Lecture 23: The Environment & International Economics

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Environmental Economics
Econ 4075

We have reviewed several national policies – prescriptive, market-based, and more – that support the environment and economic activity.

While you've hopefully gotten a rich flavor of American environmental policy, it's apparent our discussion has been abstracting from *something*.

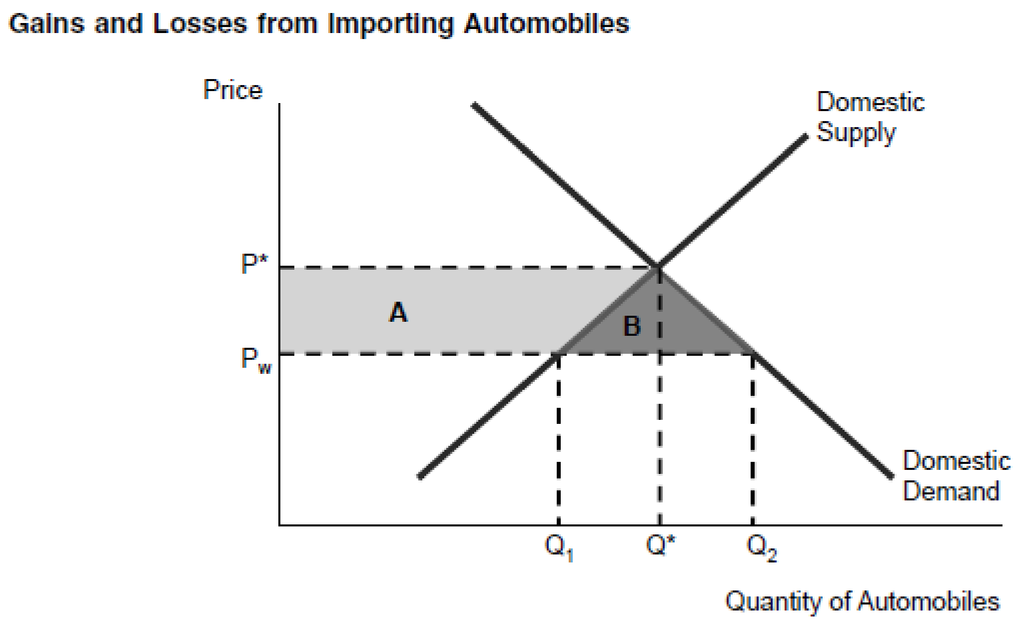
National environmental policy decisions trickle through the world economy; thinking through ripple effects is a complex general equilibrium exercise.

Today we'll consider environmental policy from a more global perspective.

Roadmap

- **The effect of trade on the environment**
- The effect of environmental policy on trade (and the environment)
- Trade policy as environmental policy?
- Leakage and border pollution taxes
- International Environmental Agreements

Trade's impact on domestic environmental quality: A stylized example



In the standard model, assume opening the domestic economy to trade results in automobile imports at a global price of P_w.

In the absence of environmental considerations, trade is unambiguously welfare improving.

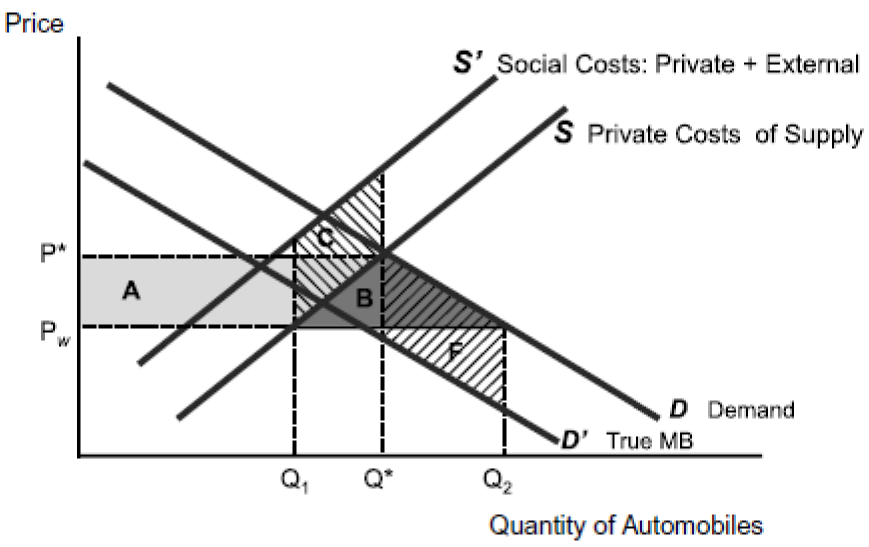
Consumer welfare improves by area **A + B**

Producer welfare decreases by area **A**.

Unambiguous net social welfare improvement of area B.

Trade's impact on domestic environmental quality: A stylized example

Environmental Impacts of Importing Automobiles



Now let's include environmental considerations.

Domestic automobile *production* results in external pollution costs (See curve ***S'***).

- The *reduction* in domestic production from trade means the domestic economy reduces external production costs by area ***C***.

Domestic automobile *consumption* also results in external pollution costs (See curve ***D'***).

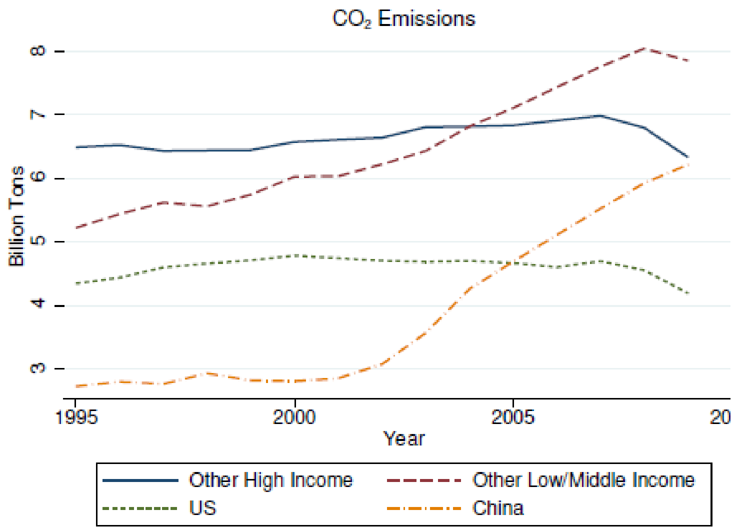
- The *increase* in domestic consumption from trade means the domestic economy increases external consumption costs by area ***F***.

Result: theoretically ambiguous whether automobile trade is welfare-improving (and environment-improving) for importing* economy.

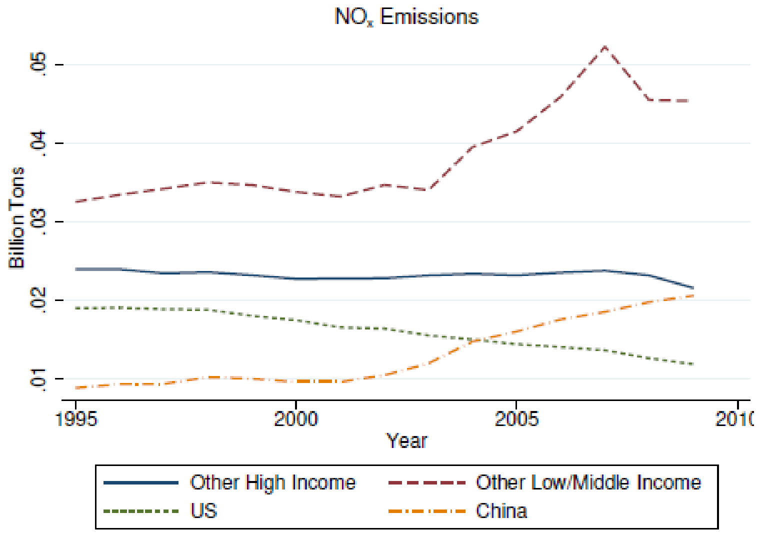
*Converse arguments also result in ambiguous impact for exporting economy.

