

# Environmental Economics in the Central European Context

Time: Tuesday 4pm – 7pm

Location: at CERGE-EI, Room # 11

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Reading materials: <http://home.cerge-ei.cz/richmanova/Teaching.html>

## Lecture 4 – Noninterventionist solutions: environmental labeling and incomplete consumer information in laboratory markets; Environmental Kuznets curve

### !!!PRESENTATION TOPICS DUE NEXT WEEK!!!

- scheduled for **October 31** (MIDTERM WEEK), 4pm-7pm
- each group (2 students) to present for about 20 minutes,
- if there is a group of 3 students, they should present for about 30 minutes
- environmental topic such as
  - o unusual/innovative environmental policies,
  - o comparing two policies in different countries/cities to deal with e.g. transportation, waste management, renewable support schemes
  - o evaluating environmental measures based on what we covered (incentive-compatibility, efficiency, implementation)
  - o International environmental issues/coordination/cooperation etc.
  - o critical review of an interesting environmental article or chapter in a book
  - o etc.,
- Discuss the topic with the instructor before starting to work on it!, i.e. send your ideas (and presentation partner) to [krajcova.janka@gmail.com](mailto:krajcova.janka@gmail.com) by **October 23**, midnight (that is, **the night before class** that week!).
- Suggested structure of your presentation:
  - o Introduction (motivation, explanation)
  - o more detailed presentation of the topic, with specifics, graphs, numbers etc. (all essential information should be on slides)
  - o link to what we discuss in class, critical evaluation, policy recommendation
  - o conclusion (summary of the main points and conclusions)
  - o List of references (all your sources)

- Also remember that also during your presentation you need to **refer to your sources**; it has to be unambiguously clear which parts are you (your contribution, critique,...) and which is original (the sources you have been using)

### **Plan for Today:**

#### **PART I – Marketable pollution permits – EU ETS (we started last week)**

Schleich et al., Incentives for energy efficiency in the EU Emissions Trading Scheme

Porter et al., The design, testing and implementation of Virginia's NOx allowance auction

#### **PART II – NON-interventionist solutions -- Environmental labeling and incomplete consumer information in laboratory markets**

Cason, Gangadharan, Environmental labeling and incomplete consumer information in laboratory markets

#### **PART III – In class experiment – Coasian solution for externality problem**

Hoyt, Ryan, Houston, The Paper River: A Demonstration of Externalities and Coase's Theorem

#### **PART IV – Environmental Kuznetz Curve**

Yandle, Vijayaraghavan, Bhattarai, The Environmental Kuznets Curve. A Primer

Stern, The Rise and Fall of the Environmental Kuznets Curve

#### **PART I – Marketable pollution permits – EU ETS (we started last week)**

#### **Schleich et al – Incentives for energy efficiency in the EU Emissions Trading Scheme**

**Q: What is the main objective of this article?**

**What do the authors do in order to find answers for their research questions?**

**Explain the difference between the micro and macro incentives in the context of this research.**

**What is the fundamental relationship between the incentives and the amount of available allowances on the macro level?**

- exploring the incentives for energy efficiency induced by the **EU ETS**
- analyzing the 27 National Allocation Plans (**NAPs**) of 27 EU member states, **in phase 2**
- hypothesize that **incentives for energy and carbon efficiency stronger in phase 2 (2008-12) than in phase 1 (2005-07)**, but only due to reduced number of allowances allocated to member states by the **European Commission**

- intuitively, **less allowances => higher prices=> stronger incentives for efficiency**
- there is also a question of distribution of pollution reduction between the **trading** and the **non-trading sector**:
  - cuts in allocation to energy and industry sectors => greater reduction in these sectors  
->**non-trading** sectors like households, transportation, or services will have to reduce less (in order to fulfill national emission target)
- improvements in the energy and industry sectors might be limited due to use of extra credits from the Kyoto Mechanisms: **Joint Implementation (JI)** or **Clean Development mechanisms (CDM)**

### What are the authors interested in?

- looking at the **stringency of the cap**, they analyze approved NAPs for phase 2 (of 27 member states) in terms of their incentives for innovation and energy efficiency; in particular
    1. they **compare approved ET budgets for phase 2** with
      - a. verified historical emissions in 2005
      - b. size of the ET budgets in phase 1
      - c. projected emissions in 2010
    2. they also look at how the burden is shared between (EU ETS) **trading and non-trading sectors (cost-efficiency)**
    3. **to what extent the use of Kyoto Mechanisms may crowd out domestic efficiencyimprovements** in EU (comparing maximum extra credits from CDM or JI that companies are allowed to use and relate it to the above stringency criteria)
- ⇒ **Looking at incentives for (in)efficiency at MACRO (country-wide) as well as MICRO (for individual installations) level**

### OUTCOMES OF THE ANALYSIS:

#### a. Incentives for efficiency at MACRO level

- in phase 1 and 2 the ETS budgets made up of budgets of individual installations based on combination of **historical emissions + growth projections + emission savings potentials** and overall **compliance factor**, required to reach the overall ETS budget

#### Phase 1

only few countries (in their NAPs) allocated to their industrial facilities total number of EUAs lower than the actual 2005 levels (Austria, Greece, Italy, Ireland, Spain and UK) ...

**Q: Based on this, what are the incentives to reduce emissions in phase 1???**

Moreover that resulted in a **SURPLUS** of EUAs on the market

=>prices plummeted down to zero towards the end of the first trading period (also, in phase 1, allowances could not be “saved” for the next trading period)

⇒ little incentives to improve efficiency!!!



## Phase 2

- European Commission (EC) developed own criterion and required budget **cuts in all but 4 initially proposed NAPs** (Denmark, France, UK, Slovenia)
- EC, compared to originally proposed NAPs, **reduced the total cap by 10.4%**, with the highest adjustments for Poland and Germany in absolute terms, and for Latvia, Estonia and Lithuania in percentage terms
- in addition, EC **set a maximum amount of credits from Kyoto Mechanisms**(CDM and JI) that companies may transfer and use to cover their emissions (thereby limiting the inflow of extra credits)
- on average, the ET budgets are about **12.8%** lower than emissions in 2005, **12.9%** lower than budgets in phase 1 and **15.7%** lower than projected emissions in 2010

