

Trade and Climate Change

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Questions

- Has international trade made the climate change problem worse?
- Can international trade be part of the solution?
- Does our experience with trade agreements have implications for the design of climate agreements?

Is Free Trade Bad for the Global Environment?

Scale, Composition and Technique Effects

Let there be n goods. Emission intensity in sector i is e_i . Total pollution is

$$z = \sum_i e_i y_i$$

Choose a base year vector of prices \mathbf{p}^o ; these will be held constant throughout any changes since their role is simply to weight outputs. Then we have

$$z = S \sum_i \tilde{e}_i \varphi_i$$

where $\tilde{e}_i \equiv e_i / p_i^o$ is emissions per unit value (at base prices) in sector i , and $\varphi_i \equiv p_i^o y_i / S$ is the share of good i in the value of output at base prices.

Take logs and differentiate (holding base prices fixed)

$$\hat{z} = \hat{S} + \sum_i \theta_i \hat{e}_i + \sum_i \theta_i \hat{\varphi}_i$$

where $\theta_i = z_i / z$ and $\hat{z} \equiv dz / z$

Any change in pollution can be decomposed into a sum of scale effects, weighted changes in emission intensities, and weighted changes in the composition of output.

Pollution rises if

- scale of overall production rises,
- emission intensity rises
- share of the polluting sectors in overall output rises.

Effects of Trade on Global Pollution

Simple example: North / South; good X pollutes

Total world pollution (asterisk denotes "South"):

$$z^w = ex + e^* x^*$$

Let $\phi_x^* \equiv x^*/(x+x^*)$; that is, ϕ_x^* is the fraction of global X output produced in the South. Similarly, $\phi_x = 1 - \phi_x^*$ is the fraction of X produced in the North.

Global pollution:

$$z^w = [e\phi_x + e^*\phi_x^*]x^w$$

where x^w is global output of x.

Global Pollution

$$\hat{z}^W = \frac{e^* - e}{e\phi_x + e^*\phi_x^*} d\phi_x^* + \frac{\phi_x de + \phi_x^* de^*}{e\phi_x + e^*\phi_x^*} + \hat{x}^W$$

*Composition
Effect*

*Technique
Effect*

*Scale
Effect*

- Expect scale effect to be positive [trade raises world income which will likely generate increased output of both goods (if both normal)]
- Composition Effect also positive ($e^* > e$)
- Technique effect (negative in South; conflicting forces in North - income rises but demand for emissions falls)

Generalizations

Heterogeneous firms

- Trade liberalization leads to exit of least productive firms; more productive firms expand
- If more productive firms are cleaner, sectoral average emission intensities will fall (Kreickemeier and Richter, 2012; and others)
- If there are fixed costs of investing in abatement, more productive firms are cleaner and firm-level selection induced by trade will magnify this effect (Forslid, Okubo and Ulltveit-Moe, 2011)

Generalizations

Transport costs (Cristea et al. JEEM 2013)

Much of the trade and environment literature focuses on indirect effect of trade on environment (via changes in level, location and mix of global production)

Direct effect of international transportation often ignored

- 3.5% of global carbon emissions, but...
- Define total carbon emissions from traded goods as sum of those generated during production and international transport
- International transport accounts for 33% of these emissions

Evidence: Estimation approach

Antweiler, Copeland and Taylor (AER, 2001). Sulfur dioxide pollution using a panel of data on ambient SO₂ pollution from 1971-1996. Estimate effects econometrically, including coefficients on openness

- Increases in scale raise pollution
- All else equal, increases in per capita income lower pollution (interpret as a technique effect).
- Composition effect due to increases in capital abundance is positive and raises SO₂ pollution
- Effects of increased trade (via composition effect) composition vary across countries (as predicted by theory) and are small.
- Adding up all the effects, openness tends to (slightly) reduce SO₂ concentrations for “average” country in sample.

Are carbon emissions different?

Probably yes for 3 reasons

- Local vs global pollutants
- Pattern of trade
- Transport costs

Local vs Global Pollutants

Cole and Elliott (2003) use emission data and apply this approach to four pollutants.

Find weaker technique effects for CO₂.

