Environmental Economics
Notes

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INTRODUCTION

I What is Environmental Economics?

Environmental economics is the study of how the economy affects the environment, how the environment affects the economy, and the appropriate way to regulate economic activity so as to achieve an optimal balance between competing environmental and economic goals.

1. The economy affects the environment:

   - U.S. carbon emissions are forecast to drop by 5% due to the recession.

   - In many cases, wealthy countries have lower pollution emissions (despite their greater GDP), as wealthy countries can afford expensive pollution control technologies.

2. The environment affects the economy:

   - Warming from climate change affects the skiing industry.

   - Sulfur dioxide and particulate emissions can increase asthma, increasing sick days, which reduces GDP.

3. The appropriate way to regulate:

   - The Waxman-Martin climate change bill proposed regulating greenhouse gas emissions in part with a cap-and-trade with a safety valve. The government would issue permits to emit greenhouse gasses, which firms can buy and sell. But if the trade price gets too high, the safety valve kicks in and more permits are issued, to keep the price of permits from rising beyond a certain point. Is this the least expensive way to reduce greenhouse gas emissions?

   - The house bill has other provisions. It imposes a technology standard: new buildings must meet certain energy efficiency requirements. Is this the least expensive way to reduce greenhouse gas emissions?

   - An effective ban on incandescent light bulbs goes into effect at the end of the year (see article). Is this the least expensive way to reduce greenhouse gas emissions?

4. Achieving an "optimal balance:"

- Nylon production produces nitrous oxide, a greenhouse gas which is much more warming than carbon dioxide. To eliminate emissions costs about $10-20 million per factory for scrubbers, plus catalysts that cost $1 million per year. Is the benefit of reduced nitrous oxide emissions worth the cost?

- In Baltimore, reducing total suspended particulates (TSP) in the air from 115 micrograms per cubic meter to 87 micrograms costs approximately $15 million. Is the benefit worth the cost?

Although the subject name is often accused of being an oxymoron, in fact the connection is clear. Environmental economics takes environmental problems identified by scientists and answers the question "what should we do about it?"

II Topics

Within the above general ideas are many topics to study:

- Can the market economy achieve an optimal balance between nitrous oxide scrubbers and other things we might care to produce? If not why?

- How do we determine what the optimal balance is?

- What is the least cost way to regulate pollution emissions?

- How do we regulate pollution that originates in one country and lands in another?

- Are environmental side agreements necessary to prevent firms from relocating to countries with lax pollution regulations? Or are they trade barriers in disguise?

- Are pollution and gas taxes a good way for the government to raise revenue?

- How do optimal greenhouse gas emissions vary over time?

- How much do households value a good environment?

III Approach

A Positive versus Normative

We will examine both positive (why resources are allocated the way they are) and normative (what is the best resource allocation) questions.

Positive question: why is air quality worse in Mexico city than in Chicago?

Normative question: what is the optimal quantity of TSP (close to 87 micrograms)?

B   Moral neutrality

Here we use a scientific approach to the environment. If improving the environment is a moral imperative, then there is no need for this course. Like religion, we simply have faith that saving the snail darter is an important thing to do. Here, environmental goods here are little different than other goods. We like clean water just like we like other goods. So the question becomes which goods, environmental or other goods, do we want to produce?

Related is how we treat households and firms. Polluting firms are not morally challenged, but instead are responding to their incentives to maximize profits for their shareholders. Those who buy swordfish in the grocery store are not sinners, but instead are balancing their (apparently strong) desire for swordfish versus the (probably negligible) effect their purchase has on the environment.

C   Resource and ecological economics

Natural resource economics deals with the production and use of non-renewable resources such as oil, and renewable resources such as forests. Environmental economics is concerned with market failures causing excessive pollution or insufficient protection of the natural world. This distinction is a fine one, and in some cases overlap exists. Rather than discuss pollution, an environmental topic, one could discuss clean air, which is a renewable resource. The production of wood from forests sometimes results from insufficient protection of the natural world. But we will not be talking about oil extraction in this class.

