri and Chapman (1998) - focused on energy consumption showed that as industrialized economies matured, they moved to services and then imported more manufactured goods from developing countries -> the global diffusion of manufacturing contributes to environmental improvements as incomes rise and development continues
- Cropper and Griffits (1994) – as income increases the rate of deforestation levels off
- Panayotou (1995) – finds that the turning point for deforestations occurs much earlier than for emissions," because deforestation for either agricultural expansion or logging takes place at an earlier stage of development than heavy industrialization"
- Shafik (1994) – four determinants of environmental quality -> mixed results
- Grossman and Krueger (1995) – more extensive empirical study , focusing on water quality , found a turning point for 11 out of 14 selected indicators
- Selden and Song (1994) – 2 G&K's air pollutants + oxides of nitrogen and carbon monoxide – found EKC for all 4, turning points for pollutants from G&K are significantly higher than G&K's estimates (they use readings from both urban and rural areas, G&K only urban)
- Cole et al – examined a wide range of indicators for different countries
- and **On property rights…**
- Panayotou (1997) examining EKC for sulfur dioxide found that faster economic growth and higher population density do increase moderately the environmental price of economic growth, but better policies such as more secure property rights under a rule of law and better enforcement of contracts and effective environmental regulations can help flatten the EKC and reduce the environmental price of higher economic growth. Similar results obtained by Qin (1998), and Bhattarai (2000)



Conclusion

- there is no single EKC relationship that fits all pollutants for all places and times
- The indicators for which the EKC relationship seems most plausible are local air pollutants such as oxides of nitrogen, sulfur dioxide, and particulate matter.
- there is no evidence to support the EKC hypothesis for gases such as carbon dioxide, which cause no harm locally but may affect the global climate as they accumulate in the atmosphere
- the evidence for water pollution is mixed

- better policies can help to flatten ECK and perhaps to achieve an earlier turning point

Stern, The Rise and Fall of the Environmental Kuznets Curve

- currently, dispute over methodology and the reality of the EKC
    - "most of the EKC literature is econometrically weak" (Stern p. 1420) because it does not account properly for the statistical properties of the data used [serial dependence, stochastic trends] and issues of model adequacy [possibility of omitted variable bias]
    - "when we … use appropriate techniques, we find that the EKC does not exist" (Stern p. 1420)
    - "It seems that emissions of most pollutants and flows of waste are monotonically rising with income", with "income elasticity" being less than 1 and moderated also by other factors ("income independent, time related effects [such as institutional quality] reduce environmental impacts in all countries at all levels of income" (Stern p. 1420))
        → In rapidly growing middle-income countries, scale effects tend to dominate time effects
        → Pure growth, without change in the structure or technology of an economy, leads to more pollution and other negative environmental impacts (scale effects)
        → As economies grow, output mix changes – from more pollution intensive to less pollution intensive industries -- input mix changes, emission specific regulations might change and actually hasten output/input mixes, etc.
    - In wealthy countries, time effects can dominate scale effects (partially because growth is slower)

- currently, also a dispute over the appropriate mix of metrics /statistics and theory, as well as the facts
    - "many environmental economists take the EKC as a stylized fact that needs to be explained by theory." (Stern p. 1421)
    - "the EKC has never been shown to apply to all pollutants or environmental impacts and recent evidence." (Stern p. 1421)

- A number of theoretical models have been developed of how preferences and technology interact to result in different time paths of environmental quality. (Stern p. 1422)
- Most of these studies can generate an inverted U-shape curve of pollution intensity but … the assumptions made and the values given to particular parameters make all the difference whether indeed the EKC gets generated.(Stern p. 1422)
- "Many EKC studies have also been published that include additional explanatory variables, intended to model underlying or proximate factors such as 'political freedom' … or output structure … or trade … In general, the included variables turn out to be significant at traditional levels. … it is not clear what we can infer from this body of work [because of potential for omitted variable bias].
- Given these problems, I do not review these studies systematically here." (Stern p. 1423)
- Turning point estimate differ widely (see Table 1, Stern p. 1425, here reproduced in parts only):
- "The only robust conclusions from the EKC literature appear to be that concentrations of pollutants may decline from middle income levels, while emissions tend to be monotonic in income. … " (Stern p. 1426)
- How about the feedback from environmental damage to economic production (typically assumed away by most EKC studies)?
- Could a EKC-type relationship, if it does indeed exist, partly or largely be the results of the effects of trade on the distribution of polluting industries, as proposed by Arrow et al. (Science 1995) and Stern et al. (World Development 1996)? -> literature on pollution havens "There is no clear answers on the impact of trade on pollution from the empirical EKC literature." (Stein 1427)
- "It seems unlikely that the EKC is an adequate model of emissions or concentrations. I concur with Copeland and Taylor (JEL 2004), who state that: "Our review of both the theoretical and

empirical work on the EKC leads us to be skeptical about the existence of a simple and predictable relationship between pollution and per capita income." (Stern p. 1435)

- "The true form of the emissions-income relationship is likely a mix of two of the scenarios proposed by Dasgupta et al. (JEP 2002) illustrated in Figure 3. The overall shape is that of their 'new toxics' EKC – a monotonic increase of emissions and income. But over time this curve shifts down, which is analogous to their 'revised EKC' scenario. [innovations being adopted in high-income countries, and with a short lag in the majority of poorer countries.]" (Stern p. 1435)

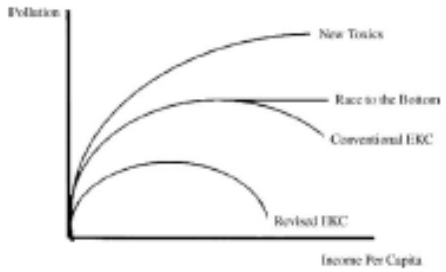


Figure 3. *Environmental Kuznets curve: alternative views. Source: Dasgupta et al. (2002) and Perman and Stern (2003).*