**Q: What does it mean for phase 2 as compared to phase 1 (incentive-wise)?**

- ⇒ **MACRO incentives are likely to be stronger in phase 2 than they were in phase 1** (but to be sure that domestic reductions via improved efficiency were achieved, also the credits from Kyoto Mechanisms need to be taken into account)
- ⇒ **BUT** the global financial crisis stroke... overall drop in economic activities... prices of allowances back to zero again (**think about why this is different from 2007**)
- **efficient distribution of reduction efforts?** (within both trading and non-trading sectors, those with lower abatement costs should reduce by more) - the authors conclude that adjustments imposed by the EC **also lead to more efficient split of reduction efforts between the trading and the non-trading sector** (and lower overall costs than in the originally proposed NAPs)
  - ⇒ the authors conclude that without the EC's intervention, the notified ET budgets would have resulted in far too little improvement in efficiency... In other words, **EC's intervention was necessary and successful to improve efficiency at MACRO level**
- b. **Incentives for efficiency at micro level**
  - assessing the observed allocation rules for existing and new installations primarily based on economic theory

**Initial endowment of allowances**

**Questions:**

**What was the allocation rule used by the EC in the early phases of EU ETS?**

**What was wrong with such allocation rule?**

**Why do economists prefer auctioning off rather than free initial endowment of allowances?**

- **Auctioning vs. free allocation for existing installations – economists prefer auctioning to free allocation**
  - one of the reasons is that the “**polluter-pays**” principle holds, so the outcome can be perceived as fair
  - auctioning also addresses “**windfall profits**” – if companies manage to pass the price of allowances on consumers [which is what we see in power sector], extra profits (windfall profits) accrue if those companies had gotten their allowances for free
  - auction **revenues can be used for R&D**, investment into efficient technologies

- Importantly, facilities' **incentives to innovate are stronger with auctioning off**:

**Q: Can you recall any of the examples used by the authors to explain why?**

- ***Incentives for replacement*** - incentives to replace old installations in the EU ETS are stronger with auctioning rather than with free allocation (because the plant has to purchase allowances at the beginning of the trading period...this enters as extra cost into the cost-benefit analysis of no replacement vs. replacement)
  - ***Updating the base period distorts incentives to innovate***– if allowances are allocated for free based on today's emissions – updating the base period distorts incentives to reduce emissions because future allocation will be lower => updating results in reduced incentives to improve efficiency when allocating for free. (with auctioning-off today's emissions do not play a role, there is no base... the government or responsible agencies offer allowances for sale and facilities bid depending on their cost of abatement)
  - ***Carbon cost pass through in the power market and demand side incentives*** – if product prices are higher due to higher carbon costs [depends on elasticity of demand, market structure and regulation and then in particular cases might also depend on whether auctioned or for free ... those interested may want to read Schleich et al. p. 10-11] =>stronger incentives for energy efficiency on the demand side when carbon emissions are costly
  - ***Diffusion effect***- adoption and diffusion of new technologies reduces emissions and surplus allowances can be sold on the market(or,fewer need to be purchased) => lower demand => lower prices... if allocated for free, the freed-up allowances will generate smaller profit for the investor as the price goes down (something of market value which he got for free, now he sees his profits going down) ... if auctioned off the future cost is lower because of lower allowance price, so in the long run investor benefits....stronger incentives for innovation
  - ***Early price signals and planning reliability for investment*** – auctioning off part of the (allowance) budget at the beginning may generate robust early price signals that reflect the scarcity of allowances (bidding behavior reflects marginal abatement cost) →lower payoff uncertainty for investors, improved planning reliability
- **the theory suggests that (micro) incentives to innovate are stronger with auctioning off**
  - **Q: Based on the above arguments, which are the two problematic rules used by the EC for initial allocation of allowances in the first two trading periods?**
  - **Reality? [until 2012]**

- the directive **allows** members to auction off **up to 5%** of the ET budget in phase 1 and **up to 10%** in phase 2 [governments to individual facilities]
  - in phase 1, only **4 members chose to auction off** parts of their ET budgets (0.2% of total EU ETS allocation), more members plan to do that in phase 2 (still, only 3.1% of total allocation)
  - **most member states allocate allowances to installations for free**, based on historical emissions (2005 data)
  - due to low auctioning share it is **unlikely that phase 2 would substantially advance as regards improvements in MICRO efficiency**
- Even in cases when the allowances are distributed for free, it matters to a great extent, on the mechanism by which the allowances are distributed to individual installation – that can affect incentives on individual level...-->
- **Conventional grandfathering vs. benchmarking for existing installations**
  - **Grandfathering Allowances:** allocation method under which the government would give (not sell) allowances to entities based on their historic production, emission or consumption levels

**Q: What is wrong with such scheme (for incentives)?**

**=> Problem:** Allocating allowances based on historical emissions in a recent reference period implies that companies which had invested in abatement measures prior to that period would receive fewer allowances than companies which had not invested in such measures (=>**no incentives to innovate**)
  - **Benchmarking,**
    - an approach used to evaluate GHG emissions performance between and amongst similar facilities or operations in the same industrial sector. It uses an objective indicator of efficiency (a benchmark) to compare the facilities or operations to their industry standard or best practice and can therefore recognize and reward facilities that have already invested in achieving emission reductions
    - allocation can be based on specific values per unit of production (e.g., kg of CO<sub>2</sub> per MW hour electricity) for a particular group of products or installations; or on the top x % performers of the EU or of the world.
    - The actual number of allowances can be derived from the specific **benchmark value per unit** of activity multiplied by historical or predicted production levels, utilization rates or the capacity of the individual installations
    - => allocation is NOT based on individual installation's (historical) emissions
  - benchmarking favors carbon-efficient over less-carbon-efficient installations (the latter need to purchase missing allowances on the market, which is costly) and accounts for early action(i.e. innovation)

- better than based on historical emissions:
  - favors low-emission installations -> FAIR
  - allocation is not based on own emissions – limits incentives to behave “strategically” (not lowering current pollution for future allowance allocation)
- **Reality**
  - several countries use benchmarking, mostly for power installations
    - In the **first phase**, only a few Member States: France, Italy, the Netherlands, and Sweden have applied benchmarking
    - In the **second phase**, Austria, Belgium, Germany, Latvia, Spain and the UK among others also used benchmarking.
  - increased use of benchmarks compared to phase1 can be expected to accelerate the replacement of old carbon-intensive technologies in phase 2
- Another important factor that affects incentives is how allocation to new installations (started within given trading period) is handled and what happens with allowances of firms that go out of business
- **Allocation rules for new projects**
  - allocating for free to new installations distorts incentives for investing in less-carbon-intensive technologies (**Why?**) – should be purchased on the market
  - **Reality**
    - in all member states new projects receive allowances for free from a new entrants’ reserve (on a 1<sup>st</sup>-come-1<sup>st</sup>-served basis)
- **Allocation rules for closures**
  - if allocation is terminated after closure companies do not properly account for true opportunity cost of closure ->because of losing allowances, the closure cost is overestimated and therefore, old plants may continue to be operated for too long and new investments might be postponed
  - **Reality**
    - most member states end the allocation after the closure (of fear that operators might shut down the installations, keep the allowances and open a new business in another country)