Frankel and Rose (2005) find that openness has a positive (although not significant) effect on carbon emissions

Pattern of trade

Carbon emissions embodied in trade (in 2007) are about 21% of global emissions (Aichele and Felbermayr, 2012)

Carbon content of trade: Examples of Net Exporters

China

India

South Africa

Czech Republic

Australia

Carbon content of trade: Examples of Net Importers

Germany, France, Netherlands

Switzerland

United States

Transport costs and trade: Quantitative evidence

- Shapiro (2013) estimates an Armington model to study effects of trade on carbon emissions and welfare
- Allows for carbon emissions from both production and international transport
- Uses the model to simulate the effects of movement from no trade to status quo
- Trade increases global carbon emissions by about 6%; about half from production effects and half from international transport.
- Policy regime held constant

Strategic Effects of Trade Liberalization: Global Agreements on Climate

Two regions, North and South

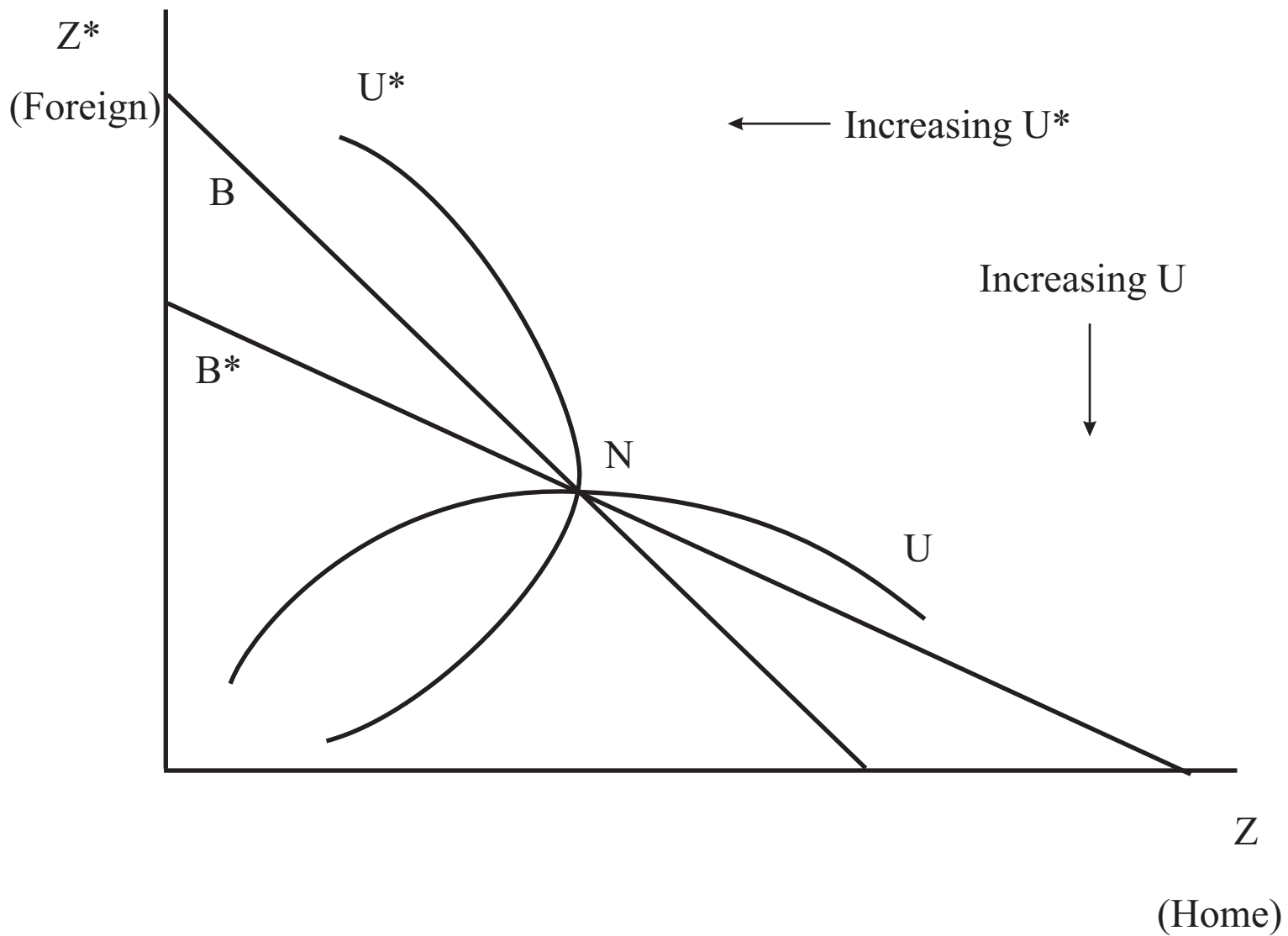
South has a comparative advantage in carbon-intensive industries

Initially there is a non-cooperative equilibrium in choice of carbon emission levels

How does trade effect the carbon game?

