Environmental Taxes

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Environmental policy instruments

- Tax on emissions
- Regulatory limit on emissions
- Cap and trade
  - Fixed limit on aggregate emissions
  - Individual firms have their individual limits but they can buy and sell emission permits from one another for a market price

  It combines features of both other approaches. It is a limit on aggregate emissions but, for any individual firm, it functions more like a tax (there is an opportunity cost of emitting).

Topics

- Environmental taxes
  - What they are
  - Why they can be a good idea
  - Who uses them
  - What the experience in Europe has been
- Greenhouse gas (GHG) reduction
  - AB32 and other actions in California
  - Past experience with emission
  - Why GHGs are different than other pollutants
  - A mixed approach is needed for GHGs

Environmental taxes

Externality

The concept of an externality was introduced by the English economist Arthur Pigou in 1918 in *The Economics of Welfare*

An externality arises when, by his actions, an individual or entity imposes a cost or benefit on *other* individuals or entities.

To explain this, Pigou introduced the notion of a distinction between the *private* cost (or benefit) of an activity and its *social* cost (or benefit).

The private cost is defined as the cost incurred by the individual or entity that undertakes the activity; similarly, the private benefit is the benefit that accrues to the individual or entity that undertakes the activity.

The social cost includes both the private cost and also the sum of *all other* costs borne by other individuals and entities. Similarly, the social benefit includes all the benefits accruing to other parties.

An example Pigou gave was a railroad. The private cost is the cost of the railroad equipment, the wages for the train engineer, the cost of the coal used to fuel the locomotive, etc. The social cost includes damage to owners of land adjacent to railroad tracks from fires on their land caused by burning embers of coal from the locomotive, or the health costs of the air pollution from the smoke.

An externality arises whenever there is a divergence between the private and social cost of an activity, or the private and social benefit.

Pigou referred to the difference between the private cost and the social cost of an activity as a *negative externality*, and the difference between the private benefit and the social benefit as a *positive externality*.

Pigou argued that, if significant externalities exist, this is likely to require some government intervention into the functioning of the economy.

REMEDIES FOR AN EXTERNALITY

What form should the government intervention take?

Pigou identified two potential remedies:

1) The government could regulate those private actions that could cause a negative externality, or it could itself provide services that cause a positive externality.

2) The government could impose a tax on activities that cause negative externalities, in an amount equal to the difference between their private and social cost. For activities that cause positive externalities, the government could offer a subsidy in an amount equal to the difference between the private and social benefit. In this way, the externality would be *internalized*. Private decisions by agents in a competitive market would now lead to a socially optimal outcome.

Environmental policy

- Starts ~1970 in US with regulation of emissions. Generally starts later (1980s) in Europe; initial efforts there often follow US regulatory pattern.
- 1990 Clean Air Act Amendment in US introduces emission trading for SO2 and, later, NOx.
- Starting ~1990, European countries introduce environmental taxes – not only Scandinavia and Germany, where green parties are strong, but also many Southern and Eastern European countries.

Table 1 **Share of Environmental Taxes in Total Tax Revenue, 2003**

Country	Share (percent)
Canada	3.99
Denmark	10.27
France	4.91
Germany	7.44
Japan	6.58
Netherlands	8.93
Norway	6.86
Sweden	5.84
United Kingdom	7.57
United States	3.46

Figure 1. Environmental revenues as percent of GDP in Europe and some other OECD countries