**European Commission for phase 3 (from 2013 on):**

## Benchmarks for free allocation



Policy

Documentation

Studies

FAQ

**From 2013 onwards the system for allocating emission allowances will significantly change compared to the two previous trading periods (2005-2012). Firstly, emission allowances will be distributed according to fully harmonised and EU-wide rules, meaning that the same rules will apply across all EU Member States. Secondly, auctioning will be the rule for the power sector, which means that the majority of allowances under the EU Emissions Trading System will not anymore be allocated for free.**

For industry and heating sectors, allowances will be allocated for free based on ambitious (greenhouse gas performance-based) benchmarks. Installations that meet the benchmarks (and thus are among the most efficient installations in the EU) will in principle receive all allowances they need. Installations that do not meet the benchmark will have a shortage of allowances and the option to either lower their emissions (e.g. through engaging in abatement) or to purchase additional allowances to cover their excess emissions.

In contrast to the most common allocation methods in force since 2005 and until 2012, this new system applying from 2013 onwards will no longer have the perverse effect of providing more free allocation to the highest emitting installations.

The benchmarks are also very important for the achievement of a low-carbon economy. They provide a strong signal for what is possible in terms of low-carbon production. The benchmarks are a milestone to show that the EU is pressing ahead with the implementation of its ambitious climate agenda and that it is serious in striving for a low-carbon economy.

### What are benchmarks?

A benchmark does not represent an emission limit or even an emission reduction target but merely a threshold for the level of free allocation of an individual installation. The benchmarks are to be developed per product, to the extent feasible.

Generally speaking a product benchmark is based on a value reflecting the average greenhouse gas performance of the 10 % best performing installations in the EU producing that product. The benchmarks were established on the basis of the principle 'one product = one benchmark', which means that the benchmark methodology does not differentiate by technology or fuel used, nor the size of an installation or its geographical location.

### Why free emission allowances?

If other developed countries and other major emitters of greenhouse gases do not take comparable action to reduce their emissions, certain energy-intensive sectors in the EU that are subject to international competition could be put at an economic disadvantage. Therefore, allocating emission allowances free of charge aims at limiting the costs for EU industries in relation to competitors outside of the EU.

At the same time, an absence of comparable action outside of the EU could lead to an increase in greenhouse gas emissions in third countries where industry is not subject to comparable carbon constraints. This would undermine the environmental integrity and benefit of actions by the EU.

To address these issues, industrial sectors that face international competition from industries outside the EU which are not subject to comparable climate legislation will receive a higher share of free allowances than those which are not at the risk of such so-called carbon leakage.

**Q: Do you think the new system will be better in terms of incentives? Can you explain?**

**Q: What is the main argument for allocating the allowances for free to certain sectors? Do you think it makes sense?**

## Auctioning



Policy

FAQ

The EU Emissions Trading System enables participating installations like factories and power plants in 30 countries to receive emission allowances (a certain amount of greenhouse gases that they can emit) which they can sell to or buy from one another as needed. While auctioning of carbon allowances is limited during the first and second trading period, it will be the main allocation method as of 2013.

During the first trading period (2005 to 2007), Member States have auctioned only very limited quantities of carbon allowances, and also during the second trading period (2008 to 2012) the lion's share of carbon allowances is still allocated for free. From the start of the third trading period in 2013 about half of the allowances are expected to be auctioned. Auctioning is the most transparent allocation method that allows market participants to acquire the allowances concerned at the market price.

### Auctioning of allowances becomes rule as of 2013

The revision of the Emission Trading Directive, agreed on 17 December 2008, foresees a fundamental change as from the third trading period starting in 2013. Auctioning of allowances will be the rule rather than the exception. No allowances will be allocated free of charge for electricity production, with only limited and temporary options to derogate from this rule.

Sectors and sub-sectors found to be exposed to a significant risk of carbon leakage will receive allowances for free based on ambitious benchmarks, but for non exposed industry such allocations will be phased out. These rules imply that as from 2013 at least half the total number of allowances is expected to be auctioned.

Source: [http://ec.europa.eu/clima/policies/ets/index\\_en.htm](http://ec.europa.eu/clima/policies/ets/index_en.htm)

## Q: What is carbon leakage?

### Summing-up Schleich et al.

#### MACRO incentives:

ET budgets for phase 2 are

- about 12.8% lower than historical emissions in 2005,
- 12.9% lower than the budgets in phase 1 (2005-2007),
- 15.7% lower than projected emissions in 2010.

→ thus, the ET budgets for **phase 2** are **much stricter** than for **phase 1**

→ and, prices for EUAs early in phase 2 support this view (remember that there were external shocks behind the fall of prices towards the end of phase 2).

→ **tighter budgets for phase 2 are primarily the outcome of the EC's intervention** (cutting allocation in NAPs) rather than the result of member states' efforts

→ for **phase 3**,

- NAPs are no longer required
- **Phase 3 is scheduled to last for 8 years** (2013-2020) rather than five, as longer phases **better match companies' investment cycles** and reduce uncertainty about

- the profitability of new investments, they are likely to increase the diffusion and development of carbon- and energy-efficient technologies.
- Longer phases, however, also **limit the system's flexibility** to react to unexpected developments, such as technological breakthroughs, sudden changes in climate policy, or improved knowledge about the causes and effects of climate change. ... “ (p. 16)
- ⇒ the incentives for carbon and energy efficiency generated through the EU ETS **have significantly improved at the MACRO level**

### **MICRO incentives**

- ⇒ in phases 1 and 2, **only small share and only in few member states auctioned off => not much of an improvement at the MICRO level between phase 1 and phase 2.**
- ⇒ use of grandfathering rather than benchmarking
- ⇒ Phase 3 – introduction of
  - harmonized allocation rules in member states, (no NAPs)
  - use benchmarking where no auctioning-off
  - no free allowances for new power installations,
  - same allocation for new as for old non-power installations...
- ⇒ implies **increased (MICRO) incentives** for carbon and energy efficiency

So now we know that auctioning off is preferable to free allocation. But there are many types of auctions... which one is the best?