Similarly, ecological economics studies ecological systems rather than resources or pollution. Some ecologists who work on environmental policy adopt different ways of valuing environmental goods. Economics, however, value goods by observing actual decisions. For example, if you are willing to travel across the country to go whale watching in the Pacific, that indicates to economists that whales are valuable. Ecologists sometimes adopt valuations which are irrelevant, unless they can convince voters to adopt their preferences.

D   Going Green

Many firms and households focus on reducing electricity/fuel consumption to reduce energy costs. This benefits the environment, but is not the focus of this course. If American

Airlines can reduce fuel consumption by only filling their fuel tanks half way, then by all means go ahead. A course in economics is not required to solve that problem. If however, reducing airplane exhaust emissions is costly to American but benefits society, then we have more interesting questions. Is it worth the enevitable higher ticket prices to reduce airplane emissions? How should we design airline exhaust regulations?

IV   Stylized Facts

A   United States

1   US Pollution

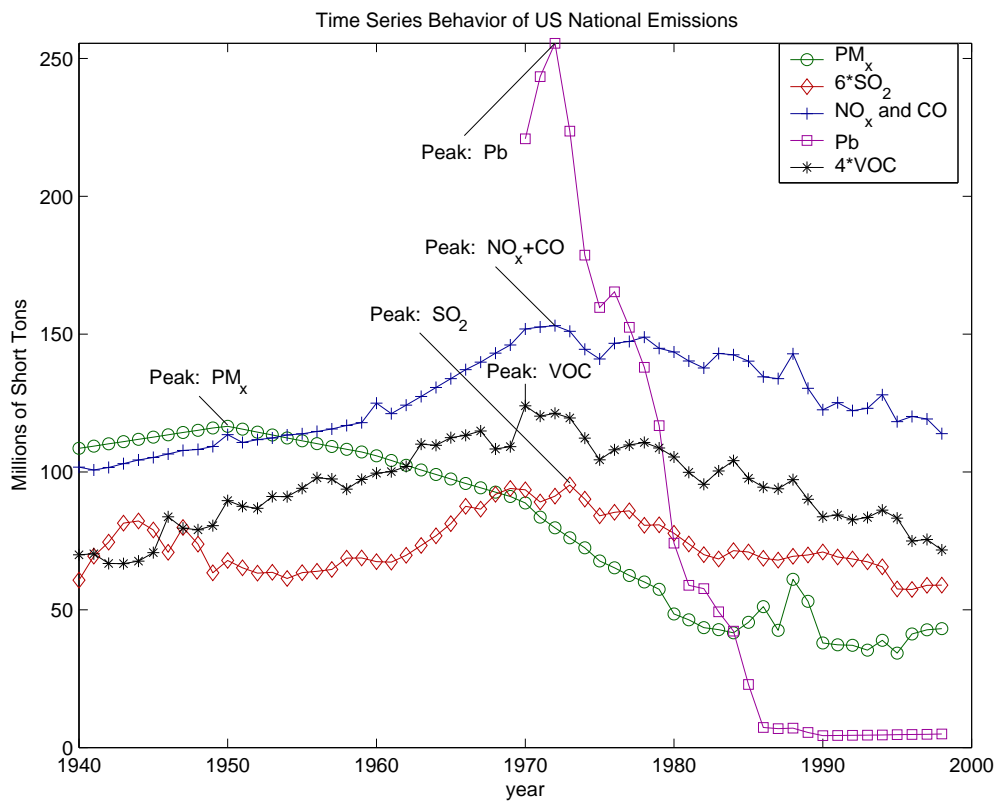Figure 1 is a graph of some major air pollutants in the United States since 1940.

Figure 1: Air pollution measures in the United States since 1940: particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO), lead (Pb), and volatile organic compounds (VOC). From Bartz and Kelly (2008).

- Particulate matter are the large (less than 10 μg, denoted PM_{10}) and small (less than 2.5 μg, denoted $PM_{2.5}$) soot and smoke particles. These damaging particles are linked to heart and lung disease. A principle source is diesel emissions.