Does it matter if trade agreement precedes carbon agreement?

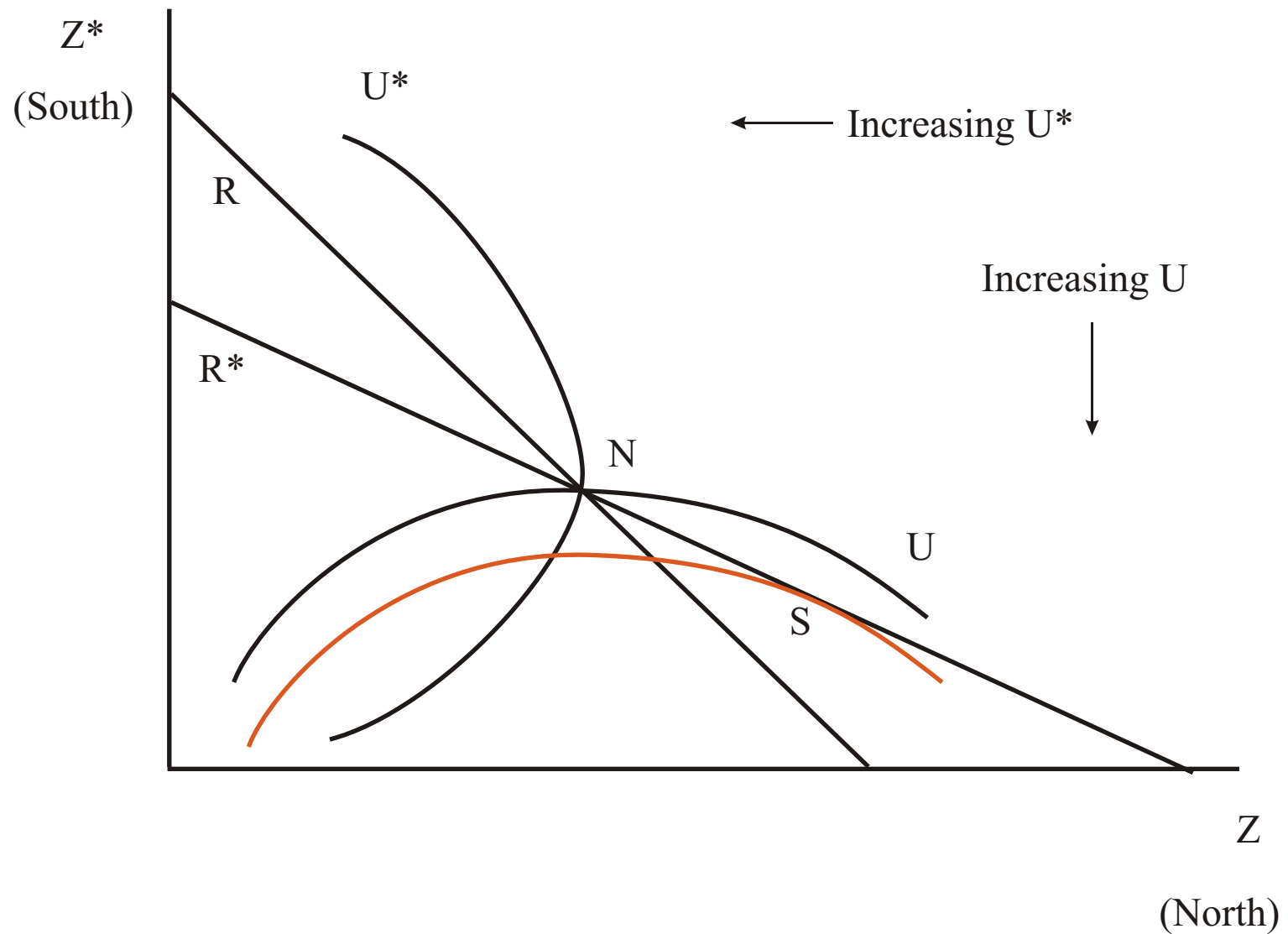
Non-cooperative choice of pollution in Autarky