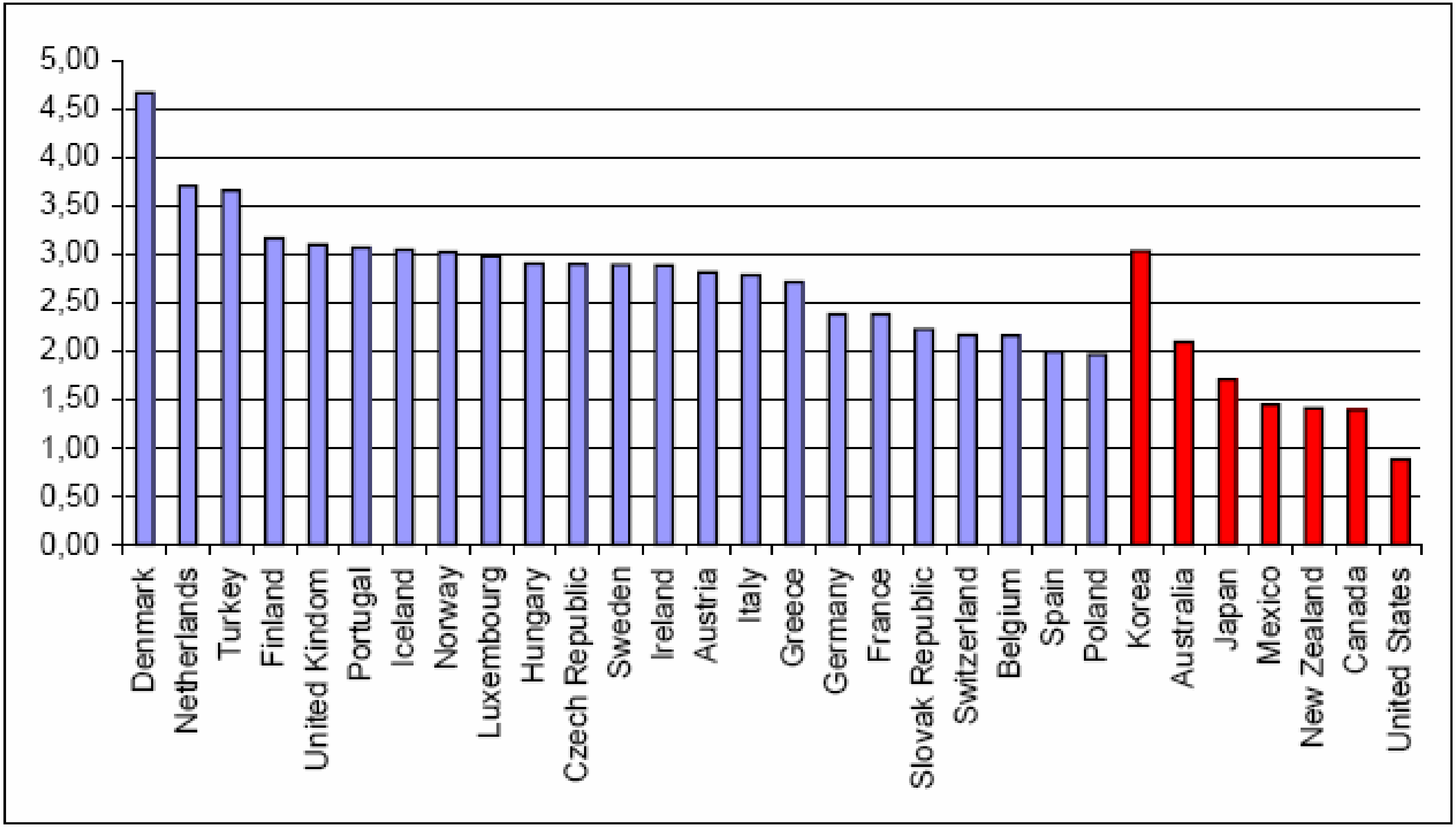


Table 3 Gasoline taxes in cents/liter in selected countries

Western European	Gas Tax
Italy	86
UK	86
Netherlands	85
France	76
Belgium	75
Finland	74
Germany	71
Norway	67
Portugal	67
Sweden	66
Denmark	64
Spain	63
Greece	59
Austria	58
Ireland	56
Luxembourg	46
Switzerland	45
Average	**67**

Eastern European	Gas tax
Hungary	131
Czech republic	120
Poland	97
Average	**116**
Non European	
Japan	38
Australia	34
New Zealand	32
Canada	25
Mexico	11
USA	10
Average	**25**

Source: IEA, 2000

Table 3. Receipts from environmental taxes in Sweden, in millions of 2003 kroner.