Pollution emissions over time

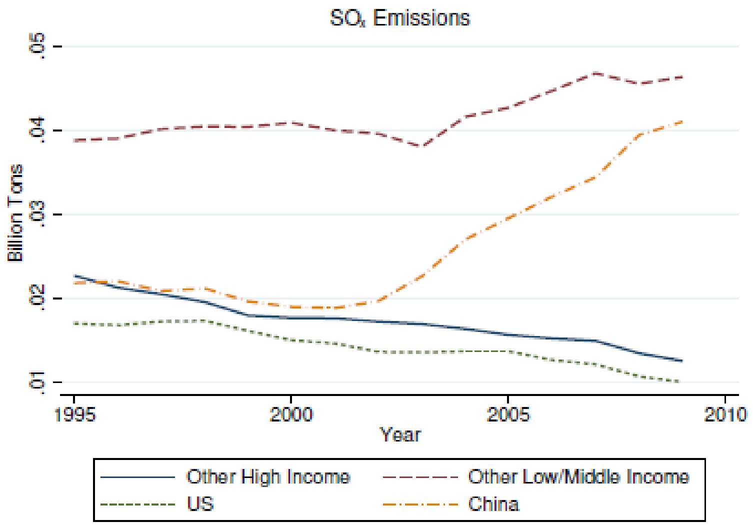
(a) Carbon Dioxide (CO_2) Emissions



(b) Nitrogen Oxides (NO_x) Emissions



(f) Sulfur oxides (SO_x)



From Copeland et al. (2022)

Decomposing the environmental impacts of trade liberalization

In seminal work, [Copeland and Taylor (1994)] build a formal model to study how opening an economy to trade impacts the environment.

In summary, they decompose the overall impact into three effects:

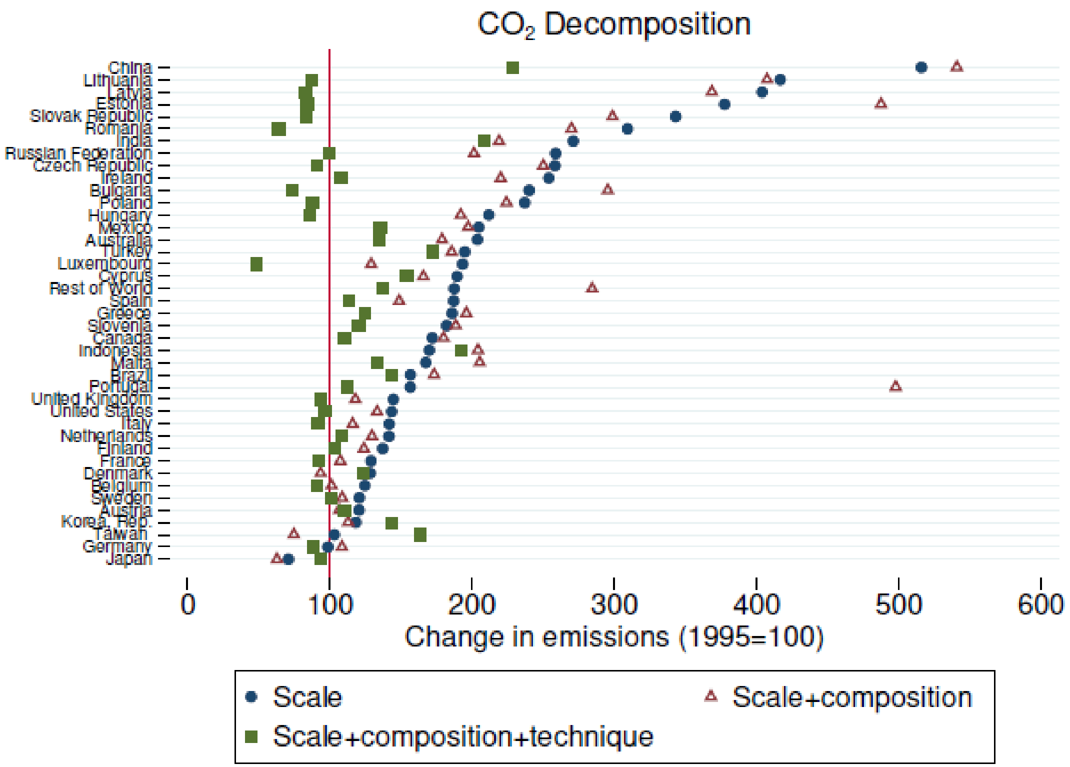
- *Scale effects*: opening an economy to trade promotes economic growth. Holding constant the mix of goods and production techniques, pollution is likely to increase as the economy grows in scale.

- *Production technique effects*: an economy can change the pollution emitted per unit of output. In a growing economy, consumers become wealthier and demand cleaner production methods.

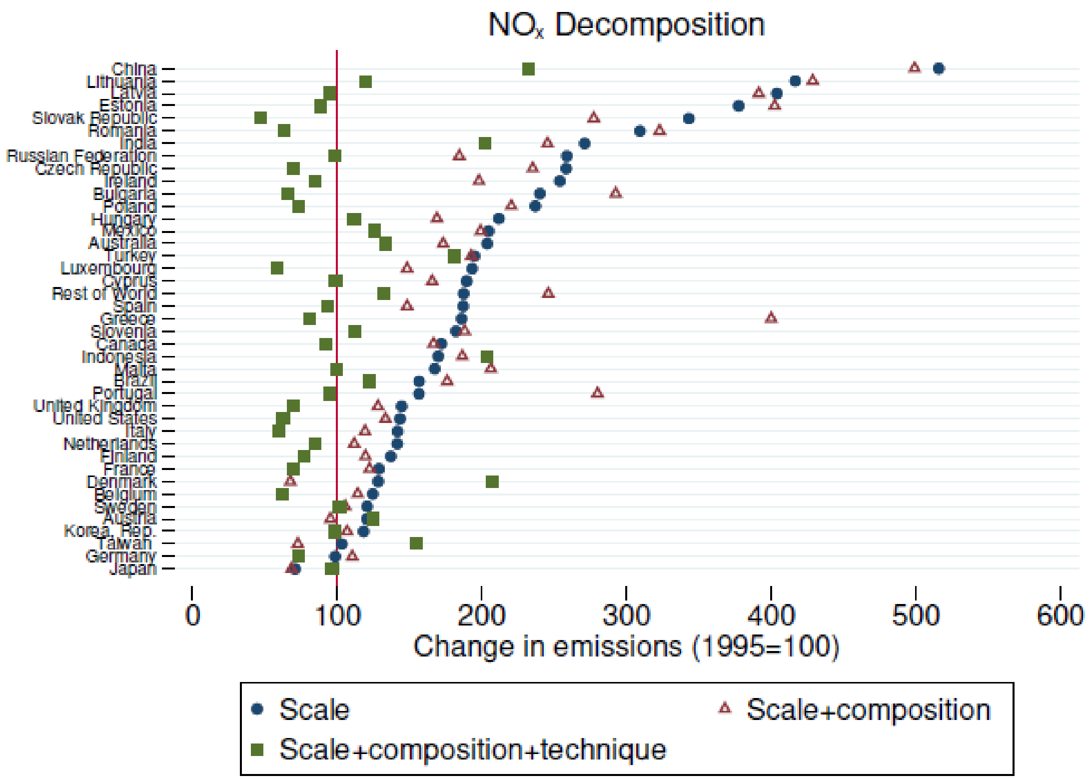
- *Composition effects*: as an economy evolves, so does the share of national output that comes from cleaner or dirtier industries.

How did emissions decompositions evolve from 1995-2009?