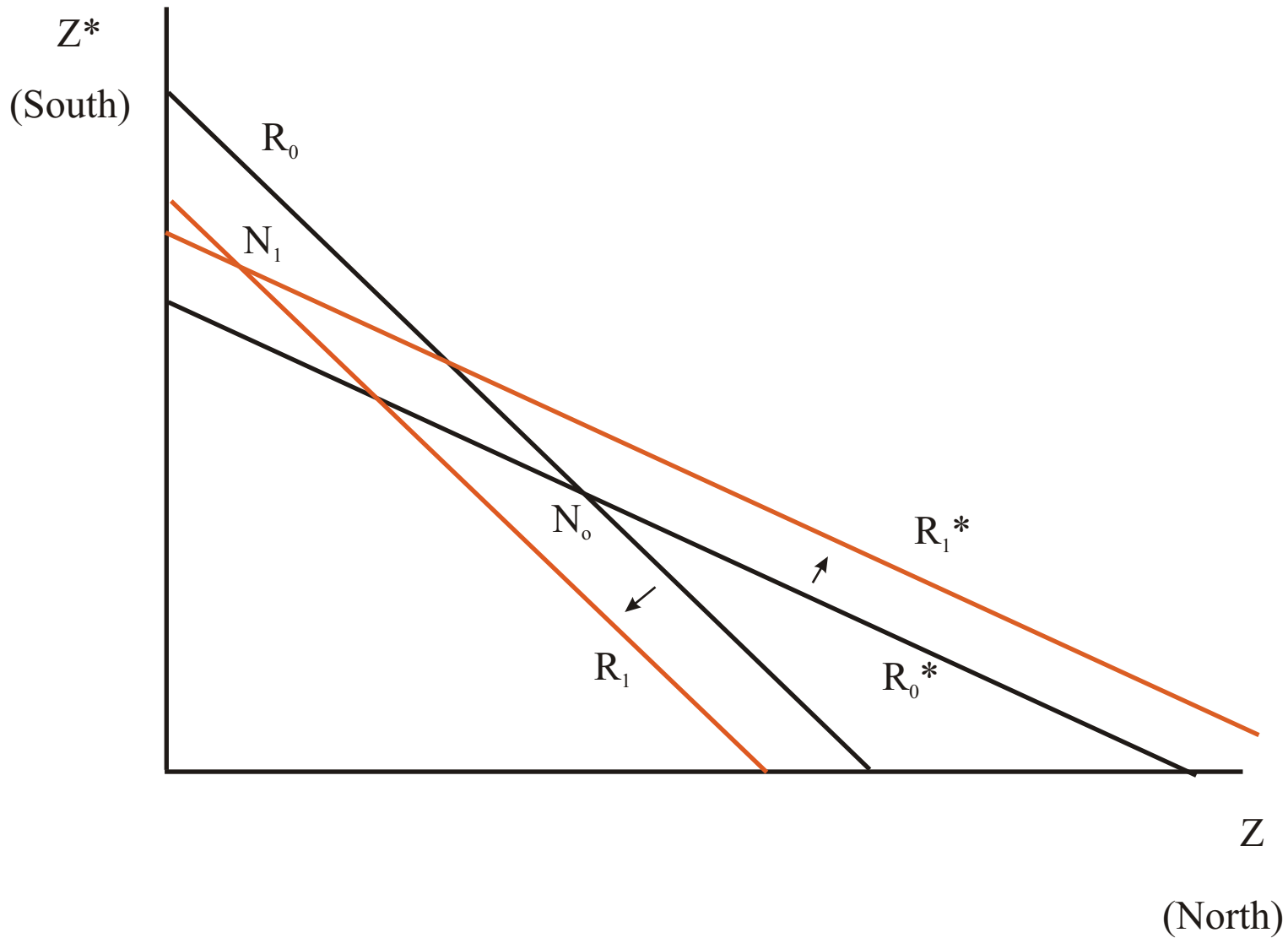
Does Free Trade Disadvantage North?

- A free trade agreement puts North at a strategic disadvantage in the pollution game
- Free trade agreement is a credible commitment by the South to pollute more.
- This hurts the North and affects the threat point of the pollution game.
- North prefers to link trade and environmental agreements
- South is better off if free trade agreement is in place first and pollution agreement is negotiated in the future.