	1993	1995	1997	1999	2001	2003
	Environmental Taxes					
CO2 tax	12046	12481	13484	13658	17725	23814
Sulfur tax	210	171	155	129	87	122
Pesticide/herbicide tax	15	35	56	43	61	67
Fertilizer tax	211	326	401	368	384	340
Refuse tax					936	906
Mining tax			141	151	128	193
Sum (A)	**12 482**	**13 014**	**14 237**	**14 348**	**19 322**	**25 442**
	Environment Related Taxes					
Fuel tax	23431	25649	28260	28686	24930	20831
Electric energy tax	6519	6727	9495	11515	13080	15651
Waterpower tax	1175	1018				
Nuclear tax	114	145	1587	1662	1939	1829
Ultimate waste disposal tax	1272	1495	867	1017	760	459
Sum (B)	**32 510**	**35 034**	**40 208**	**42 879**	**40 709**	**38 770**
	Weakly Related Environmental Taxes					
Vehicle tax	4675	4418	6728	6881	7303	7687
Sales tax on vehicles	1469	1908	225	281	-23	
Mileage tax	3125					
Sum (C)	**9 269**	**6 326**	**6 954**	**7 162**	**7 280**	**7 687**
Environmental Tax (%)[1]	*23*	*24*	*23*	*22*	*29*	*35*
A+B+C ,	**54 261**	**54 373**	**61 399**	**64 389**	**67 311**	**71 899**
Percent of Total Tax		*6,1*	*6,1*	*5,5*	*5,5*	*5,5*
Percent of GNP	*3,1*	*2,8*	*3,0*	*2,9*	*2,9*	*2,9*

[1] (A) / (A+B+C)

Types of environmental tax

- Gasoline tax
- Carbon tax
  - Sweden, Norway, Denmark, Finland, Italy, the Netherlands
- Sulfur tax
  - Sweden, Norway, Denmark, Poland, Italy, France, Switzerland, Spain, Finland, Bulgaria, Czech, Hungary, Estonia, Lithuania, Slovakia
- Nitrogen tax
  - Sweden, Bulgaria, Czech, Estonia, France, Hungary, Italy, Lithuania, Poland

Other (local) taxes

- Water pollution discharge charge
  – France, Germany, Netherlands
- Waste/Landfill charge
  – Denmark, Netherlands, Finland, Estonia, Latvia, Poland
- Garbage disposal/recycling charge
- Congestion pricing
  – Singapore, Stockholm, London, Bergen, Valletta, Milan, German & Austria (trucks)
- Taxes on chlorinated solvents (Denmark, Norway), batteries (Sweden), non-refillable containers (Sweden, Finland), ozone-depleting substances (Denmark), VOCs (Switzerland, France).

Recycling green tax revenues

Country	Taxes cut or items funded	Taxes raised on	Magnitude
Sweden (1990)	• PIT • Energy taxes on agriculture [2] • Continuous education	• CO_2 • SO_2 • Various	2.4% of total tax revenue
Denmark (1994)	• PIT • SSC	• Various (gasoline, electricity, water, waste, cars) • CO_2 • SO_2 • Capital gains	Around 3% of GDP by 2002, or over 6% of total tax revenue
Netherlands (1996)	• CPT • PIT • SSC	• CO_2	0.3% of GDP in 1996, or around 0.5% of total tax revenue
United Kingdom (1996)	• SSC	• Landfill	Around 0.1% of total tax revenues in 1999
Finland (1997)	• PIT • SSC	• CO_2 • Landfill • Corporate profits	0.3% of GDP as of March 1999, or around 0.5% of total tax revenue
Norway (1999)	• PIT	• CO_2 • SO_2 • Diesel oil	0.2% of total tax revenue in 1999
Germany (1999)	• SSC • Renewable energy	• Petroleum products	Around 1% of total tax revenue in 1999
Italy (1999)	• SSC	• Petroleum products	Less than 0.1% of total tax revenue in 1999

Environmental tax dividends

- Leads to a reduction in pollution emissions
- Raises revenues that could be used to lower other taxes that cause distortions in the economy (revenue recycling effect)
- But, also interacts with existing taxes that create distortions in the economy and may exacerbate the effects of those distortions – substituting a narrow-base tax for a broad-base one.

- The magnitude of a harmful tax-interaction effect is questionable.
  - Alleged pathway – pollution tax makes commodities more expensive, reduces real wage and encourages a reduction in labor supply, which generates an increased distortion – is questionable empirically.
  - Analysis assumes that emissions can only be reduced by reducing production of offending good – not by changing production technology.
  - Analysis assumes that pollution itself has no adverse impact on consumption or production of commodities. If this is false, the adverse tax-interaction effect can be reversed.