(a) Carbon Dioxide (CO_2) Decomposition



(b) Nitrogen Oxides (NO_x) Decomposition



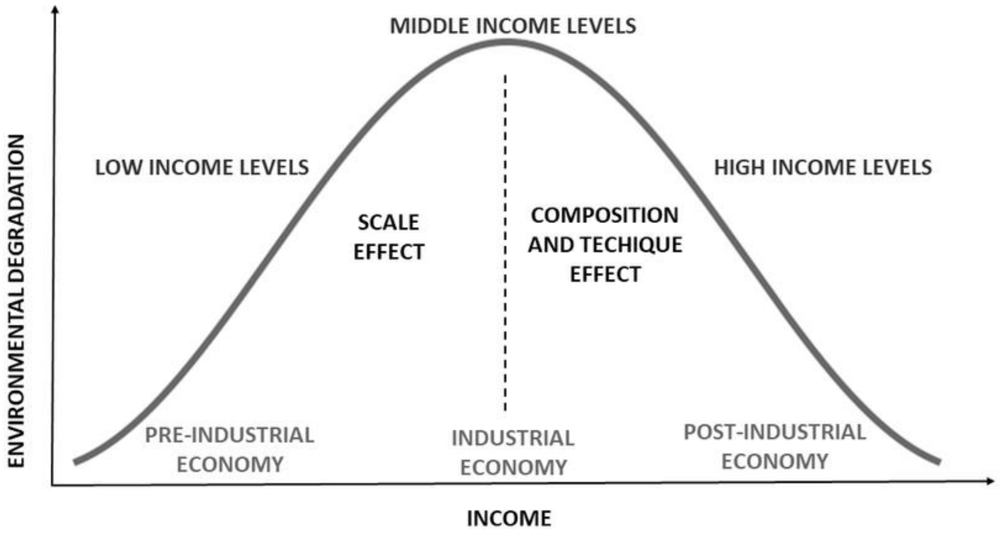
NOTES: scale represents 100 times national value added (GDP) in 2009, divided by national value added in 1995. Scale+composition modifies the scale value to keep emission rates (technique) the same for each country*sector in 2009 as it was in 1995. Emission rates are measured as tons directly emitted per dollar of value added. Scale+composition+technique represents 100 times emissions in 2009, divided by emissions in 1995. Vertical red line at "Change in emissions "=100 represents the value for no change in emissions between 1995 and 2009.

From Copeland et al. (2022)

Where does that leave us?

We can tell a reasonable story of trade being beneficial to the environment:

1. A country opens to trade.
2. This results in growth and likely increased pollution, but with growth comes higher consumer income.
3. Since environmental quality is a normal good, demand for environmental quality rises with income.
4. Through policy (or otherwise), production techniques are implemented and reduce pollution on both production and consumption sides of economy.
5. Maybe economy's composition becomes *cleaner*.
6. Empirics suggest whether environmental quality rises or falls is a function of the technique effect's size.



Environmental Kuznets Curve

Lingering question(s): are trade's effects on the environment different than the effects from growth? Can we expect the growth path of a country to be cleaner if it is more open to trade?

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Q1: How do environmental policy and trade interact to affect production-generated pollution?

Pollution haven hypothesis

Trade theory suggests that if a country has a comparative advantage in pollution-intensive industries, then liberalizing that country's trade policy will result in a *composition effect* where production shifts to more polluting industries.

Conversely, a trade-induced composition effect in countries with low-pollution production would shift further to clean industries.

The pollution haven hypothesis suggests **environmental regulation is a crucial driver of this comparative advantage**: that countries with relatively weak environmental regulation will attract "dirty" industrial production.

Intuition is straightforward: more stringent environmental policy increases a country's cost of production. This results in reduced exports and discourages foreign direct investment.

Pollution haven hypothesis

Overall, recent body of evidence is supportive of a limited pollution haven *effect.*

One very compelling representative result is from Tanaka et al. (2022).

They provide evidence that when the US tightened the NAAQS for lead in 2009, the recycling of used lead-acid batteries relocated to Mexico.

They also show that the corresponding increases in ambient lead pollution near Mexican battery-recycling plants resulted in 4.8% increase in the incidence of low birthweight hospital births.

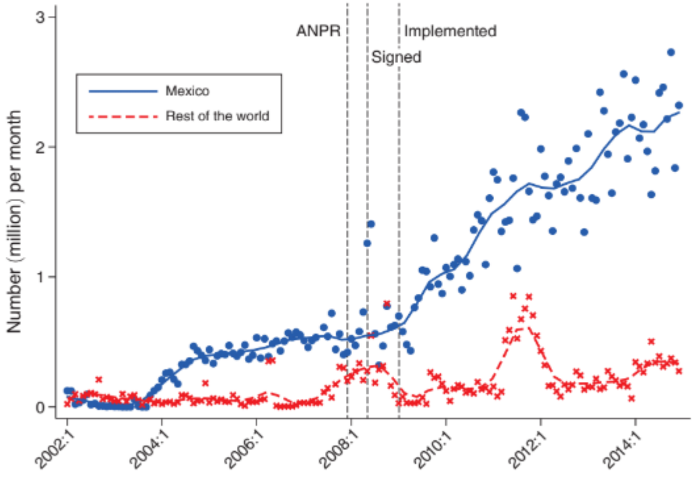


Figure 2. US Monthly Exports of Used Lead-Acid Batteries

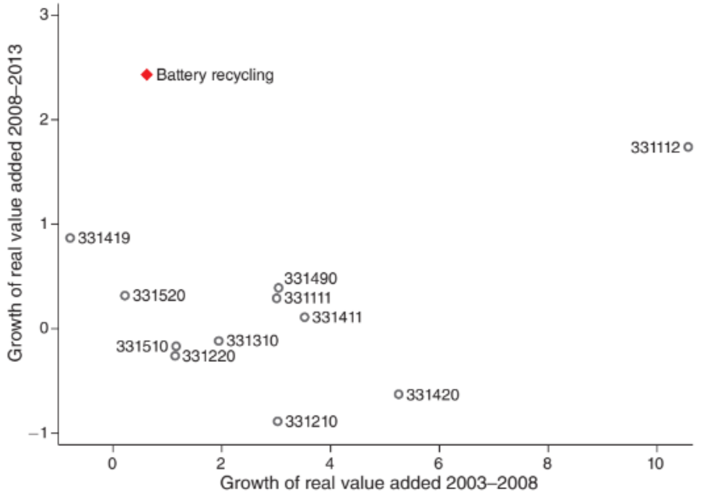


Figure 3. Value Added in Battery Recycling versus Similar Industries in Mexico

Pollution haven hypothesis

Less evidence supporting a strong version of the pollution haven *hypothesis:* that differences in environmental policy are pivotal in determining comparative advantage.

There are many factors that are more likely to determine trade flows and comparative advantage: technology, factor abundance, distance, agglomeration, etc.

While on the margin, environmental policy may contribute to a comparative disadvantage in pollution-intensive industries, a wide body of evidence shows these other factors to be first-order concerns, while environmental policy might be second- or third-order.

Under some conditions, a causal shift of *some* pollution-intensive industries to other countries with weaker regulation may occur, but it does not seem to be systematic.

Pollution offshoring hypothesis

Modern supply chains are incredibly fragmented. It takes many intermediate production steps to reach a final good.

And *direct emissions* from production in a given industry are often only a small fraction of *total emissions* produced along the supply chain up to that point.

Sample Emissions Intensities

		1,000 kg per 2013 $US of production				
		PM_{10}		*CO_2*		*Percent of US manufacturing output 2021*
NAICS	*Industry*	*Direct*	*Total*	*Direct*	*Total*	
334516	Analytical Laboratory Instrument Manufacturing	0.000006	0.08	3.4	198	0.41
334112	Computer Storage Device Manufacturing	0.000044	0.05	2.2	147	0.10
339910	Jewelry and Silverware Manufacturing	0.000078	0.37	6.2	340	0.14
336112	Light Truck and Utility Vehicle Manufacturing	0.000086	0.16	9.4	342	1.95
322230	Stationery	0.000210	0.21	13.3	507	0.06
333415	Air-Conditioning, Heating, and Refrigeration Equipment	0.000346	0.17	9.4	303	0.70
326160	Plastics Bottle Manufacturing	0.000637	0.29	13.1	682	0.22
335911	Storage Battery Manufacturing	0.001127	0.42	41.3	565	0.14
336414	Guided Missile and Space Vehicle Manufacturing	0.001631	0.04	2.1	97	0.28
311513	Cheese Manufacturing	0.003952	2.24	26.9	516	0.58
337127	Institutional Furniture Manufacturing	0.009099	0.20	18.4	369	0.09
311111	Dog and Cat Food Manufacturing	0.009550	2.22	42.1	493	0.43
325510	Paint and Coating Manufacturing	0.003914	0.39	98.0	592	0.53
331420	Copper Rolling, Drawing, Extruding, and Alloying	0.006126	0.73	36.0	505	0.39
322110	Pulp Mills	0.262743	0.68	328.9	827	0.13
327310	Cement Manufacturing	1.473377	1.82	7,199.0	8,077	0.20

Levinson (2023)

Pollution offshoring hypothesis

Is there evidence that firms outsource the "dirty" parts of their production process or supply chain to countries with weaker environmental regulation?