**If North Could Pre-Commit to a Pollution Level,
It Would Increase Pollution and Move to S**



Trade liberalization allows South to credibly commit to increase its pollution



Unilateral (subglobal) Emission Reductions and Leakage

Leakage occurs in autarky via free-rider effect

Trade adds other channels

- Income effects from terms of trade; availability of additional varieties, etc.
- Relocation of production via pollution haven effect
- Tightening up pollution policy reduces demand for fossil fuels, which reduces their price and increases use elsewhere.
- Vertical linkages in production across countries

Leakage via strategic response to unilateral foreign emission reductions

Home's best response function is

$$z = z(z^*, p, T)$$

where T is a transfer (could be zero)

Then Home's response to a change in z^* is

$$\frac{dz}{dz^*} = \frac{\partial z}{\partial z^*} + \left[\frac{\partial z}{\partial p} \Big|_u - \frac{\partial z}{\partial T} m \right] \frac{dp}{dz^*}$$

Effects of fall in foreign emissions

$$-\frac{dz}{dz^*} = -\frac{\partial z}{\partial z^*} - \left[\frac{\partial z}{\partial p} \Big|_u - \frac{\partial z}{\partial T} m \right] \frac{dp}{dz^*}$$

Free rider effect $-\frac{\partial z}{\partial z^*} > 0$

Substitution effect $-\frac{\partial z}{\partial p} \Big|_u \frac{dp}{dz^*} > 0$
(+) (-)

Assuming that substitution effect in production is stronger than in consumer demand for environmental quality.

Standard carbon leakage effect

Income effect $m \frac{dp}{dz^*} \frac{\partial z}{\partial T} < 0$ if $m < 0$ (export X)
(-) (-)

Leakage and Directed Technical Change

Hemous (2012) based on Acemoglu et al. (AER 2012)

North-South Pollution Haven model with directed technical change.

Clean and Dirty sectors; Dirty sector uses clean or dirty technology

Innovative activity concentrates in sectors with large market size

Lock-in effects - if dirty technology has a head start, then innovative activity tends to focus on the dirty technology.

Leakage and Directed Technical Change

Quality of environment is a stock

$$S_t = (1 + \gamma)S_{t-1} - \lambda(Y_{dNt} + Y_{dst})$$

Doom if S hits zero

Can North save the world unilaterally?

North's carbon tax shifts dirty production to South (Leakage)

Pace of Southern innovation in dirty technology increases.

World continues on path to doom

South keeps getting richer but no endogenous policy response to impending doom

Empirical Evidence on Leakage

- Econometric Evidence (Aichele and Felbermayr, 2013)
- CGE models
- Wide range of estimates (small to over 100%)
- Consensus is that leakage is positive (15% - 25%)
- But factors (and policy design) affecting magnitude of leakage still not well understood.

Summary:

Has trade exacerbated the climate change problem?

- Trade has likely increased global emissions via global composition effects and direct effect of transport costs
- Trade reduces efficacy and political feasibility of sub global agreements via leakage
- Trade agreements give strategic advantage to countries with comparative advantage in polluting industry; this likely affects difficult of achieving global agreements

Can trade be part of the solution?

Trade can lower mitigation costs by adding an additional channel of adjustment

- Adjustment to arbitrary allocation of emission targets across countries (Copeland and Taylor)

Labour mobility may be more important than trade in adapting to climate change

- Desmet and Rossi-Hansberg (2012)
- Donaldson, Costinot and Cory (2012)

Linkage between trade and environmental agreements can increase scope for global cooperation (Ederington, Limao)

Allocation of emission quotas

Tradeoffs between efficiency and equity

Standard argument is

- allocation of permits by simple rules (uniform percent emission reductions) is not efficient unless permits can be traded internationally
- allocation of permits can therefore be used to target income distribution with no adverse efficiency effects only if permits are freely tradable

With international trade in goods, things are more complicated

- allocation of permits by simple rules need not be inefficient

Allocation of emission permits: Simple example

Heckscher-Ohlin model

Two goods X and Y; both pollute

One primary factor (human capital) in fixed supply h

Treat emission as an input

$$X = f(h_x, z_x) \quad Y = g(h_y, z_y)$$

Zero profit conditions (both hold if both goods are produced:

$$c^x(w, \tau) = p_x \equiv p \quad c^y(w, \tau) = p_y \equiv 1$$

Solving yields w and τ as a function of p (independent of h and supply of permits). Well-known **factor price insensitivity** result.