Climate change policy

California's 2006 GHG laws

- AB 32, places a cap on all GHG emissions in California; requires that, by 2020, these be reduced to their 1990 level, a reduction of ~29%.
- SB 1368 Prohibits any load-serving entity from entering into long-term financial commitment for baseload generation unless GHG emissions are less than from new, combined-cycle natural gas. Applies to out-of-state generators, also to municipals.

Electricity Initiatives in California

- Emission Performance Standard for New Procurement
  - New long-term procurements in base load facilities not allowed unless the facility emits less than 1100 pounds CO_2 per MWh
  - Coverage includes new or renewed contracts longer than 5 years
- Renewable portfolio standard for electricity (33% by 2020)
- One million solar roofs in California by 2018
- Carbon adder by PUC
- Cap and trade for GHG emissions from electricity generation (PUC)

Transportation Sector Policies

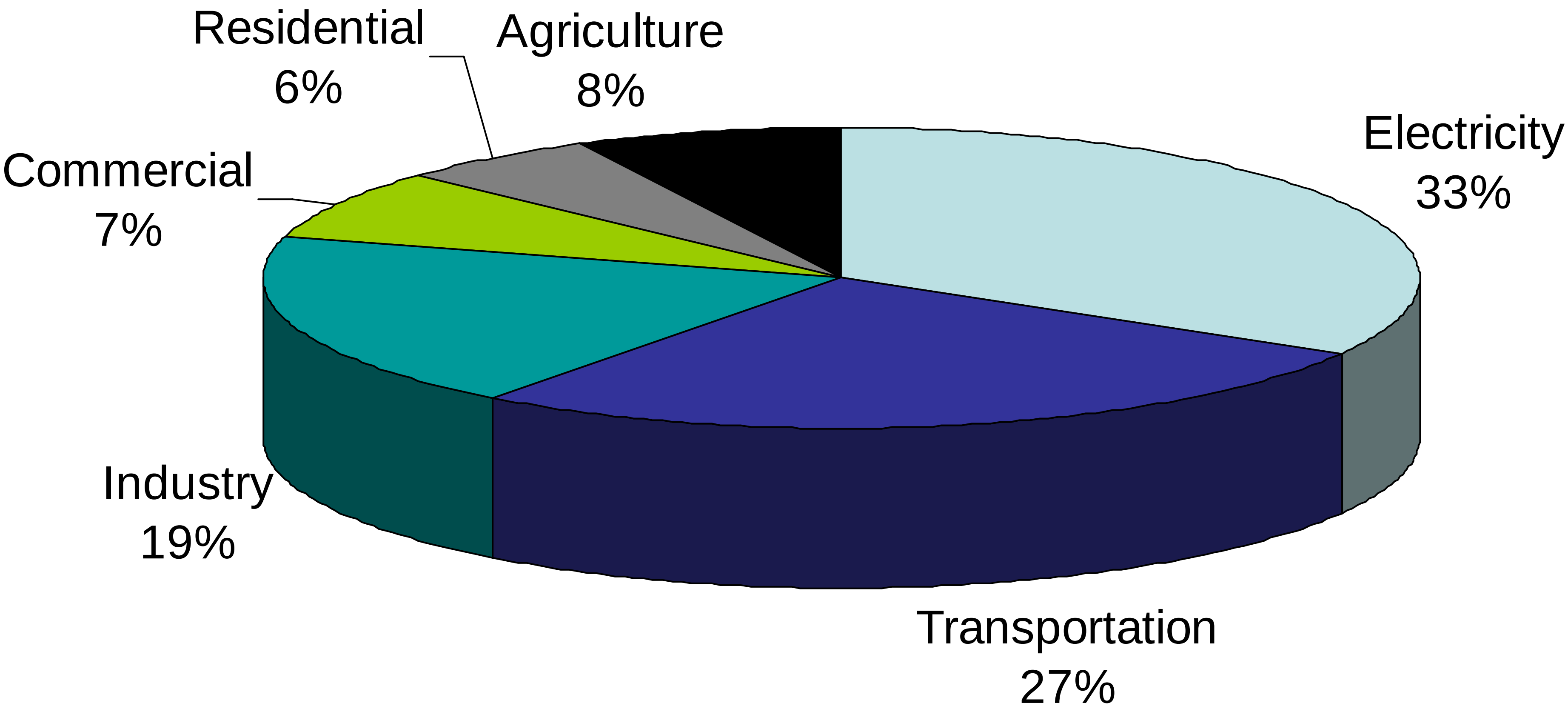
- Vehicle GHG emission standard (AB 1493)
  - Reduces emissions of vehicles by ~30% by 2016, and total fleet emissions cut ~20% by 2020.
  - Possible automaker responses: engine valve technologies, transmissions, diesel, hybrids, etc.
  - Alternative compliance mechanism: alternative fuels, purchase emission reductions in carbon market.
- Low Carbon Fuel Standard (LCFS)
  - At least 10% emissions reduction by 2020
  - Implemented through a market-based system
- Smart growth, mass transit, land use planning??