If so, what we observe as a large *industrial* "technique" effect in countries with stricter regulation might simply be the offshoring of *intermediate* emissions.

There does seem to be limited empirical work supporting this hypothesis.

- Michel (2013): Belgian firms substitute towards imported intermediates, which lowers domestic emission intensity.
- Cherniwchan (2017): NAFTA induced US firms to purchase dirty intermediates, which lowered US manufacturing intensity.
- Li and Zhou (2017): US plant-level emissions are lower when the plant's parent company imports more intermediates from low wage countries.
- Cole et al. (2017): Japanese firms outsourcing production internationally have lower carbon emission intensity than those that outsource domestically.

Q2: How do environmental policy and trade interact to affect <u>consumption</u>-generated pollution?

Consumption-generated pollution

Like in the production case, one can think of separate scale, composition, and technique effects resulting from trade.

Scale: as trade increases real income, consumption of goods (and ceteris paribus, pollution) will increase.

Composition: relative price changes, access to different mixes of products, and shifts in consumer preferences as they become wealthier have an ambiguous effect on pollution.

Technique: the effect on consumption-generated pollution is ambiguous. If environmental policy or corporate ESG initiatives become more common due to consumers' new wealth and tastes, likely to reduce pollution.

Consumption-generated pollution

Table 8—Change in Total Emissions

	Baseline assumptions	Alternative specifications		
		Mexican vehicle retirement rate doubles	Vehicle exits in the United States tripled	Mexican drivers substituting away from minibuses
	(1)	(2)	(3)	(4)
Panel A. Annual emissions				
Carbon dioxide (millions of tons)	5.6	5.6	3.4	2.9
Hydrocarbons (thousands of tons)	3.4	3.4	2.1	1.8
Carbon monoxide (thousands of tons)	41.3	41.3	25.1	21.4
Nitrogen oxide (thousands of tons)	7.9	7.9	4.8	4.1
Panel B. Lifetime emissions				
Carbon dioxide (millions of tons)	83.9	72.4	68.2	47.2
Hydrocarbons (thousands of tons)	50.9	44.0	41.4	28.7
Carbon monoxide (thousands of tons)	618.7	533.9	502.9	348.1
Nitrogen oxide (thousands of tons)	118.9	102.6	96.7	66.9

One empirical example of this is Davis and Kahn (2010).

They study how pollution evolved after NAFTA opened trade of used vehicles from the US to Mexico in 2005.

These used vehicles were less emission intensive than the US average, but more emission intensive than the Mexican average.

Opening of trade resulted in *decreased US emissions*. (*Due to US policy* – new cars have modern CAFE standards to meet).

Trade opening resulted in *increased* Mexican emissions: the scale effect of additional cars outweighed the composition effect.

Q3: How do environmental policy and trade interact to affect transport-generated pollution?

Transport-generated pollution

The opening of trade creates a demand for additional transportation of goods.

Physics 101: you can't move something without energy. (Newton, 1687)

In modern times (though perhaps less in historic and very recent times), energy for transportation requires the generation of pollution.

So a marginal increase in trade-generated transportation almost systematically increases pollution.

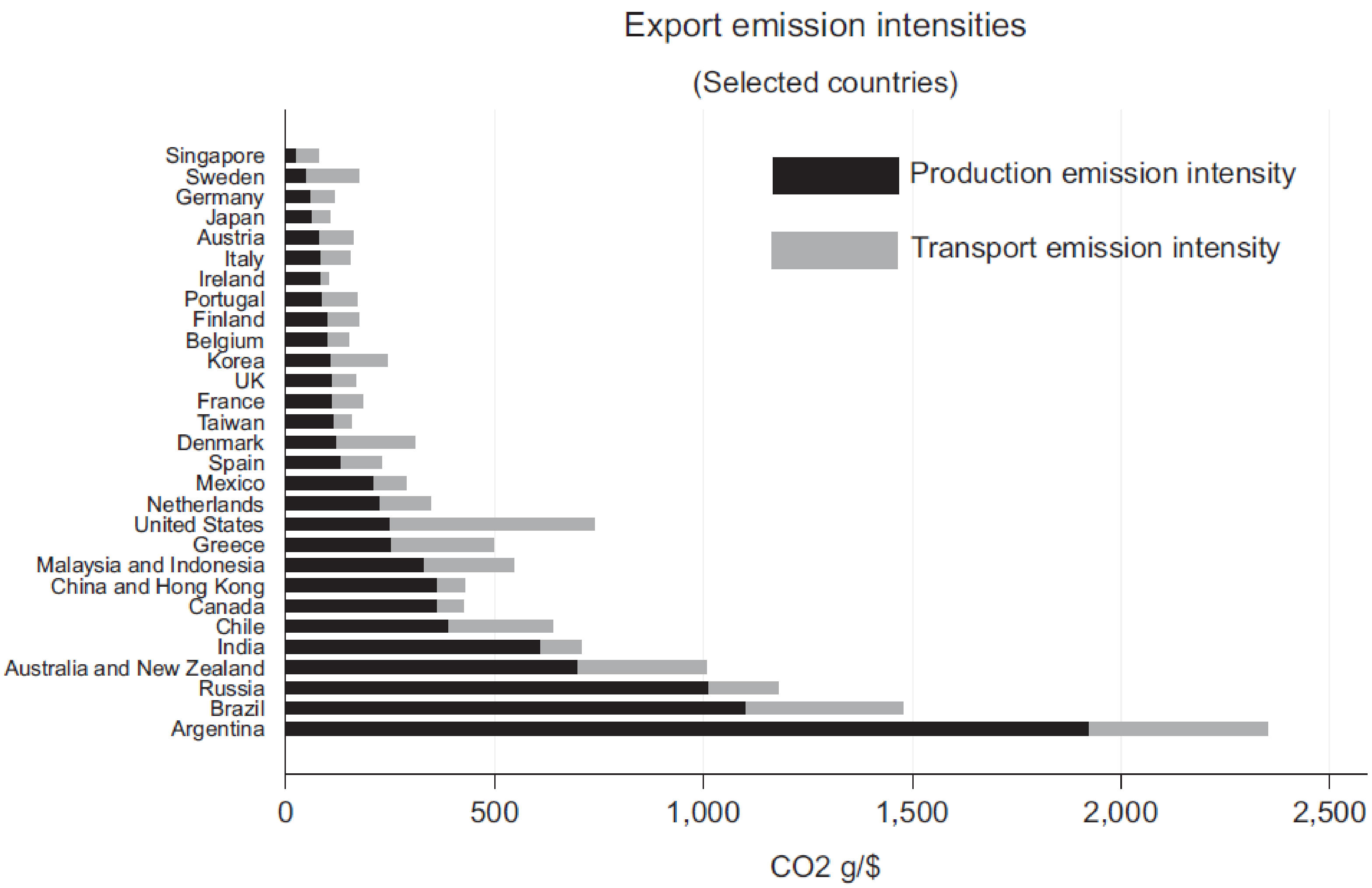
But: are increases in transportation emissions offset by a more efficient supply chain? And are the environmental costs of this pollution large in relation to welfare gains from trade that result from transport?