Autarky

Consider two countries with identical technology that are not trading. They have endowments of human capital h and h^* , respectively.

Suppose there is a global agreement to cap global emissions at Z^W .

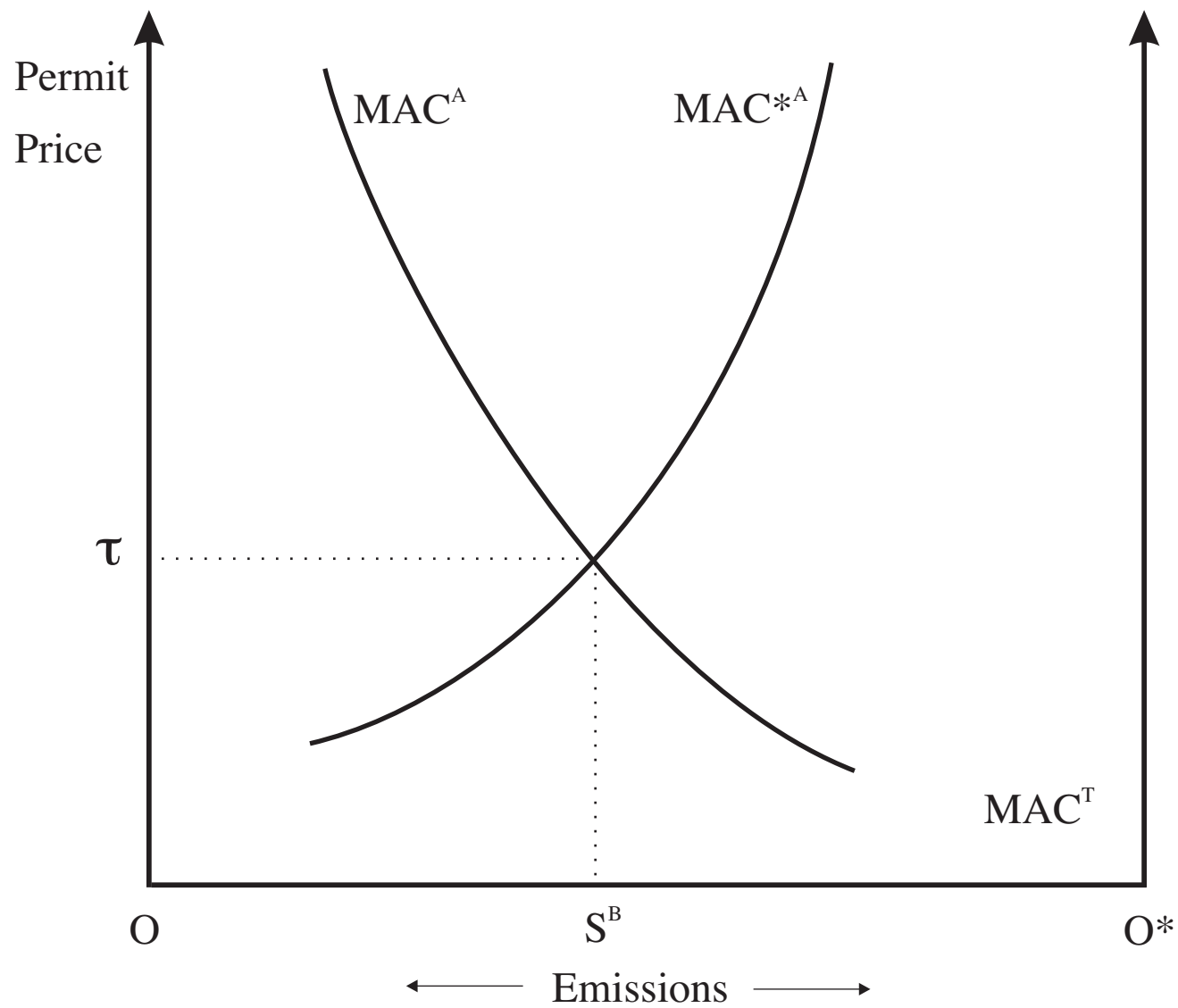
Assume that lump sum transfers are available to address income distribution.