Other program areas

- Energy efficiency in residential and commercial buildings
  - Green buildings
  - Improved lighting
  - Improved heating/cooling
  - Combined heat and power

- Taken together, these are the most ambitious and comprehensive effort to control GHG emissions in force in the US.
- They apply:
  - To all GHGs, not just CO2 (CO2 from fossil fuel combustion is 81% of all GHGs in CA)
  - To all sources, not just electric power plants (= 22% of all GHG emissions in CA).
- The only other binding cap on emissions is Regional GHG Initiative in 9 northeastern states (RGGI).
  - RGGI applies only to GHG from electricity; target is to reduce emissions 10% below 2005 level by 2019.

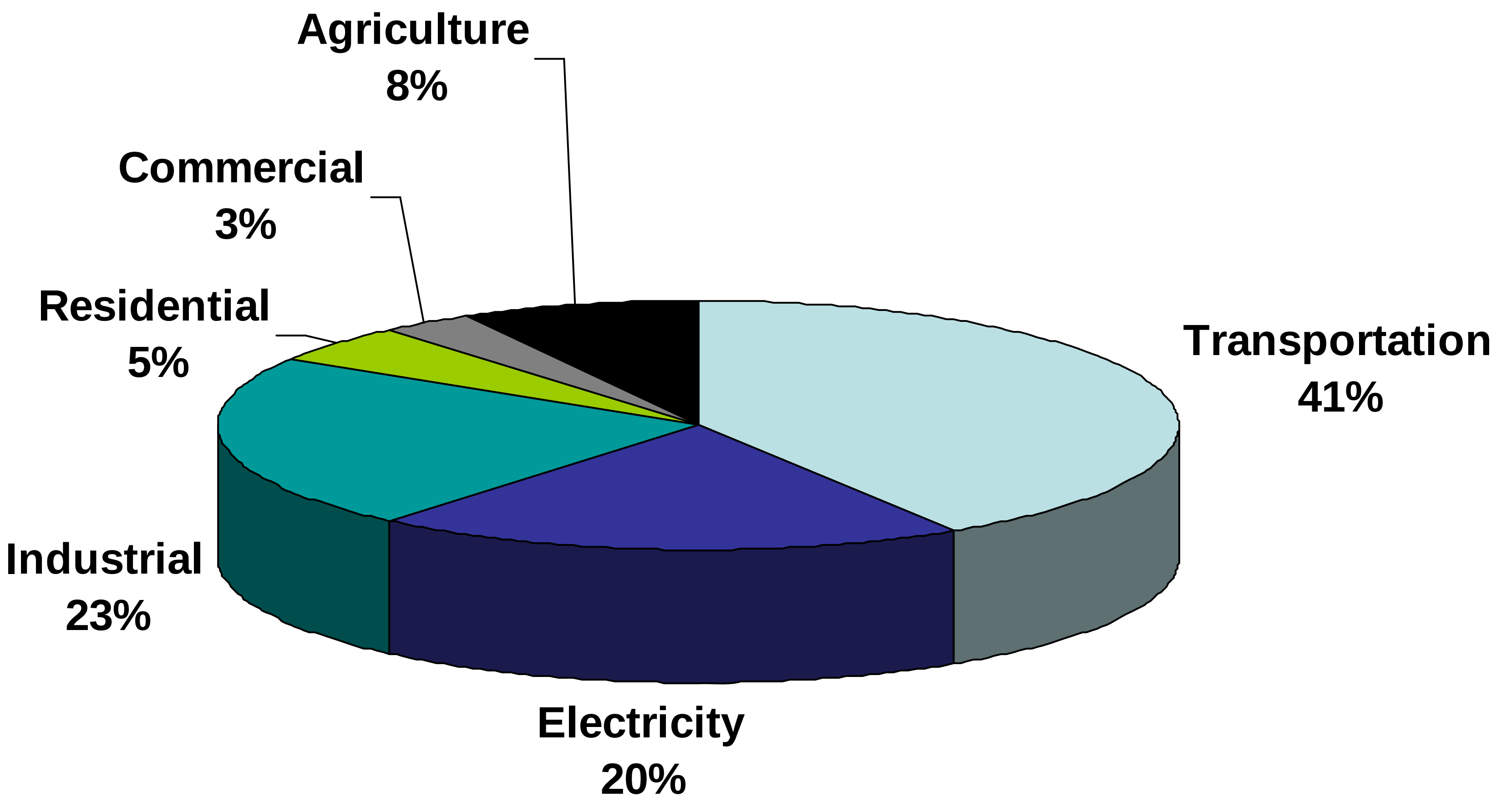
US Greenhouse Gas Emissions



Source: EPA. 2002 Emissions, including CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6.

California GHG Sources

2002 Emissions



Source: CEC. Gross emissions only.

Emission trading

- The idea was first proposed by economists in the late 1960s.
- There is a cap on emissions – both a cap on overall emissions, and caps on the emissions of individual firms.
- But, firms can buy and sell emission permits.
- With a fixed set of firms and a given technology, allowing trading should achieve the overall cap at the lowest total cost.

1990 Clean Air Act (CAA) emission trading programs

- SO_2 trading program achieved ~50% reduction in emissions from electric power plants.
- NO_x trading program achieved ~50% reduction in emissions from electric power plants.
- In both cases the cost of emission reduction was significantly less than had been predicted
- Inspired design of Kyoto, EU-ETS, & RGGI

How emissions were reduced

- Existing power plants
  - Modify combustion by switching from high- to low-sulfur coal.
  - Install scrubber to remove emissions post-combustion
  - Change dispatch order to favor lower-emission plants
- New power plants
  - Fired by natural gas rather than coal

- Strategies used all relied on known, mature technologies.

- Strategies *not* used:
  - Conservation, demand management
  - Switch to renewables
  - New combustion technologies

- Technological innovation played essentially no role

But CO_2 is different than SO_2

- Input switching is not such a major option