Transport-generated pollution

Some stylized facts from Cristea et al. (2013) and Shapiro (2016):

- CO_2 generated by trade-related transport makes up less than 4% of global emissions.
  - But: transport emissions make up 35% of total emissions from traded goods!
- Surprising which goods are “clean”/”dirty”, accounting for transportation.
  - Commodities are energy-intensive to produce but often shipped efficiently by sea.
  - Machinery/electronic equipment efficiently produced but shipped by air – dirty!
- Compared to autarkic world, current international trade practices increase CO_2 emissions by only 5% annually.
- At a SCC of ~$30, the global welfare gains from trade exceed the costs of CO_2 emissions by a factor of 160x.

Transport-generated pollution



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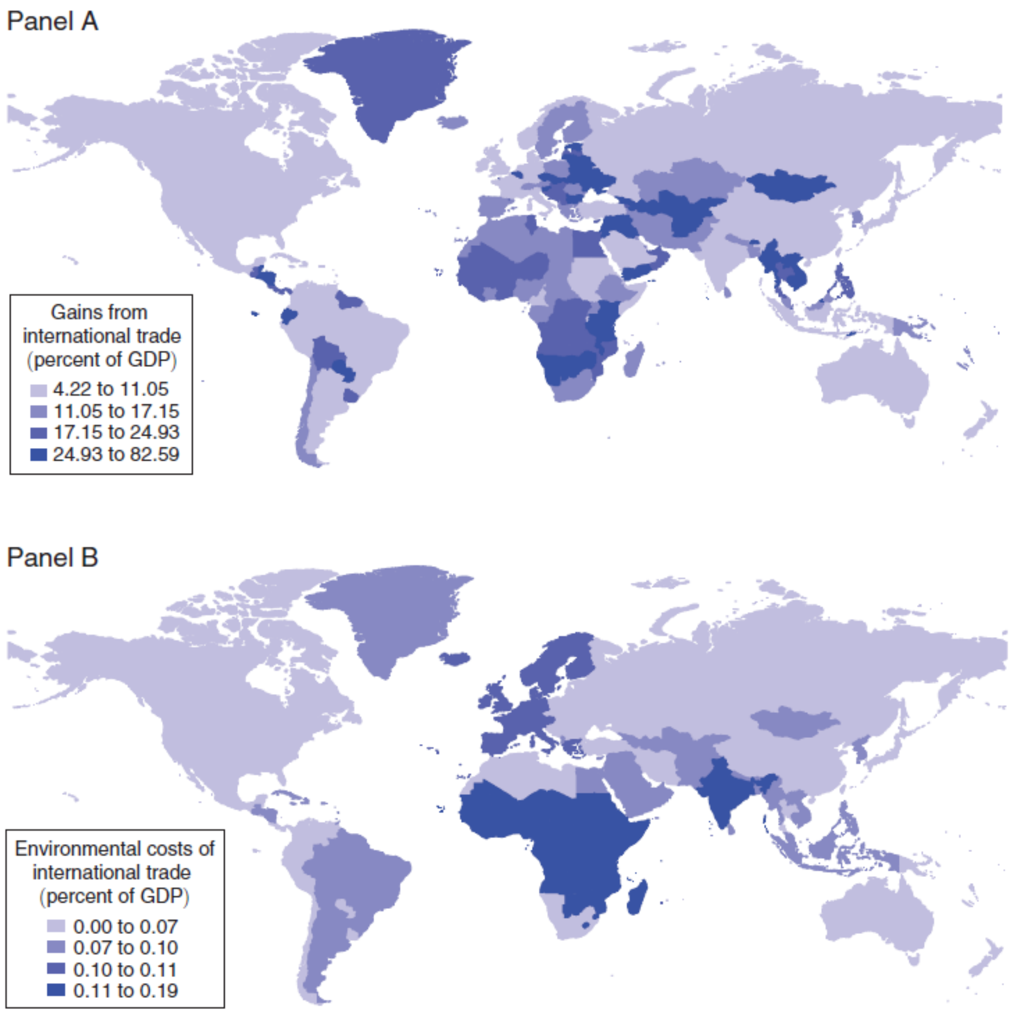

Figure 1. Benefits and Environmental Costs of International Trade by Country (*percent of GDP*)

Transport-generated pollution

Building on that last result, Shapiro (2016) asks:

What happens to welfare if a global carbon tax on shipping of $30/ton is imposed?

Table 4—Counterfactual Carbon Taxes on Shipping: Effects on Social Welfare
(billions of US dollars)

Group of countries	Gains from trade (1)	Environmental costs of trade (2)	Social welfare: Total (3)	Social welfare: Basis points (4)
Panel C: Global counterfactual				
All (global)	−6.5	−16.7	10.2	0.18
	[−8.0, −4.8]	[−20.0, −13.2]	[8.5, 11.8]	[0.15, 0.21]
United States	2.2	−1.3	3.5	0.23
	[1.1, 3.7]	[−1.5, −1.0]	[2.4, 4.7]	[0.16, 0.31]
European Union	8.8	−9.2	18.0	1.00
	[5.5, 13.8]	[−11.0, −7.3]	[13.2, 23.0]	[0.73, 1.28]
Richest third	10.3	−11.9	22.2	0.53
	[8.5, 14.3]	[−14.2, −9.4]	[19.1, 26.2]	[0.46, 0.63]
Middle third	−10.5	−2.5	−8.0	−0.72
	[−15.3, −7.7]	[−3.0, −2.0]	[−12.7, −5.7]	[−1.14, −0.51]
Poorest third	−6.4	−2.3	−4.1	−1.29
	[−7.3, −5.6]	[−2.8, −1.8]	[−5.4, −3.1]	[−1.71, −0.99]

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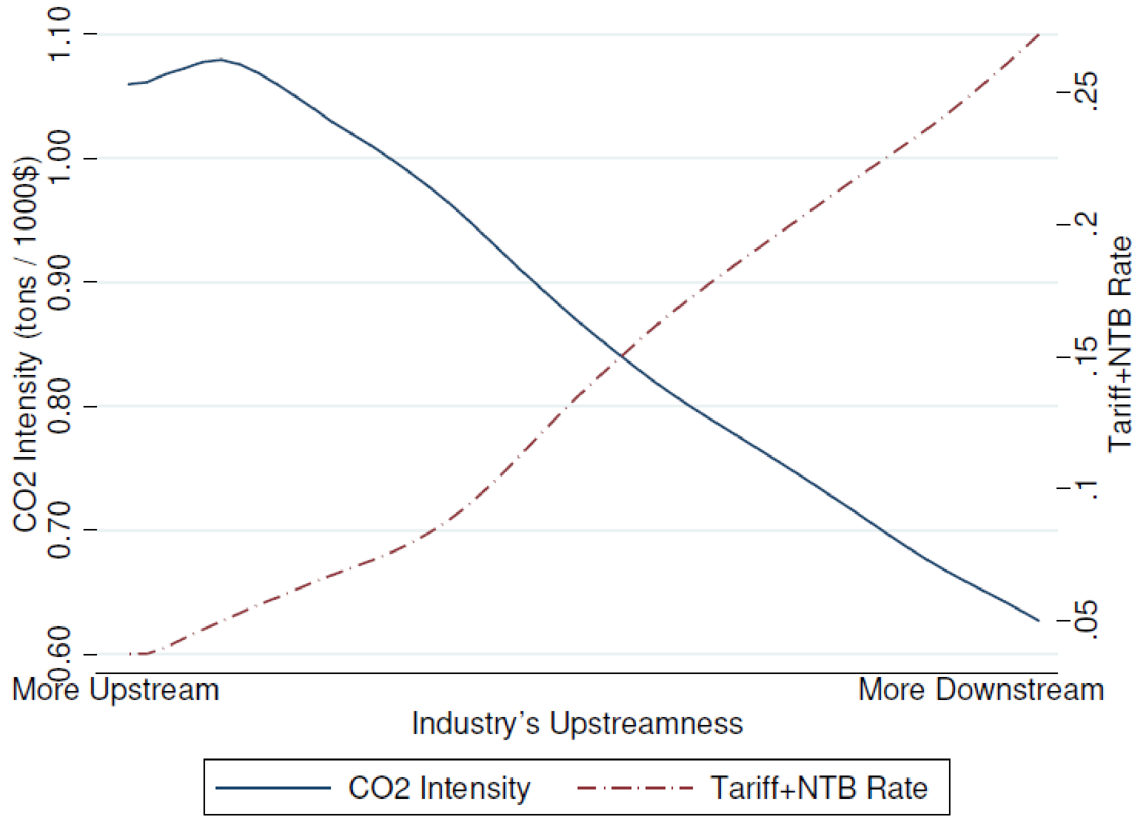
Trade policy as environmental policy?