Porter et al. address this question....maybe even more importantly this has been a very interesting experiment, in which the government really asked experimental economists for advice before deciding on auction mechanism to be employed

### **Porter et al. – The design, testing and implementation of Virginia's NOx allowance auctions**

- one of the first known cases where emission allowances were auctioned with the explicit intention of maximizing government revenues
- sale of 3710 allowances for emission of nitrogen oxides (NOx) in fiscal years 2004 (1,855) and 2005 (1,855) ultimately using **a sequential English auction** format

- before settling on an auction format, Virginia engaged services of experimental economists to assist in the auction design process => the authors designed, tested and implemented the auction
- auction mechanism designed, tested, implemented by Porter et al.
- 1,855 allowances account for about 8 percent of the annual total allotment. Where do the other allowances go? ... to firms in recognition of **their historical "rights to emit"** ... the 8 percent were set aside for distribution among new sources of NOx emissions .. originally meant to be handed out for free ... but then budget crisis struck ...
- part of a cap-and-trade system of pollution allowances that involves Virginia and 18 other states in the eastern U.S.; allowances are freely tradable throughout the 19-state region ... there is an active private market ...
- brought the Department of Environmental Quality (DEQ) of Virginia **\$10.5 million**, 19 percent above target revenue of \$8.8 million

*An **English auction** is a type of auction, whose most typical form is the "open outcry" auction. The auctioneer opens the auction by announcing a Suggested Opening Bid, a starting price or reserve for the item on sale and then accepts increasingly higher bids from the floor consisting of buyers with a possible interest in the item. The highest bidder at any given moment is considered to have the standing bid, which can only be displaced by a higher bid from a competing buyer. If no competing bidder challenges the standing bid within a given time frame, the standing bid becomes the winner, and the item is sold to the highest bidder at a price equal to his or her bid. More generally an auction mechanism is considered "English" if it involves an iterative process of **adjusting the price in a direction that is unfavorable to the bidders** (increasing in price if the item is being sold to competing buyers or decreasing in price in a reverse auction with competing sellers).*

*When the auction involves a single item for sale and each participant has as an independent private value for the item auctioned, the outcome of an English auction is theoretically equivalent to that of the **Vickrey auction** (type of sealed-bid auction, where bidders submit written bids without knowing the bid of the other people in the auction, and in which the highest bidder wins, but the price paid is the second-highest bid). Both the Vickrey and English auction, although very different procedurally, award the item **to the bidder with the highest value at a price equal to the value of the second highest bidder**.*

*In contrast, a **Dutch auction** would **adjust the price in a direction that favored the bidders**. The auctioneer begins with a high asking price which is lowered until some participant is willing to accept the auctioneer's price, or a predetermined reserve price (the seller's minimum acceptable price) is reached. The winning participant pays the last announced price. This is also known as a "clock auction" or an open-outcry descending-price auction.*

*This type of auction is convenient when it is important to auction goods quickly, since a sale never requires more than one bid. Theoretically, the bidding strategy and results of this auction are equivalent to those in a sealed-bid first-price auction (**the bidder with highest value wins and pays his bid**).*

## Design restrictions

- tight time constraint (from the first time Porter et al. were contacted to required deliverytime, about two months)
- transparency of the pricing rule critical
  - **option 1: discriminatory** (or “pay-as-you-bid”, every bidder pays the amount he/she bid)
    - ⇒ this poses ex post problem to participants since nearly all participants included in final allocation realize that they could have had the license to pollute for less ...”a bidder who wins has paid too much, a bidder who loses has bid too little”
  - **option 2: uniform pricing** (market-clearing price is set and everyone bidding that or more pays uniform, market-clearing price)
    - ⇒ this might pose a problem to the government because public is likely to find out what bidding prices were and how much the government left on the table – not extracting maximum possible (keeping information secret not an option due to Virginia’s Freedom of Information Act)
- **auction mechanism rules had to be simple** since complicated bidding and allocation rules might scare potential buyers off
  - with respect to 2 vintages, they considered two possibilities, **sequential** and **combinatorial** (=bidding for both vintages at once) bidding → combinatorial clock auction is certainly the more complicated one
  - another important complicating factor, in this respect, was the asymmetric substitutability of the two kinds of allowances involved →
    - Emitters cannot borrow against future issuances of allowances but ... allowances are “bankable”, i.e., 2004 allowances can be used in 2005
    - **use of banked allowances subject to restrictions**; if region-wide carried-over licenses exceed 10 percent of the total regional budget then only a fraction of the carried-over licenses may be used, the remainder gets devalued by 50% (in early March, local exchanges were trading 2004 allowances for about \$2,000 and 2005 allowances for about \$3,500, reflecting a probability that 2004 allowances may lose some of their face value)

## Which auction mechanism / pricing rule to use?:

- “DEQ selected initially a combinatorial clock design (based on the results of the experiment), the complexity of the implementation proved prohibitive in the available timeframe, and ultimately a sequential (first one vintage, then the other) clock was implemented instead.”
- Three auction mechanisms were investigated:

- i. **Sealed bid (first-price auction)** without iteration (participants submit their bids by given deadline and units are allocated to the high bidders on a pay-as-bid basis (**discriminatory** pricing), **combinatorial** in that bidding at both vintages, **(CSB)**)
- ii. **Iterative English** (second-price auction, clock quoting successive process and each bidder is required only to indicate his quantity demanded at the standing price, the auction ends when the market clears (total demand=total supply – **uniform pricing**, no info on individual willingness to pay beyond market clearing price)
  1. **simultaneously linked clocks** (for two vintages) ~ Combinatorial English Clock (**CEC**)
  2. **sequential** (takes into account potential substitutability of 2004 and 2005 allowances) ~ Sequential English Clock (**SEC**)

- similarly as in previous experiments, subjects were given “redemption” value for each “product (neutral wording) to simulate the market demand

## Results

The aim was to estimate revenue and allocative efficiency under the three auction formats

### Revenues

1. The **CSB** outperformed both English clock designs in **inelastic** environments (generating more revenue).
2. **Elastic** demand increased revenue in **both English clock** mechanisms, but not in the **CSB**.

=> given sufficiently elastic demand, the **CEC** is the **revenue maximizing mechanism**, but the **CSB** raises more revenue in inelastic demand environments

### Efficiency

- Efficiency across mechanisms is comparable irrespective of the environment.