- Sulfur dioxide (SO_2) causes acid rain and is linked to asthma and bronchitis. A primary source is the burning of coal for electricity.

- Carbon monoxide (CO) is a poisonous gas produced through fuel combustion.

- Nitrous oxide (NO) and nitrogen dioxide (NO_2), collectively (NO_x) are greenhouse gasses that also contribute to ground level ozone (smog) problems. Road traffic and many industrial processes contribute to NO_x emissions.

- Hydrocarbons and volatile organic compounds (VOCs) are emitted via fuel combustion and from evaporation of solvents. Some are carcinogens and others lead to smog.

- Airborne lead is a poison that results primarily from the combustion of leaded gasoline.

Looking at Figure 1 we can see a lot of success: all major air pollutants are in decline, with most peaking around 1970 and decreasing since the clean air act was passed. Particulates peaked around 1950 and continues to decline. The success is especially striking when considering that economic output has nearly tripled (256% increase) from 1970-2000. Our production methods are becoming so much cleaner that overall pollution is falling despite great increases in output. Figure 2 measures US emissions intensity, that is emissions divided by GNP, which is falling for all pollutants.
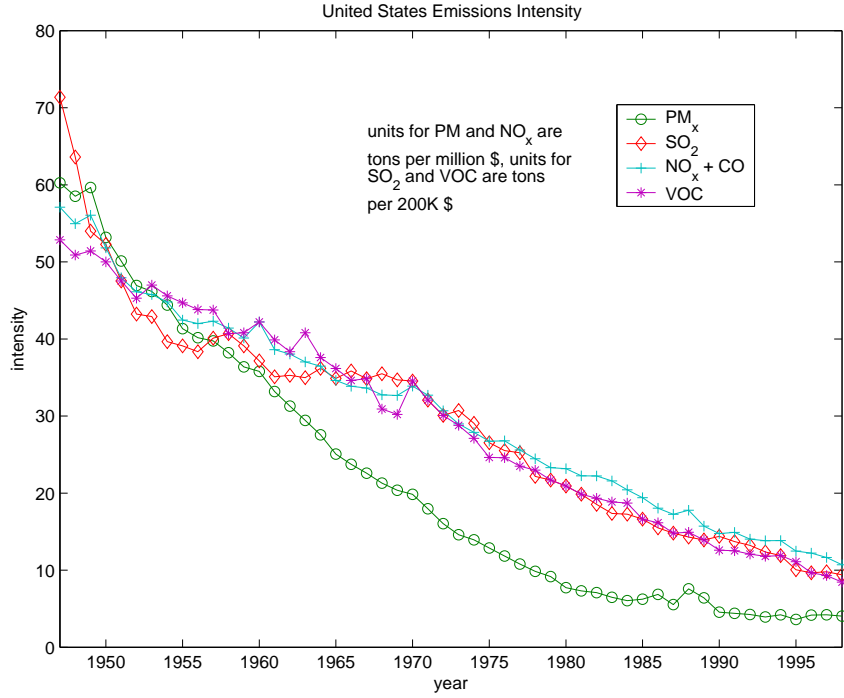
Figure 2: Air pollution emissions intensity (emissions per unit of GNP).