In a 2021 paper, Shapiro notes that existing global trade policy is distorted towards promoting trade in carbon-intensive goods.

The existing global tariff structure (likely due to lobbying) is one where tariffs are low on imported inputs and high on final goods (to protect high-margin domestic production).

Shapiro asks: what happens to trade and carbon emissions if all countries simplify trade policy via a single tariff rate per trading partner (taken at the bilateral-average) for all goods?

Result: 0.65% *increase* in global income and 3.6% *decrease* in global carbon emissions.

Second-best policy for trade and the environment

In cases where a market distortion can't be removed due to technical reasons, politics, distributional effects, etc., economists advocate for a *second-best policy*.

- When making second-best policy, *adding an additional distortion in an interdependent market* might lead to a more efficient outcome.
- When addressing environmental issues, we are often in a second-best world.

Example: Costello and McAusland (2004) suggest that using a commodity import tariff as a Pigouvian tax can deter invasive species introduction by reducing both import volume and infestation levels.

Example: In 2010, China increased export restrictions on rare earth metals, claiming the restrictions were necessary to reduce pollution. This "environmental policy" resulting in massive price increases and gains in trade. In 2015, the WTO ruled against China, saying the restrictions were clearly not necessary to reduce pollution.

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Climate policy and carbon leakage

We’ve discussed pollution generally thus far, but let’s now focus on carbon emissions.

Carbon emissions are a global pollutant, and there is not an “international” level of government that can overrule national sovereignty in order to correct the externality.

Imagine a coalition of countries agrees to reduce carbon emissions. What do we expect to happen to emissions in non-coalition countries?

- Coalition production of carbon-intensive goods will become less competitive globally, production may be offshored resulting in increased non-coalition emissions.

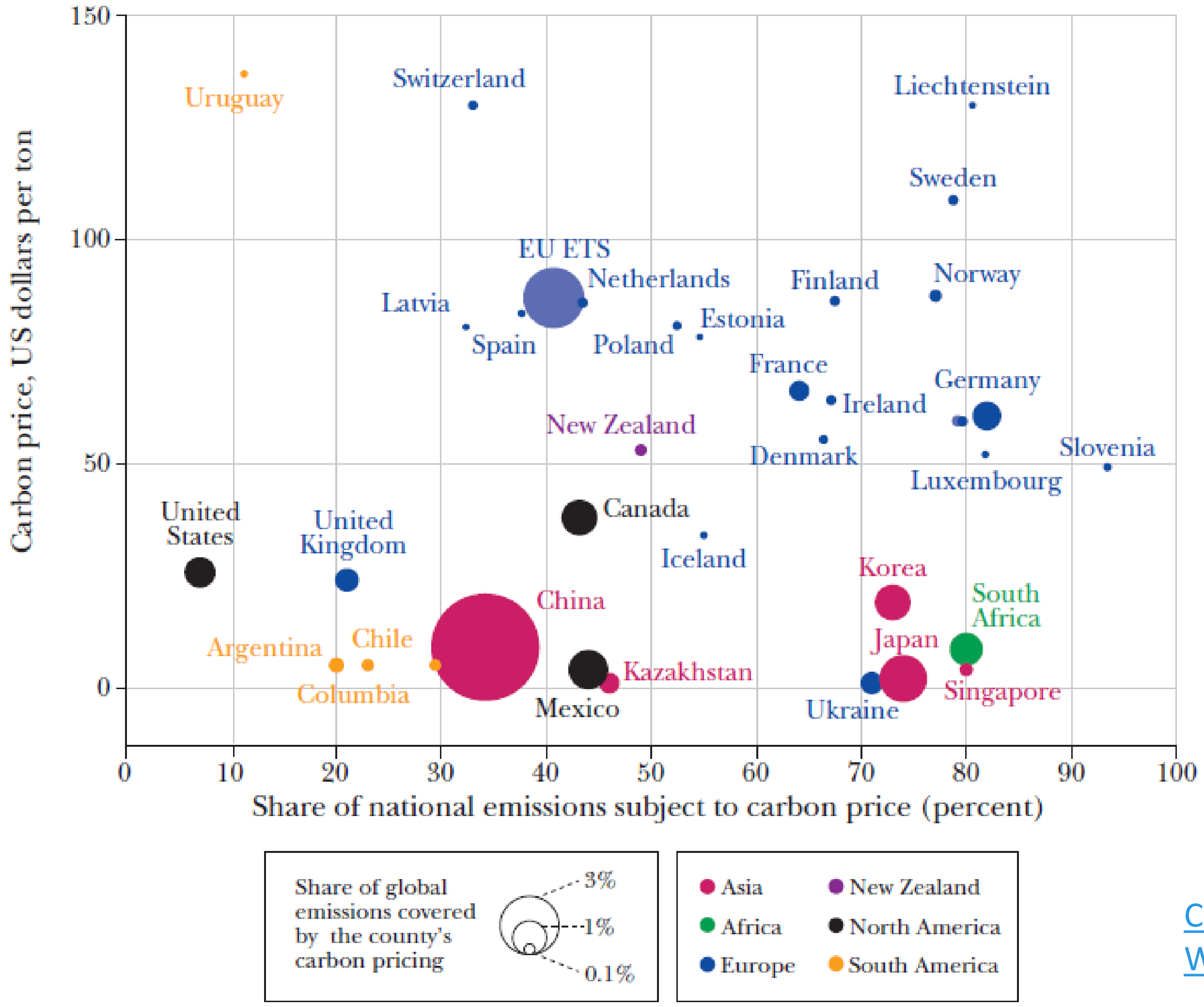
- Coalition demand for fossil fuels will decline. The global price of fossil fuels will respond in kind (decreasing) thus encouraging increased use in non-coalition countries

Increased emissions in non-coalition countries is *leakage* that undermines the coalition’s climate policy.

Carbon pricing, leakage and trade

This leakage can even occur in countries with climate policy and generate trade or competitiveness concerns.

Consider the global heterogeneity in carbon prices and coverage, and ask yourself how this variation might affect trade…



[Clausing and Wolfram, 2023]