### Conclusions

- Experiments are being used (and that is probably for a good reason) to inform public policy decisions
- The Virginia NOx allowance auction had to be implemented on an extremely tight timeline ... three important effects:
  - a. It forced state administrators to make very quick decisions

- b. It forced selection of an easily implemented auction design that would be attractive and understandable to potential participants
- c. Limited opportunities for involvement of outside parties in the process
- The advantages of test-bedding a new application are:
  - a. Exploration of parameter space when there are no empirical guidelines to identify the parameters (e.g., demand elasticity for allowances)
  - b. Comparing revenue and efficiency of auction formats makes for better informed decisions.
  - c. Increases confidence in process and outcome
  - d. Might facilitate the final choice of a contractor to run the auction
  - e. All that at relatively low cost (less than 1 percent of the revenue, i.e. about \$100,000)

## **PART II - Environmental labeling and incomplete consumer information in laboratory markets**

### **Product certification**

From Wikipedia, the free encyclopedia

**Product certification** or **product qualification** is the process of certifying that a certain product has passed performance and [quality assurance](#) tests or qualification requirements stipulated in regulations such as a [building code](#) and nationally accredited test standards, or that it complies with a set of regulations governing quality and minimum performance requirements.

### **Questions:**

**Which environmental/quality labels are you aware of?**

**Do you rely on labels? Are you willing to pay higher price for higher (environmental) quality?**

**Which are the possible problems with certification as a solution to informational asymmetries?**

**How much of a problem informational asymmetries can constitute here?**

Certification of ENVIRONMENTAL QUALITY....

		
<p><b>Name:</b> International Energy Star Program  <b>Countries of operation:</b> Japan, U.S., many in the EU</p> <p>The mark is awarded to models of OA equipment such as computers and printers with standby power consumption levels that are within the prescribed levels. The mark is applicable to all products currently sold by NEC.</p>	<p><b>Name:</b> Blue Angel Mark  <b>Country of operation:</b> Germany</p> <p>The mark was the world's first environmental label to be established. It is used on 80 different categories of products, including stationary, IT equipment, and sanitation products. The mark is awarded to products that fulfill a broad number of requirements concerning power consumption, life length, and recyclability.</p>	<p><b>Name:</b> TCO  <b>Country of operation:</b> Sweden</p> <p>The mark is used on computers and other peripheral products that satisfy the requirements for recyclability and energy efficiency. In FY 2006, the mark was awarded for 30 different types of NEC monitors.</p>
		
<p><b>Name:</b> Eco-Mark  <b>Country of operation:</b> Japan (The Japan Environment Association)</p> <p>The mark is awarded for products that have low environmental impact through-out the entire product lifecycle, from raw material extraction to disposal. The mark has been awarded for a number of NEC desktop PCs, displays, laser printers, and dot printers.</p>	 	

**Experimental evidence:**

**Cason, Gangadharan, Environmental labeling and incomplete consumer information in laboratory markets**

**Questions:**

What is the paper about, what do the authors test?

How much of a problem incomplete information constitutes in this context?

What is the key assumption for price discrimination based on environmental quality?

Do you think it is a reasonable assumption, i.e. does it seem to hold in the real life?

Can we expect the unregulated market to achieve the efficient equilibrium? Explain.

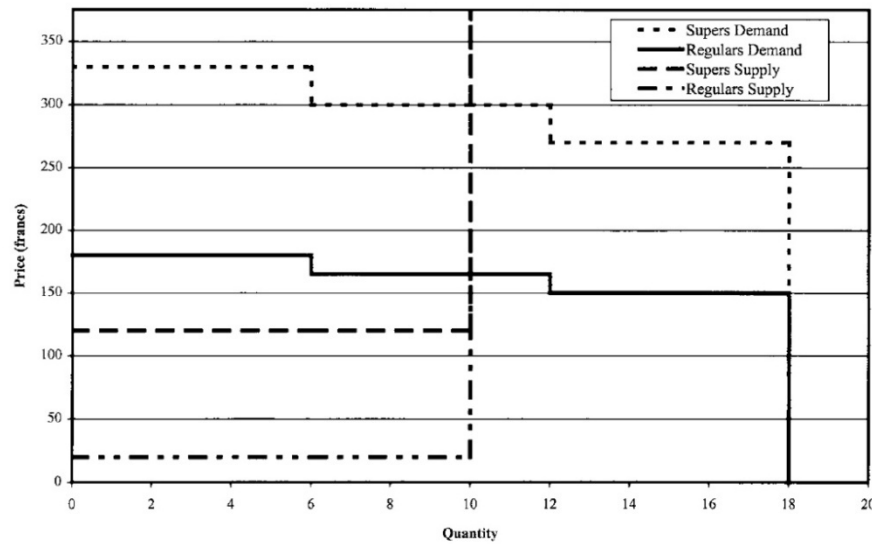
Do the authors offer solutions?

- survey evidence exists suggesting that the consumers care for the environment and are willing to pay a higher price for more environment-friendly products
- they study a market with incomplete information – prior to purchase the consumer is unaware of the product's (environment-related) quality (moral hazard problem)
- no signaling with no reputational concerns typically lead to market failure (under-provision of high-quality products)
- the key real-world issue is that with some types of products the consumer is not able to assess the quality even post consumption! here, the authors deal with the less complicated case, when the consumers can indeed discover the true quality after consumption
- various treatments to remedy the market failure: **cheap talk signals**, **seller reputation**, **(costly) certification** (“eco-labeling”)

### Experimental Design and Implementation

- 21 sessions, 20 periods each (except 1<sup>st</sup>); 5 sellers+6 buyers, roles randomly assigned
- neutral wording of instructions
- sellers can sell up to 2 units of REGULAR(=low environmental quality) or up to 2 units of SUPER (=high environmental quality) grade in each period
- SUPERS are more expensive to produce than REGULARs: 120 experimental francs (EF) vs. EF 20; this is common knowledge
- ⇒ buyers' resale value of SUPERS > of REGULARs (this means that buyers prefer, and thus are willing to pay higher price for, SUPERS) which is common knowledge but buyers' specific marginal values are private info (not known to sellers)
  - SUPERS: 1<sup>st</sup> unit brings EF 330, 2<sup>nd</sup> unit EF 300, 3<sup>rd</sup> unit EF 270
  - REGULARs: 1<sup>st</sup> unit brings EF 180, 2<sup>nd</sup> unit EF 165, 3<sup>rd</sup> unit EF 150
    - ⇒ all buyers and sellers have identical cost and value schedules
    - ⇒ induced demand and supply curve

FIG. 1. Market supply and demand.



- ⇒ Efficient equilibrium all (10) SUPERS are produced and traded at EF 300
- ⇒ Inefficient equilibrium all (10) REGULARS are produced and traded at EF 165

### Questions:

How is the baseline treatment set up? What is the outcome?

Can you explain, intuitively, the incentives of market participants and the resulting equilibrium?

What changes in reputations/cheap talk/certification setup?

To what extent the individual mechanisms improve the information available to the buyers? Do they help – and if yes, to what extent – to increase the market efficiency? How stable any such improvement might be?