Globally efficient allocation of emission permits across countries (conditional on no goods trade) requires

$$G_z(p, h, z) = G_{z^*}(p^*, h^*, z^*)$$

That is, general equilibrium marginal abatement costs should be equated across sources (countries).

There is a **unique** allocation of permits that does this.



Marginal abatement cost curves and efficiency: Autarky

Free trade

Now suppose there is free trade.

There will be some equilibrium goods price p .

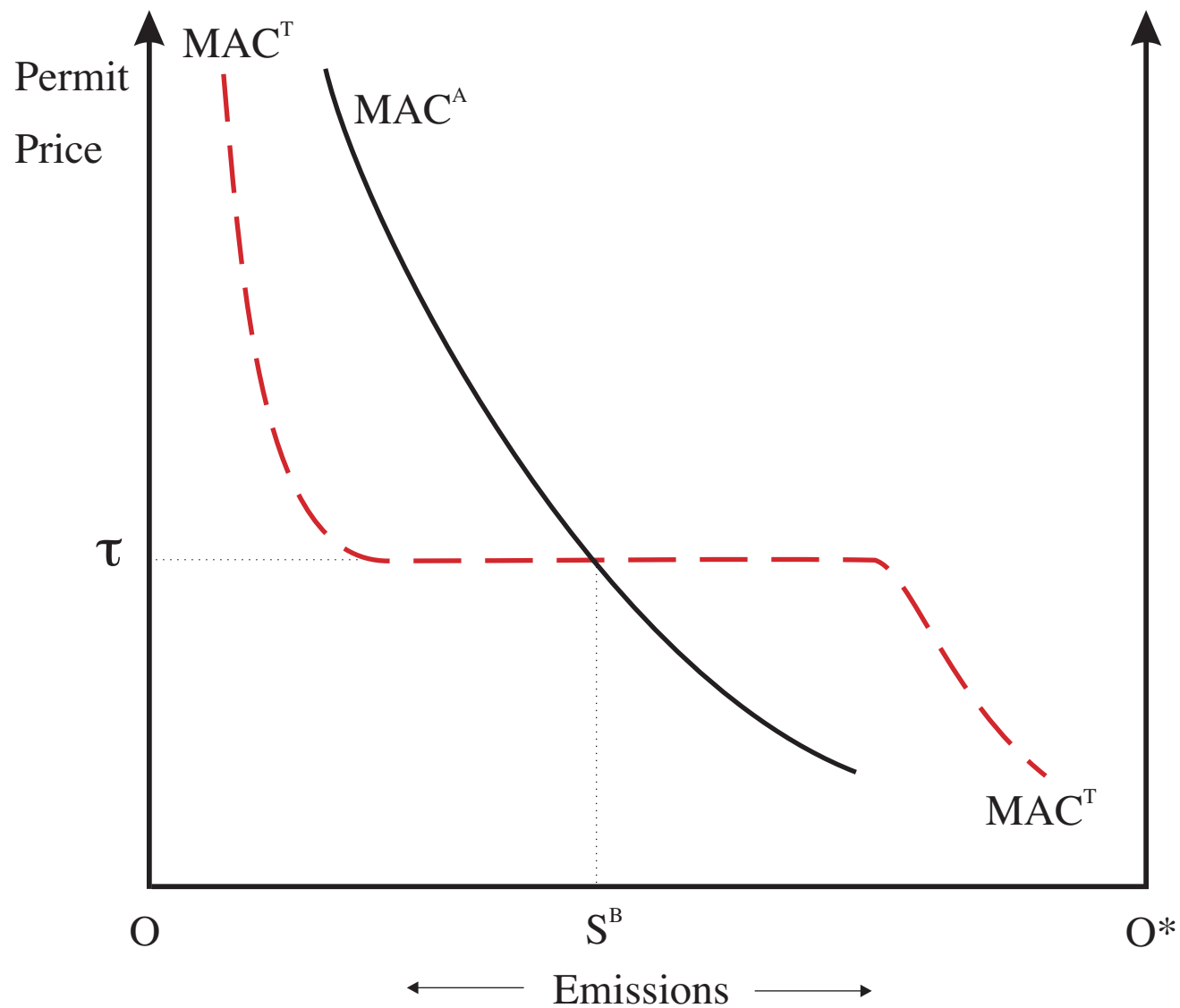
Given p , if countries are not too different, then permit prices are determined by the zero profit conditions (assuming both goods are produced in each country):