Carbon pricing, leakage and trade

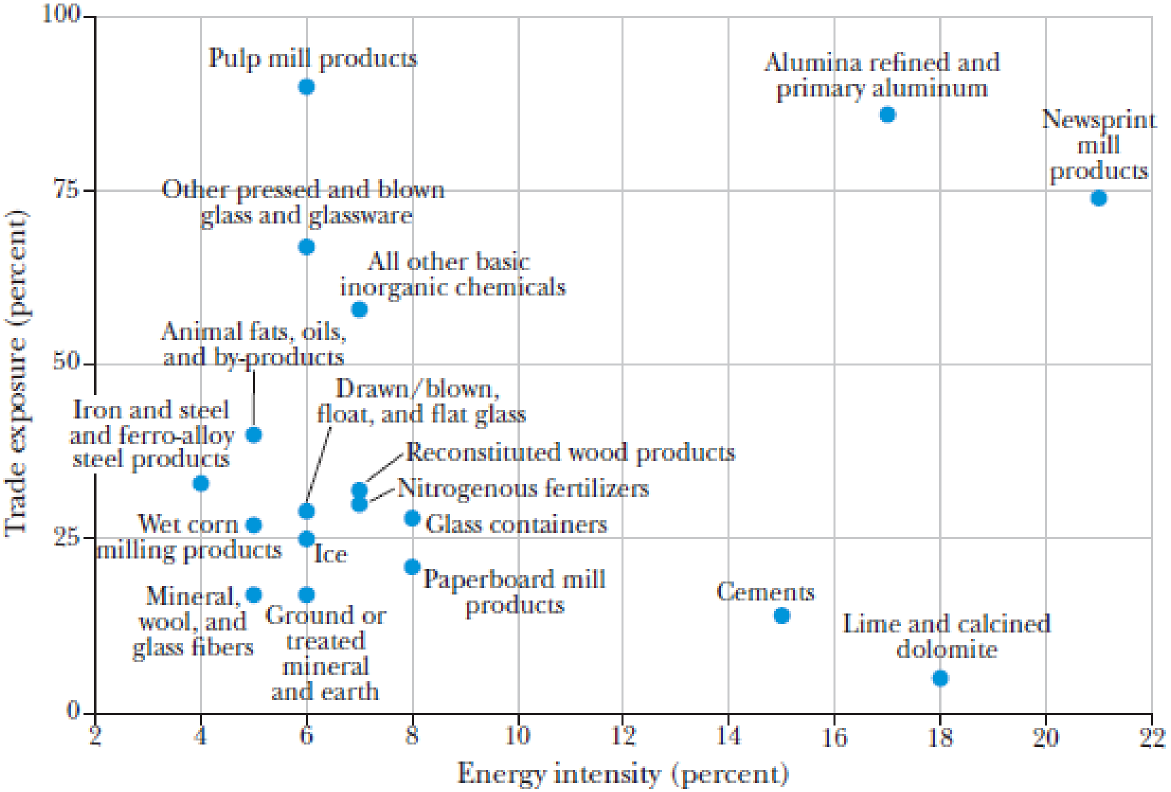
Imagine the US implements a carbon price in the form of a $100/ton tax.

US production now must compete with production from other parts of the world that *don't* cost this carbon price.

The further to the NE of graph at right, the more the industry is exposed to this competition .

Figure 2

Energy Intensive and Trade Exposed Industries in the United States



[Clausing and Wolfram, 2023](#)

Carbon pricing, leakage and trade

A standard approach to partially mitigate these trade competitiveness effects is to use a **cap-and-trade system** with grandfathering (see lecture 16).

- Note: free permit allocations will only cover direct costs. If input costs (e.g. energy) are more expensive, this will still pass through to firms.

When jurisdictions are reluctant to directly impost carbon costs on firms/consumers (perhaps for political economy reasons), they can instead turn to **subsidies**.

- This is the carbon-policy path the US government has recently taken. Dr. Austin will discuss the Inflation Reduction Act (IRA) and Infrastructure Bill next week.

Carbon subsidies have the opposite competition effect on trade: foreign countries are likely to suffer from the treatment benefits handed to domestic industry

- In response to the IRA's advantageous subsidy treatment for "American-made" products, the EU has discussed retaliatory industrial policy.
- Tit-for-tat trade policy can (theoretically) result in an expensive **subsidy race**

Carbon border adjustments

More recently, **carbon border adjustment mechanisms** have become a popular way to protect domestic industry when implementing carbon pricing.

For example, a jurisdiction with carbon pricing can apply import fees based on the carbon content of imported goods.

- Imagine a jurisdiction has a $100 per ton carbon tax and imports a good from a foreign market with a $10 per ton carbon tax.
- The jurisdiction can impose a **border adjustment tariff** of $100 per ton of carbon embedded in the good.
- The result: all domestic consumption of the good face identical carbon costs.

Earlier this year, the EU finalized an agreement to implement this kind of policy to offset competitive disadvantages that have accrued due to EU carbon pricing.

Note, however, that this does not help the jurisdiction with export competition.

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International Environmental Agreements

IEAs are often the only viable solution to solving global, *transboundary pollution problems.*

Climate IEAs are obviously the big fish, but to date more than 3,000 IEAs have been identified.

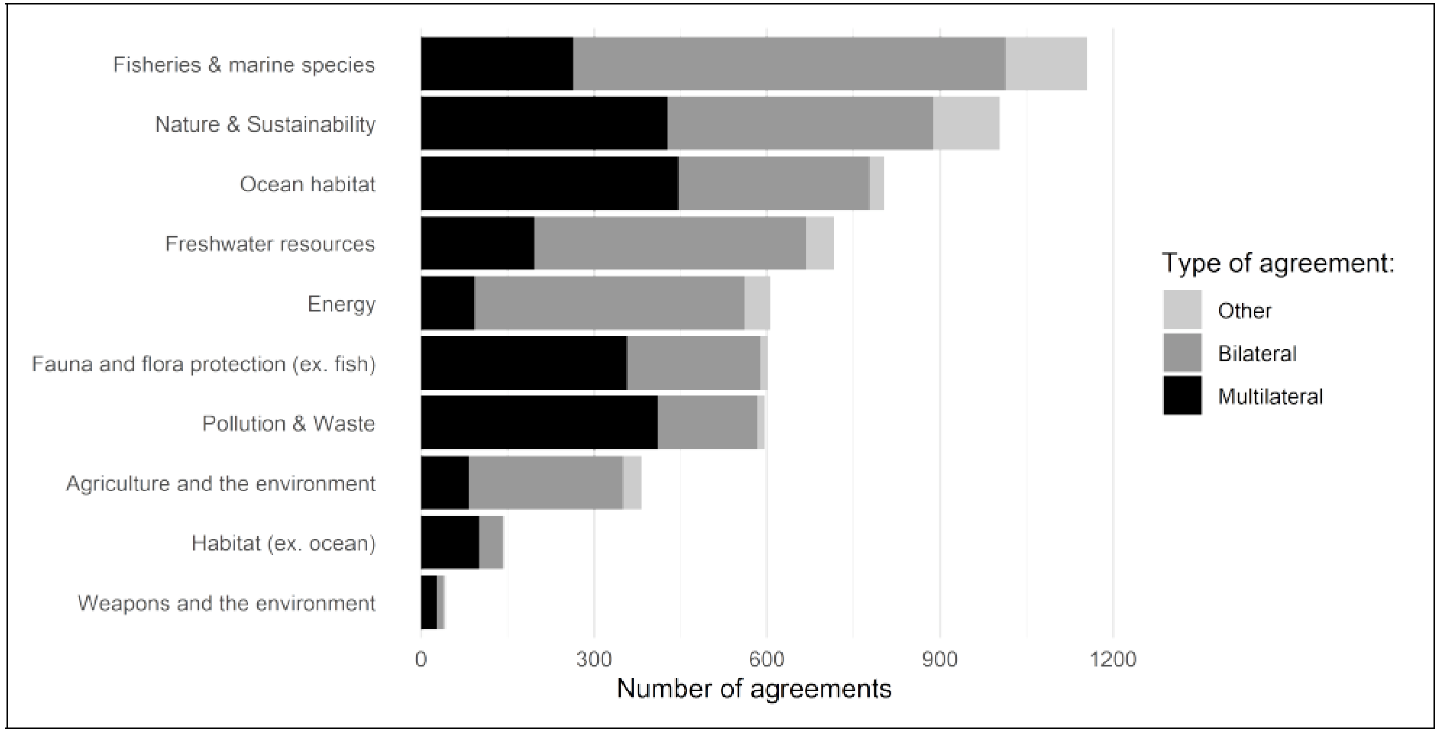


Figure 1: Number of environmental agreements by subject

Bellelli et al. (2023)

International Environmental Agreements

IEAs are typically modeled as a *participation game*, a form of public good problem.