2   US Environmental Compliance Spending

Figure 3 shows total US spending on compliance with air pollution regulations (also called pollution abatement expenditures). Estimating such costs are fraught with uncertainty, nonetheless, it is clear that compliance costs are modest in a $13 trillion dollar economy.
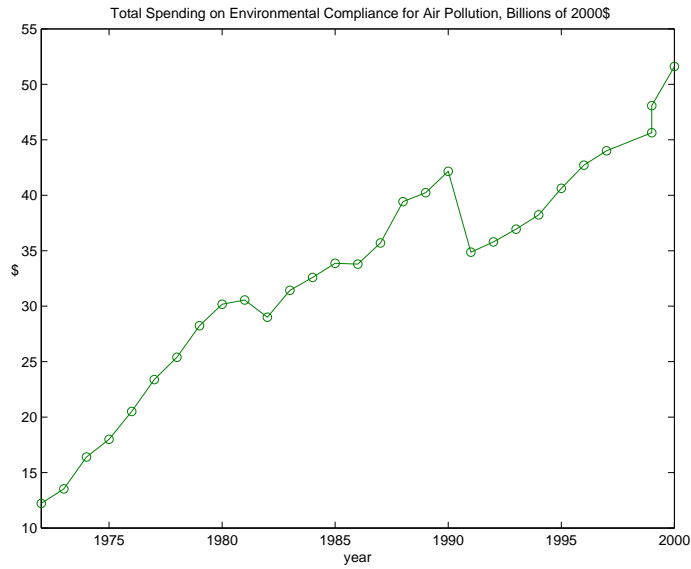
Figure 3: Air pollution compliance costs, calculated using EPA data.

Figure 4 gives total costs as a share of GNP. The US spends about one half of one percent of income on compliance with air pollution regulations. The total compliance share for all types of pollution regulation is under 2% of GNP.
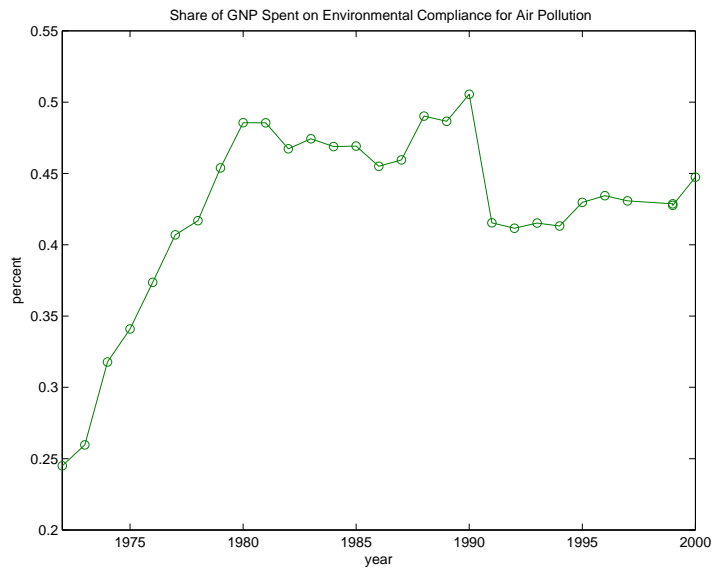

Figure 4: Air pollution compliance costs, calculated using EPA data.

The graphs indicate some surprising facts. We have reduced our air pollution emissions

substantially for only a few billion dollars per year. An interesting question is why we waited until 1970 to start major emissions reduction, given that reducing emissions is relatively cheap. The data seems to indicate that we don't care much about low air pollution, and are therefore unwilling to spend much on it. Other ideas are possible, though. It could be that further reductions are more expensive, or that we care a lot about reducing air pollution to current levels, but don't care much about reducing it further. Compliance costs could fall on a relatively small set of industries, leading to more opposition. Nonetheless, the stylized facts remain that in the US pollution is falling and compliance costs are relatively small.