Which mechanism(s) help(s) to establish and maintain the efficient equilibrium?

### TREATMENTS

- **BASELINE**

- the sellers are asked to indicate privately the number of units they want to sell, the offer price per unit and the grade of the units at the beginning of each period.
- the price offers (with no additional info) by the sellers are posted on the board in a random order to hide the seller identity (no reputations)
- buyers are randomly selected to take turns accepting the offers
- after all the buyers have an opportunity to purchase, or all the units are sold, the grades of the units are written next to each price offer (in all treatments, grade info of all sellers is revealed publicly at the end of each period)

- in all treatments, sellers must commit to a specific quality level privately to the experimenter at the start of the period.
- **REPUTATIONS ONLY**
  - the same trading procedure as in BASELINE, except that here the first seller's price offer is always written in the first row on the board, the second seller's offer in the second row, etc.
  - allows the buyers to track the sales record of each seller and identify if a particular seller has a history of selling REGULARs or SUPERs
- **THE CHEAP TALK SIGNALLING**
  - Similarly as in REPUTATIONS, prices are written on board in specific order to identify sellers' history
  - sellers have, in addition, the following 2 options:
    - 1) indicate no grade information to buyers (thus, only the price and the number of units offered for sale appear on the board) – this would be analogical to REPUTATIONS, or
    - 2) indicate a grade to be shown on the board, although this need not correspond to the actual grade offered
  - the 2<sup>nd</sup> option represents the unregulated environmental quality claims -> so-called cheap talk (claims made by producers that have not/cannot be verified by a third party)
  - to see whether unregulated claims could by themselves help in increasing the number of SUPERs sold
- **CERTIFICATION**
  - also here, prices are written on the board in the specific order to identify sellers' history
  - sellers have the following 3 options:
    - 1) indicate no grade information to buyers (thus, only the price and the number of units offered for sale appear on the board)
    - 2) indicate a grade to be shown on the board, although this need not correspond to the actual grade offered
    - 3) sellers can pay EF 30 to certify that the product they are offering is a SUPER (thus, the buyers would be sure they are buying a SUPER)
  - the certification is indicated by a “star” next to the price offer, and it corresponds to third-party verified environmental labeling schemes
  - the certification is costly (in practice real resources are needed to test products); the cost of certification is set such that it can lead to the efficient equilibrium

**Q: Would a seller choose the option of certifying his/her product at extra cost of EF 30?**

**TESTED MODELS – theoretical predictions:**

**Lemons Model**

*When sellers face buyers who cannot distinguish between REGULARs and SUPERS, they will only offer REGULARs. Buyers observe only REGULARs delivered and so they will behave as if they expect only REGULARs. Hence in equilibrium, only REGULARs will be delivered and the price prevailing in the market will be  $P_R$  (= EF 165). This equilibrium is particularly likely when sellers cannot establish reputations, as in the BASELINE treatment.*

**Reputation Model**

*In the presence of some imperfect information, even in finite period games sellers may establish reputations for delivering SUPERS in sequential equilibrium. According to this model, for some early range of periods some sellers will deliver SUPERS at a price of  $P_S$  (EF 300). A buyer who observes a seller delivering a REGULAR will update her beliefs and expect that seller to always deliver REGULARs in the future. Therefore, in later periods more REGULARs will be delivered at  $P_R$ .*

**Signaling Models with Unverifiable Signals**

*When it is not possible to verify product claims by sellers, then no cost differential exists between adding the “SUPER” signal to SUPERS and to REGULARs. In a “babbling” cheap-talk equilibrium, no seller adheres to her signals, and buyers do not believe that the signals convey any information. Consequently, market outcomes would be unchanged by the introduction of signaling. Signaling could, however, assist sellers in establishing the reputations in early stages.*

**Signaling Models with Verifiable Signals**

*When the signaled product claims are verifiable, sellers would find it profitable to deliver certified SUPERS since the certification cost is less than the marginal profit from delivering SUPERS rather than REGULARs at their respective equilibrium prices. Buyers know that if the product is certified, they are guaranteed to receive a SUPER and are thus willing to pay the higher equilibrium price  $P_S$ . Hence, when certification is available, outcomes correspond to the full information equilibrium.*

**RESULTS – What would you expect?**

Market performance is measured by frequency of SUPERS delivered to consumers and by the overall market efficiency.

- 1) Allowing seller reputations increases the rate at which SUPERS are traded, but Cheap Talk does not affect the rate at which Supers are traded compared to the treatment with Reputations Only. Certification is sufficient to increase the rate at which SUPERS are traded.**

TABLE II  
Treatment Average of Number of Super and Regular Units Sold.

	Number of super and regular units sold							
	Baseline		Reputations only		Cheap talk signaling		Certification	
	Reg	Sup	Reg	Sup	Reg	Sup	Reg	Sup
Treatment average (all periods)	6.5	0.9	4.8	3.4	5.7	3.4	2.6	6.2
Treatment average (final 5 periods)	7.1	0.5	5.2	3.2	6.3	3.2	1.8	7.4
Treatment average (final 10 periods)	6.9	0.7	4.9	3.6	5.9	3.5	2.4	6.9

- ⇒ in the BASELINE, SUPERS account for about 12% of total sales (all periods), whereas in the REPs ONLY it is about 40% (the difference is statistically significant)
- ⇒ in the CHEAP TALK, about 1/3 are SUPERS (not significantly different from REPs ONLY)
- ⇒ in the CERTIF., more than 2/3 are SUPERS (significantly more than in REPs ONLY)
- ⇒ the results also confirmed by econometric analysis
  - subjects accumulate evidence from offering SUPERS and REGULARS and update their beliefs about their expected profits
  - in REPs ONLY, # of SUPERS rises over time, then drops in final periods
  - initial periods of BASELINE are not sign. different than in REPs ONLY, in later periods the # is lower in BASELINE
  - early periods of CHEAP TALK – more SUPERS than in REPs ONLY, the difference disappears
  - CERTIF. not different in early periods, later on, significantly more SUPERS
  - even though SUPERS tend to be delivered in later periods, in the final periods, most units offered are REGULARS except in the CERTIF. (end-game effect – **can you explain why it happens?**)

**2) Allowing seller reputations marginally increases efficiency, but neither Cheap Talk nor Certification significantly improves efficiency compared to the treatment with Reputations Only.**

TABLE II Efficiency

	Efficiency including surplus loss from certification			
	Baseline	Reputations only	Cheap talk signaling	Certification
	Efficiency	Efficiency	Efficiency	Efficiency
Treatment average (all periods)	0.646	0.787	0.813	0.813
Treatment average (final 5 periods)	0.643	0.812	0.826	0.866
Treatment average (final 10 periods)	0.658	0.806	0.834	0.870

- ⇒ efficiency measured as the fraction of the maximum possible gains from trade actually realized by subjects
- ⇒ efficiency goes up from 65% to near 80% when sellers can establish reputation
- ⇒ the difference between BASELINE and REPs ONLY significant, between REPs only and CHEAP TALK or CERTIFICATION not significant (in CERTIFICATION efficiency loss due to the cost of certification)
- ⇒ efficiency tends to rise over time

### 3) *Non-certified Super signals are frequently false.*

- ⇒ about 22% in the CHEAP TALK are false. Non-certified SUPER signals are more rare in the CERTIFICATION, but still 33% of them is false.
- ⇒ REGULAR signals are much less common in both treatments, they are almost always truthful (??? **What is wrong here?**).