- Each country maximizes social welfare.
- Independent countries have an incentive to free ride on IEAs, obtaining some benefits without contributing to the costs of the agreement.

$$\Pi_i = B(Z) - C(z_i), \qquad \text{for } i = 1, \dots, I$$

Π_i : net benefit to country *i*
z_i : pollution abatement by country *i*
$Z = \sum_I z_i$ (total pollution abatement by all countries)

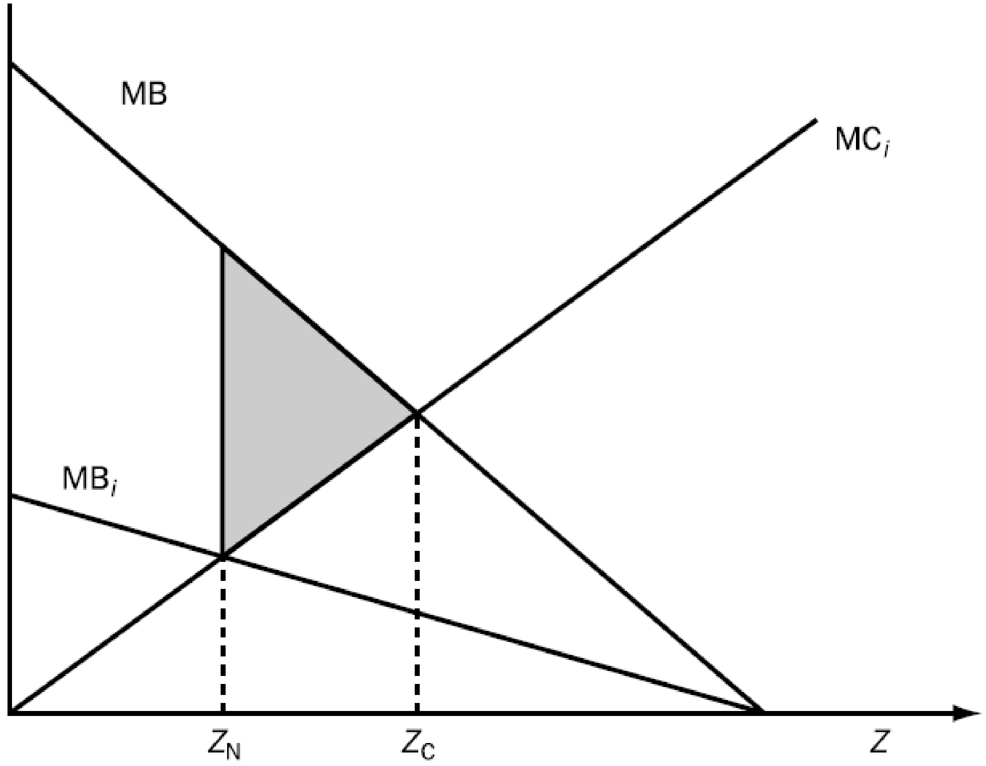
International Environmental Agreements

Under *non-cooperative behavior*, countries abate up to the point where its own marginal benefit is equal to its own marginal cost:

$$\frac{dB(Z^N)}{dz} = \frac{dC(Z^N)}{dz} \quad \text{where } Z^N = \sum_I z^N$$

Under *fully cooperative behavior*, countries abate up to the socially optimal level, where the marginal abatement cost is equal to the sum of marginal benefits over all recipients of the public good:

$$\mathrm{N}\frac{dB(Z^C)}{dz} = \frac{dC(Z^C)}{dz} \quad \text{where } Z^C = \sum_I z^C$$



International Environmental Agreements

A third possibility is *partial cooperation*: some countries agree to abate pollution (by negotiated amounts) while the rests act independently.

For partial cooperation to be an equilibrium outcome, the following must hold:

- There are *N* countries in total, of which *K* choose to cooperate and so *N* – *K* defect.
- Each cooperating country selects an abatement level that maximizes the aggregate pay-off of all countries that cooperate.
- Each defecting country pursues its individually rational unilateral policy.
- No signatory can gain by unilaterally withdrawing from the agreement: $\Pi_s(K^*) \geq \Pi_n(K^* - 1)$
- No non-signatory can gain by unilaterally acceding to the agreement: $\Pi_n(K^*) \geq \Pi_s(K^* + 1)$

International Environmental Agreements

Barrett (1995) summarizes the key implications of any such equilibrium:

- When there are large potential gains from cooperation, the benefits from free-riding are also larger, and so defection is more attractive.
- When the incentives to defect are larger, there will be a smaller number of signatories.
- Thus, there is a trade off between the level of participation in environmental agreements that can be attained (*breadth)* and the abatement commitments implied by the treaty *(depth)*.
- Full cooperation is an especially rare outcome.
- Barrett's dismal punchline: any IEA with a large number of signatories is limited in its capacity to deliver social benefits. **Thus, treaties tend to simply codify actions that nations are already taking.**

What is the most successful IEA you have heard of?

International Environmental Agreements

Some people argue the **Montreal Protocol** was only a success because private industry saw an opportunity to consolidate market power, and made government buy-in less politically costly:

There's money in the air: the CFC ban and DuPont's regulatory strategy

James Maxwell, Forrest Briscoe

First published: 04 December 1998 |

Abstract

DuPont, the world's dominant CFC producer, played a key role in the development of the Montreal Protocol on Ozone Depleting Substances. We argue that DuPont's pursuit of its economic interests, along with the political impact of the discovery of an ozone hole and the threat of domestic regulation, shaped the international regulatory regime for ozone-depleting substances. International regulation offered DuPont and a few other producers the possibility of new and more profitable chemical markets at a time when CFC production was losing its profitability and promising alternative chemicals had already been identified.

International Environmental Agreements

Okay, enough pessimism.

What are some factors or approaches that improve the probability of an IEA succeeding?

Bellelli et al. (2023) review the empirical evidence and find:

- Regional IEAs are substantially more likely to be ratified; likely because of mutual economic interests, cultures, and similar benefit/cost functions.
  - Can a combination of regional IEAs outperform a global agreement on participation?

- Side payments – through financial or technical support to developing countries – increase the likelihood of ratification, at least initially.

- Early ratification by “big nations” increases ratification likelihood of other nations. This “domino effect” implies that a handful of countries are driving the success or failure of an IEA.

Buy Coal! A Case for Supply-Side Environmental Policy

Bård Harstad

Northwestern University, University of Oslo, and National Bureau of Economic Research

Free-riding is at the core of environmental problems. If a climate coalition reduces its emissions, world prices change and nonparticipants typically emit more; they may also extract the dirtiest type of fossil fuel and invest too little in green technology. The coalition's second-best policy distorts trade and is not time consistent. However, suppose that the countries can trade the rights to exploit fossil-fuel deposits: As soon as the market clears, the above-mentioned problems vanish and the first-best is implemented. In short, the coalition's best policy is to simply buy foreign deposits and conserve them.

International Climate Agreements under the Threat of Solar Geoengineering

David M. McEvoy, Matthew McGinty, Todd L. Cherry and Stephan Kroll

November 13, 2022

Abstract

The possibility of overshooting global emissions targets has triggered a public debate about the role solar geoengineering (SGE) - using technologies to reflect solar radiation away from Earth - may play in managing climate change. One major concern is that SGE technologies are relatively cheap, and could potentially be deployed by a single nation (the "free driver") that could effectively control the global climate. Another concern is that SGE opportunities may alter countries' incentives to cooperate on abatement. Here we develop a game-theoretic model to analyze how opportunities to deploy SGE impact global abatement and the effectiveness of international environmental agreements (IEAs) on climate change. We show that non-cooperative abatement levels may increase or decrease under the threat of SGE, depending on how damaging the free-driver's level of deployment is on others. We also show the stability of IEAs that govern abatement is challenged by two competing strategic incentives. One is a familiar free-rider incentive, which is the benefit a country earns by leaving an agreement and lowering its abatement. The other incentive is the benefit a country earns by joining an agreement and increasing abatement in order to motivate the free-driver to reduce its level of deployment. We introduce the term *anti-driver* to describe this second incentive. Ultimately, we find that if the anti-driver incentives are high enough, the threat of SGE can expand both the depth (i.e., abatement level) and breadth (i.e., participation level) of stable IEAs compared to a world without SGE.

Next class

- Next lecture is our last of the semester. Prof. Austin to cover some current environmental policy topics.
- No readings beforehand – enjoy your Thanksgiving holiday!
- Reminder to keep making progress on Case Study #4 (due Nov 27)