B   Other Countries

1   Pollution

As might be expected, the data is more mixed across countries. Figure 5 shows that China has experienced small declines in soot (PM) and chemical oxygen demand (COD), a measure of water pollution. But untreated waste water and SO_2 continue to rise. Keep in mind however, that the increases are far less than the increases in GDP over the same period.
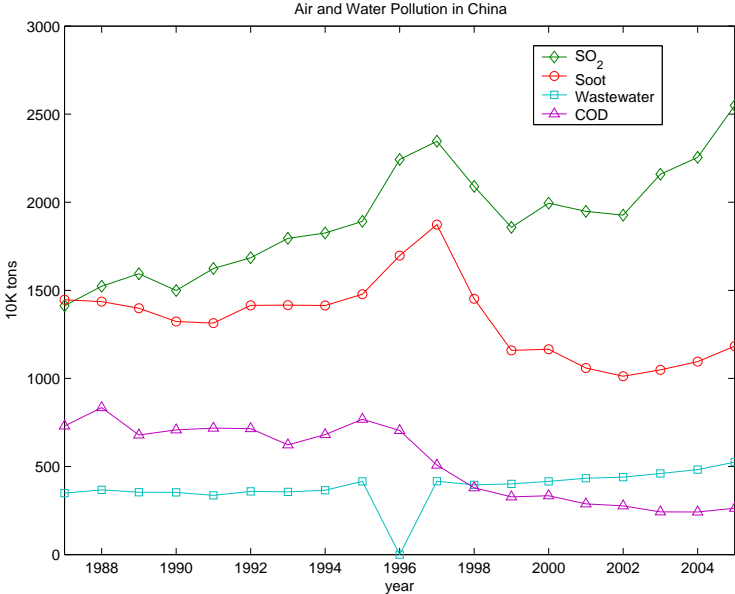

Figure 5: Air and water pollution in China.

Figure 6 shows that China is producing less and less pollution per unit of GDP.
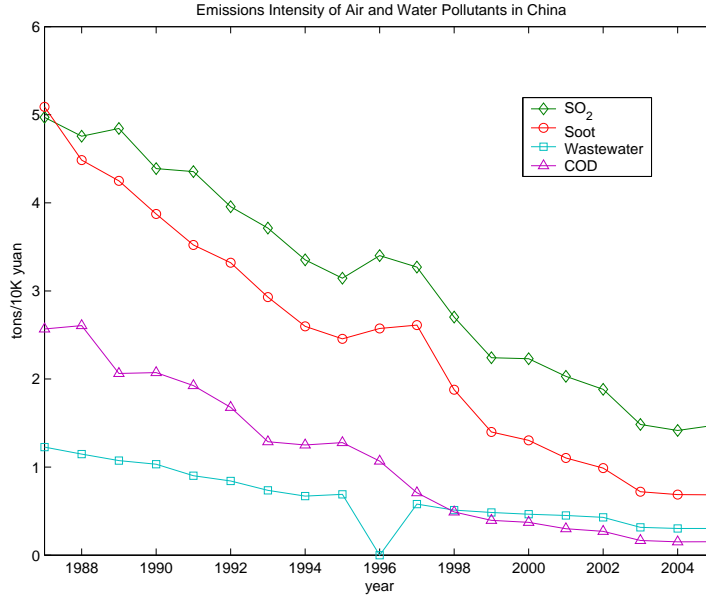
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Figure 6: Air water pollution emissions intensity (tons per 10K yuan of output) in China.

Table 1 compares some countries across the development spectrum.

	1980	1990	1995
China			
GDP per capita (US$)	907	1783	3072
SO_2 concentration (Beijing)	66	107	90
PM concentration (Beijing)	475	413	377
CO_2 emissions per capita (tonnes)	0.4	0.6	0.7
Iran			
GDP per capita (US$)	5377	4843	5351
SO_2 concentration (Tehran)	130	165	209
PM concentration (Tehran)	226	261	248
CO_2 emissions per capita (tonnes)	0.8	0.9	1.1
Japan			
GDP per capita (US$)	15538	20794	22173
SO_2 concentration (Tokyo)	42	19	18
PM concentration (Tokyo)	61	NA	49
CO_2 emissions per capita (tonnes)	2.1	2.4	2.5

Table 1: Air pollution indicators for selected cities and countries.

We can see that China is the least developed country, and Japan has the highest GDP per capita. Among these three countries, SO_2 pollution rises and then falls with income.

Definition 1 *THE ENVIRONMENTAL KUZNETS CURVE (EKC) hypothesis states that pollution first rises and then falls with income.*

The EKC hypothesis is controversial. It certainly does not hold for many pollutants, and it is not clear it even holds for SO_2 when more countries are added. Indeed, one could just as easily hypothesize that China's large high sulfur coal reserves explain China's high SO_2 concentrations, whereas Japan's reliance on nuclear power explains Japan's low sulfur concentrations.