  - There is no low-CO_2 coal
  - There is low-CO_2 from renewable power, but not from existing fossil fuel power plants0
  - At this point, there is no low-CO_2 gasoline (this will change with cellulosic ethanol)

- There is no post-combustion scrubber
  - Carbon capture and sequestration can’t be retrofitted to an existing power plant; it requires a new plant.

- With existing power plants, there is not much can be done to reduce emissions by modifying their operation. The key opportunity to reduce emissions is new plants and how they are designed:
  - Higher thermal efficiency through technologies such as supercritical combustion or IGCC
  - Designed so they can accommodate CCS

Otherwise, what is needed is:

- Conservation
- More efficient energy-using appliances
- Using renewables to generate electricity

- For GHGs, the key is:
  - Technological innovation
  - Downstream behavioral adjustment

  by

  - Suppliers of energy-using equipment
  - Users of energy

- Will the downstream price signal from an upstream cap be entirely adequate, by itself, to trigger the needed innovation and behavioral change? I think not.

Upstream vs Downstream

POTENTIAL ACTORS

- Existing suppliers of fossil-fuel based energy [UPSTREAM]
- New energy suppliers, using non-fossil fuel, who enter industry.

- Suppliers of energy-using equipment [DOWNSTREAM]
- End user of energy [DOWNSTREAM]

AB 1493 as a downstream cap

- It sets a cap on the emissions of new vehicles sold in California by an auto company.
- The company can come into compliance by securing other emission reductions in California

Past success with upstream

- An upstream approach was used in the past with great success to phase out automobile lead emissions by limiting the quantity of lead that refineries could use in gasoline. Similarly, emissions of ozone-depleting substances were phased out through limits on the their production rather than on their use.

- In both cases, however, the producer essentially *reformulated* the product in a manner that met the emissions cap without requiring the users of the product to (i) switch to a different type of product produced by a different manufacturer, or (ii) reduce their use of the product. There was *minimal* adjustment downstream.