### 4) *Given the opportunity in the Certification treatment, sellers frequently certify their units as Super.*

- ⇒ in some sessions nearly all units are certified, e.g. average number of sellers who choose to certify is 4.75 out of 5 in all periods, rises to 5 in both the last 10 and 5 periods; in other sessions the certification rate is 2-4 and tends to increase in time.
- ⇒ many sellers use certification to establish reputation and then, later, use cheap talk to obtain higher prices; buyers, however, often refuse to buy uncertified units for SUPER prices (except of 1 session)

### 5) *a) Reputations modestly impact transaction prices in certain conditions;*

*b) signals have an impact on transaction prices in the Cheap Talk treatment; and*

*c) certification is necessary for sellers to sell at substantially higher prices in the Certification treatment.*

**6) Sellers who reveal themselves as “cheaters” by delivering Regular units at “Super prices” can frequently regain a positive reputation quickly – often in the next period. This seems to be due in part to the lack of an explicit outside option for buyers in most of our sessions.**

- ⇒ “immediate reputation recovery” -- when a seller is able to sell an uncertified unit at a high price one period after they sold a Regular at a high price
- ⇒ this puzzling high rate of reputation recovery could be due to the fact that buyers’ only source of profit is from making purchases in the market.
- ⇒ to test this conjecture, they conducted three additional sessions where buyers could choose not to purchase from any seller and still earn 10 francs, focusing on the REPs ONLY as here the reputation recovery rate was particularly high (70%)
- ⇒ the buyers opt for the no purchase option in exactly one-quarter of the periods
- ⇒ in general, the overall performance in this new treatment is similar to the five sessions with REPs ONLY and no outside option.
- ⇒ Importantly, the reputation recovery rate declines substantially in these new sessions with an outside option, to 33%..
- ⇒ The puzzling high reputation recovery rate in the REPs ONLY without the outside option treatment could hence be explained in part by the inability of the buyers to exit the market profitably.

## CONCLUSION

- 1) Seller reputations increase the number of high-quality goods delivered relative to the no-reputation baseline (=> just some information to the market helps to improve the outcome substantially)
- 2) Unverified claims are not sufficient to further improve market outcomes.
- 3) Although certification is costly, sellers usually opt to certify; consequently, the number of high-quality units increases, even though efficiency does not significantly increase due to the certification costs. Certification appears sufficient to overcome the moral hazard problem.
- 4) Seller reputations modestly influence prices in some conditions, and signals and certification have a significant impact on transaction prices.
- 5) Buyers are willing to forgive sellers quickly who previously delivered Regulars at Super prices; it is explained at least in part by the absence of a profitable exit from the market.
- 6) laboratory results suggest that government regulators or non-governmental organizations can improve environmental performance by providing the option of certified green labeling (only a single dimension of the product studied here).

**Discussion: Which are the obvious practical problems with certification (and its quality)?**

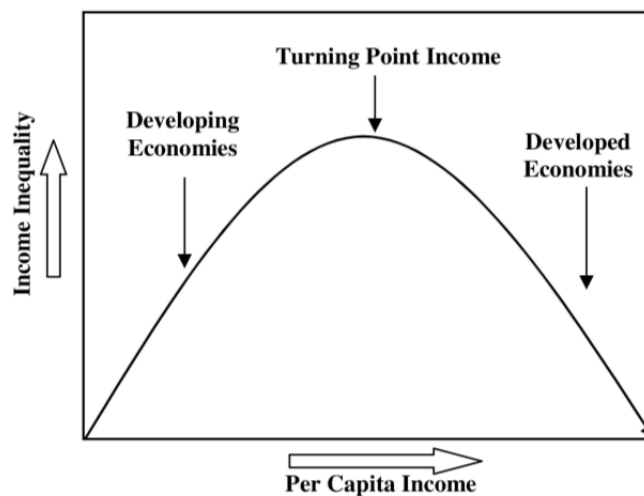
**PART III – In-class experiment ...****Part IV - ENVIRONMENTAL KUZNETZ CURVE**

mostly based on: Yandle, Vijayaraghavan, Bhattarai, The Environmental Kuznets Curve: A Primer.

[additional reading: **Stern, The Rise and Fall of the Environmental Kuznets Curve** which is quite technical, you might still want to read at least the non-technical parts]

**Q: What is the basic relationship claimed? What would it mean if it were true (and as simple as hypothesized)?**

**Kuznets** (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



1. EKC first reported in 1991
  - Grossman and Krueger's analysis of air quality measures
    - a cross-section analysis of countries for different years,
    - investigating the claim that economic growth accompanying the NAFTA would foster environmental degradation
    - the authors identified a turning point beyond which with higher income air quality started to improve (for two indicators: SO<sub>2</sub> and dark matter(smoke)),
  - EKC has become standard fare in technical conversations about environmental policy
  - the theoretical framework is still in early stages (see e.g. Lopez 1994 or Munasinghe 1999, in Yandle et al.)

**What is the basic issue?**

- Can economic growth be the means to \*eventual\* environmental improvement?
- Can 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?