Particulates decline with income across countries and across time, as they have in the US. Carbon dioxide emissions increase with GDP over time and across countries. Carbon dioxide is unique in that each country contributes very little to global CO_2 concentrations in any given year. Since climate change is based on CO_2 concentrations, each country suffers very little damage as a direct result of their own emissions. Thus, each country has an incentive not to undertake costly emissions reductions.

2 Compliance spending

Table 2 shows that abatement spending in other developed countries is similar to the US.

Year	US	France	West Germany	Netherlands	United Kingdom
1981	1.5	0.9	1.5	-	1.6
1982	1.5	0.9	1.5	1.2	-
1983	1.5	0.9	1.4	-	-
1984	1.4	0.8	1.4	-	-
1985	1.4	0.9	1.5	1.3	1.3
1986	1.4	0.8	1.5	1.5	1.3
1987	1.4	1.0	1.6	1.5	-
1988	1.3	1.0	1.6	-	-
1989	1.4	1.0	1.6	1.5	-
1990	1.4	1.0	1.6	-	1.5

Table 2: Pollution abatement expenditures as a percentage of GDP.

V Environmental Regulation

A Command and Control Regulation

Definition 2 *COMMAND AND CONTROL REGULATION. The regulator specifies what steps the polluter must take to reduce pollution, and usually how much pollution must be*

reduced.

Command and control is by far the most common form of regulation. Command and control regulations typically specify a TECHNOLOGY STANDARD, where the regular specifies the environmental performance of a particular production technology. Command and control regulations may go even further and specify in great detail exactly how a good is to be produced.

Examples:

- CAFE standards: minimum average fuel economy for all cars sold by a given company in a year (currently 27.5 MPG for cars and 23.5 MPG for trucks).

- Low flush toilets: maximum water use per flush (1.5 gal/flush).

- Coral Gables lawn watering limits (Wednesday and Saturday on the odd side of the street, and only early in the morning).

- Surface coatings (e.g. furniture manufacture): limits on the types of furniture coatings, requirements to use a certain type of vent to recapture vapors emitted during painting.

- Renewable energy standard: house climate change bill requires 20% of each utility company's power to come from renewable sources by 2020.

- Household appliance standards: the house climate change bill has standards for fluorescent lamps, base lamps, candelabra base lamps, dishwashers, portable spas, faucets, televisions, buildings, and many other products. The article discusses the energy standard for light bulbs which effectively bans incandescent bulbs.

B   Market based instruments

Definition 3 *A MARKET BASED REGULATION provides economic incentives to reduce pollution.*

Market based instruments come in 3 flavors:

1. Taxes. Charge a tax per unit of pollution emitted.

2. Tradeable permits (cap and trade). Limit pollution, but allow the right to pollute to be traded.

3. Liability. Allow pollution victims to pursue compensation from polluters through the legal system.

Examples:

1. Gasoline taxes (gas tax), gas guzzler car taxes, "by the bag" garbage disposal fees.

2. Cap and trade sulfur dioxide program, NO_x cap and trade in the Northeastern states, proposed cap and trade program in the Waxman-Martin climate change bill.

3. Various lawsuits associated with toxic chemical leaks.

The key difference between command and control and market instruments is that market based instruments do not proscribe any particular method of reducing pollution. Consider the gas tax versus CAFE standards. Note that we are implicitly assuming that the goal of saving fuel is really about reducing car pollution. Many possible responses exist to the gas tax. Some may drive less, others may buy more fuel efficient cars, some may give their car a tune up, and some will of course pay the tax because the alternatives are too costly. CAFE standards cause firms to raise prices on gas guzzlers to induce consumers to buy cars which meet the standard, but they provide no incentives for tune-ups or reduced driving. Indeed, CAFE standards create incentives for households to buy less fuel efficient used cars. Thus we cannot even say for sure that fuel use declines with the CAFE standard.