- With lead in gasoline, the automobile manufacturers had to produce cars that could run on unleaded gasoline, but this was a relatively minor modification. The consumers did *not* have to adjust their behavior at all (e.g., buy cars with a higher fuel–efficiency, or drive less).

Theory of upstream approach

- The theory of an upstream approach is that it raises the price of fossil fuels which sends a price signal to all downstream actors, who respond accordingly and reduce their use of fossil fuels.
- But, this is *not* what actually happened in practice with lead, CFCs, SO2, or NOx. In these cases, the upstream energy supplier reformulated his product/production process, with essentially *no* adjustment by the downstream customers.

Will this work for GHGs?

- Will it be possible for the upstream supplier to reformulate his product or production process, requiring essentially no further adjustment by the downstream customers?
- I think not.
- If so, this calls into question the value of an upstream strategy.

The Potential Actors:

- Automobile producers
  - What type of cars are produced
  - How they are priced
- Automobile users
  - Which type of car is bought
  - How much it is operated (Vehicle miles traveled)

Compare the effects of AB 1493 vs an upstream cap that raises the price of gasoline by, say, 25 cents per gallon. I believe the former might have a significantly larger impact.

Will the price signal from an upstream cap be adequate?

- This is an empirical question. I don’t believe that economic theory can offer a useful answer.
- My hunch is that the answer is: NO

Emissions tax vs. cap

- The question of when an emissions tax or cap should be preferred is a classic question that was addressed by Weitzman (1974) for a flow pollutant.
- Pizer (2002) and Hoel and Karp (2002) extended the analysis to a stock pollutant (e.g., greenhouse gasses).
- I believe that Weitzman's approach provides the key to the answer, but I disagree with how it has been applied.

Price versus quantities

- In the face of uncertainty, the two instruments perform differently.
  - Price leads to uncertainty about amount of emission reduction. But, whatever emission does occur, will be achieved efficiently (at least total cost).
  - Quantity regulation generates certainty about reduction in emissions; but the amount of reduction may turn out ex post to have been non-optimal.
- Which instrument is preferred depends on which is the more serious error.

- Weitzman relates this to the relative slopes of the marginal abatement benefit and marginal abatement cost curves.
- He shows that an emissions cap is preferred if the slope of the marginal abatement benefit curve is steeper than the marginal abatement cost (e.g., there is a sharp threshold effect with damages). When the marginal cost of abatement is steeper, an emissions tax is preferred

Implication

- For many conventional externalities – including most water and air pollution, and congestion – the Weitzman criterion is likely to argue for an emission tax.
- For GHG's I believe it argues for an emissions limit (e.g., Kyoto), but this is at odds with the conclusion drawn by Pizer (2002) Newell and Pizer (2003) and Hoel and Karp (2002). They conclude that the Weitzman approach argues for a carbon tax.

What may be missing:

- 1) They conduct an annual analysis, and this may not be appropriate. The issue is *not* reducing emissions in one isolated year. If it were, clearly
  - Marginal benefit is low: a single year contributes relatively little to stock of CO_2 in atmosphere.
  - Marginal cost of reducing emissions 20%, say, in one year is high.
- What is lacking is analysis of a multi-year policy commitment. This may reverse the relative slopes of marginal benefit and marginal cost.

- 2) The original Weitzman analysis of prices vs quantities has certain limits. By using quadratic functions for costs of abatement and damages from pollution, it generates a certainty equivalent effect. The result is that uncertainty regarding the damages from pollution, and risk aversion, have no impact on the choice between prices vs quantities.
- If one changes the structure of the damage function and/or adds risk aversion, this appears to strengthen the case for quantity controls.

Summary

- I don't believe that prices vs quantity conclusively justifies a preference for the tax approach in the specific context of California GHG policy.
- While price volatility is certainly an issue, there may be mechanisms within C&T that can soften it
  - Multi-year permits
  - Borrowing and banking
  - A "Federal Reserve" Board

My conclusion

- Environmental taxes are likely to be a good idea for California as a general principle.
- But, a carbon tax may *not* be a good means with which to implement AB 32. What's needed is a combination of:
  - Efficiency standards and other regulations
  - Emission trading with some downstream caps