1420

## WORLD DEVELOPMENT

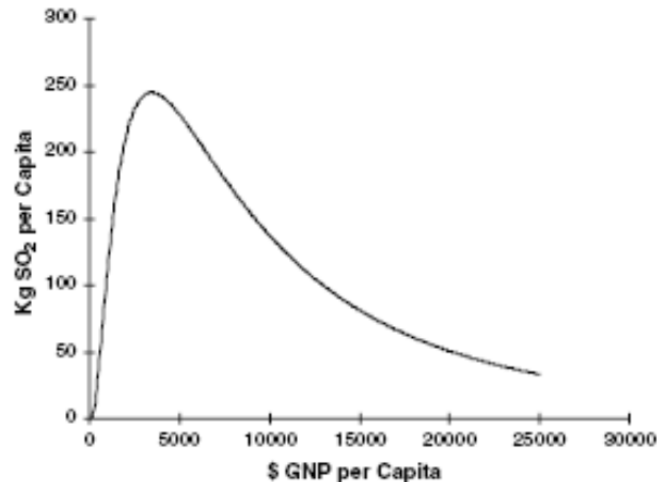


Figure 1. *Environmental Kuznets curve for sulfur emissions. Source: Panayotou (1993) and Stern, Common, and Barbier (1996).*

### 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?

**Q: What is the intuitive justification of such U-shaped relationship between growth and pollution?**

### 1. ...[luxury good]

2. ...[property rights]

3. ...[trade]

### So what is the intuition?

#### 1. At the low levels of per capita income

- typical for pre-industrial and agrarian economies, not very industrialized
- rather pristine environmental conditions, relatively unaffected by economic activities (i.e. relatively low “industrial” pollution)
- **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,**
- also, typically, high priority is given to increases in material output with disregard for the environmental consequences of growth.

#### 2. As economic growth continues (and life expectancies increase)

- cleaner water, improved air quality, and a generally cleaner habitat become more valuable
- 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.** [Do you think this could be true?] 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.”*

#### 3. **“The movement along an environmental Kuznets curve is also a movement through a well-known set of property right stations!”**

- In primitive societies managed by tradition or tribal rule, part of the resource base may be treated as commons.
- With growing scarcity, however, a time comes when some aspects of the commons become defined as public or private property.
- As “property-ness” expands, individuals have a greater incentive to manage, to conserve, and to accumulate wealth that can be traded or passed on to future generations. ...

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

#### 4. ....

### Empirical Evidence:

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

- Shafik and Bandopadhyay (1992) – for **SO<sub>2</sub>, 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 - found EKC for toxic intensity per GDP, not for “per manufacturing output”...
  - o Manufacturing did not become cleaner as income changed; it just **became smaller relative to services and trade in expanding economies**. ...
  - o **This could mean that dirty production shifts elsewhere!!!**
  - o They also found that “toxic intensity in manufacturing has grown much more rapidly in economies that are relatively closed to international trade”
- Suri and Chapman (1998) - showed **that as industrialized economies matured, they moved to services and then imported more manufactured goods from developing countries**
  - o the global diffusion of manufacturing contributes to local environmental improvements as incomes rise
  - o ... **another support for trade argument**
- Gokany 2001 – “**Open economies improve their environments**” (**positive (local) impact of international trade?**)
- Cropper and Griffiths (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) – “**mixed results**” for four determinants of environmental quality
- Grossman and Krueger (1995) – more extensive empirical study of **water quality, found a turning point for 11 out of 14 selected indicators**
- following up, Selden and Song (1994) – 2 G&K’s air pollutants + oxides of nitrogen and carbon monoxide – found EKC for all 4, the turning points for the two G&K’s pollutants are significantly higher in S&S study as compared to original G&K’s estimates (they use readings from both urban and rural areas, G&K only urban)

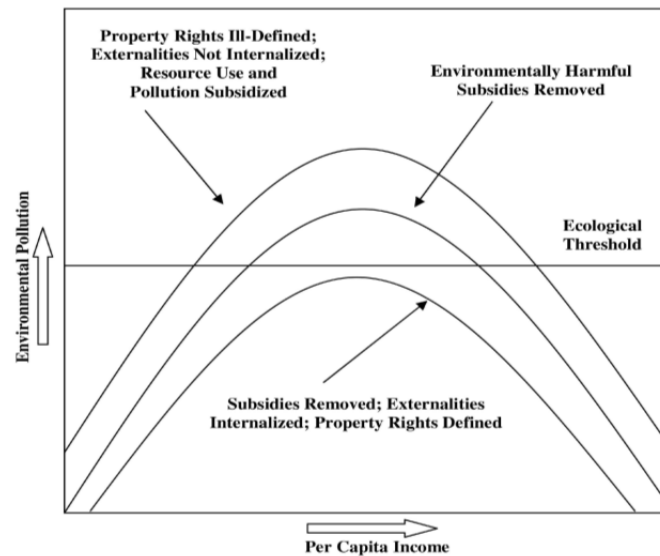
and specifically on **property rights...**

- 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 and enforcement can help to flatten EKC and perhaps to achieve an earlier turning point.



### A Critique of EKC - Stern, The Rise and Fall of the Environmental Kuznets Curve

- currently, a dispute over methodology and the reality of the EKC – theoretical and econometric critique of EKC literature
  - recent evidence suggests that developing countries are addressing environmental issues, adopting high standards (of developed countries) and sometimes performing better than some wealthy countries
  - “most of the EKC literature is **econometrically weak**” (Stern p. 1420) because
    - it does not account properly for the statistical properties of the data [serial dependence, stochastic trends]
    - and there are issues of model adequacy [possibility of omitted variables]
  - “**when we ... use appropriate techniques, we find that the EKC does not exist**” (Stern p. 1420)
  - “e.g., it is clear that **emissions of many pollutants per unit of output have declined** over time in developed countries with increasingly stringent regulations and technical innovations. But the mix of residuals has **shifted** from sulfur and

nitrogen oxides to carbon dioxide and solid waste... so that **per capita waste (total) might not have declined...**"

- ... "an effort to reduce some environmental impacts may just aggravate other [environmental] problems."
- "It seems that emissions of most pollutants and flows of waste are monotonically rising with income", though the "income elasticity" is less than 1 and is **not a simple function of income alone** -- other factors, income independent or **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
  - In wealthy countries, time effects can dominate scale effects (partially because growth is slower)
- Arrow et al. (1995) and Stern et al. (1996) argue that EKC relationship (if there were any) might be partly or largely a result of **the effects of trade** in the distribution of polluting industries (developed countries specializing in human capital and manufactured capital intensive activities that might to some extent explain reduction of environmental degradation in those countries)... no consensual answer on the impact of trade in EKC literature
- currently, also a dispute over the appropriate mix of econometrics /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"** (Stern p. 1421)
- A number of theoretical models have been developed on 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 ... but **the results are assumption and parameterization sensitive**
  - Many studies also include additional explanatory variables,
    - intended to model underlying factors such as 'political freedom', or output structure, or trade
    - these factors, in general, turn out significant at traditional levels.
    - ...

- *“it is not clear what we can infer from this body of work because of potential for omitted variable bias”* (Stern)
- Turning point estimates differ widely (see Table 1, Stern p. 1425):
- **“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)
- “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)