$$c^x(w, \tau) = p_x \equiv p \qquad c^y(w, \tau) = p_y \equiv 1$$

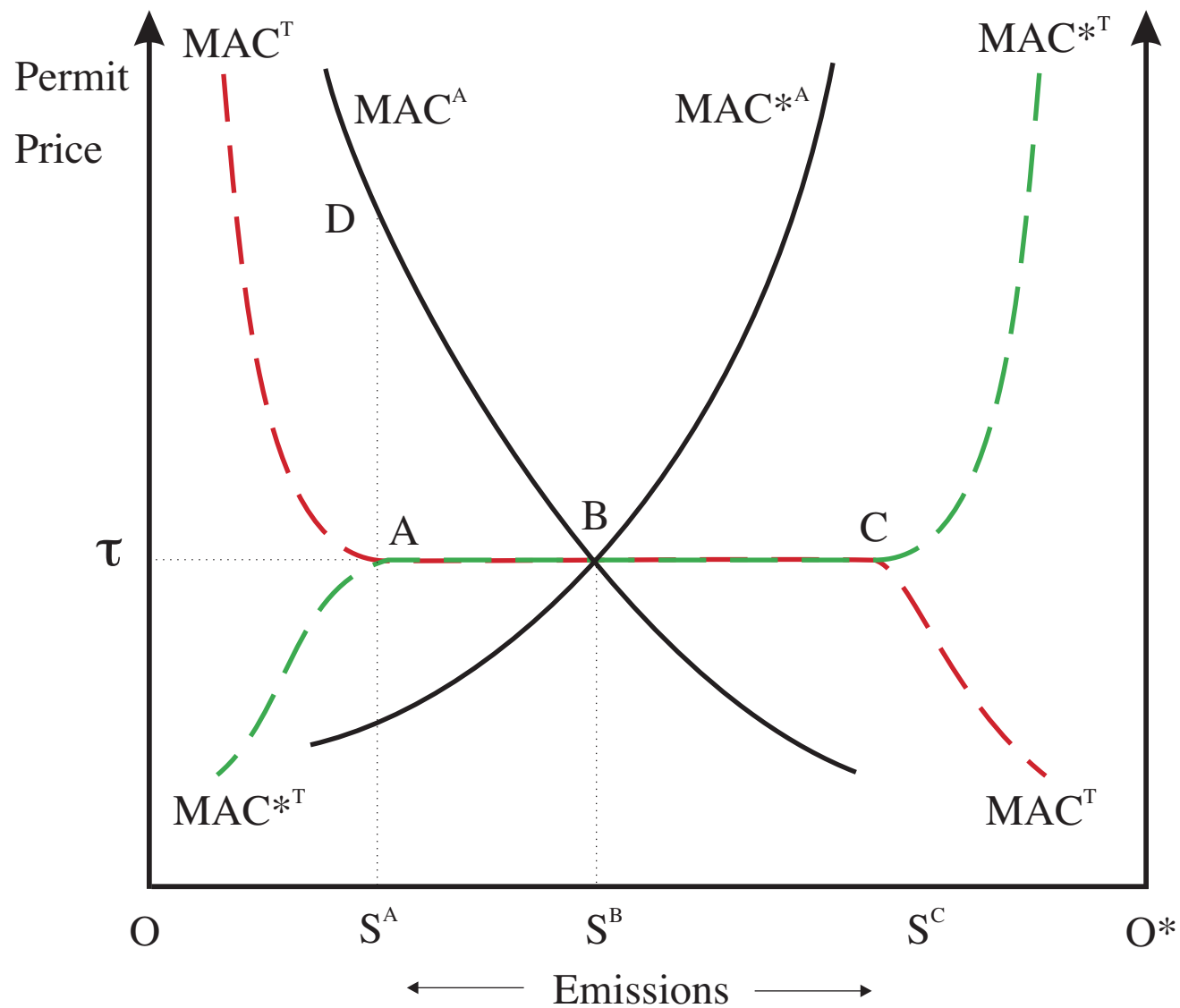
The permit price in each country is the same, **and is independent of how permits are allocated across countries**

This is the factor price equalization theorem of international trade

Implies that there is a continuum of allocation of permits across countries that is efficient



Effect of free trade on the relation between Home's permit price and share of permits allocated to Home



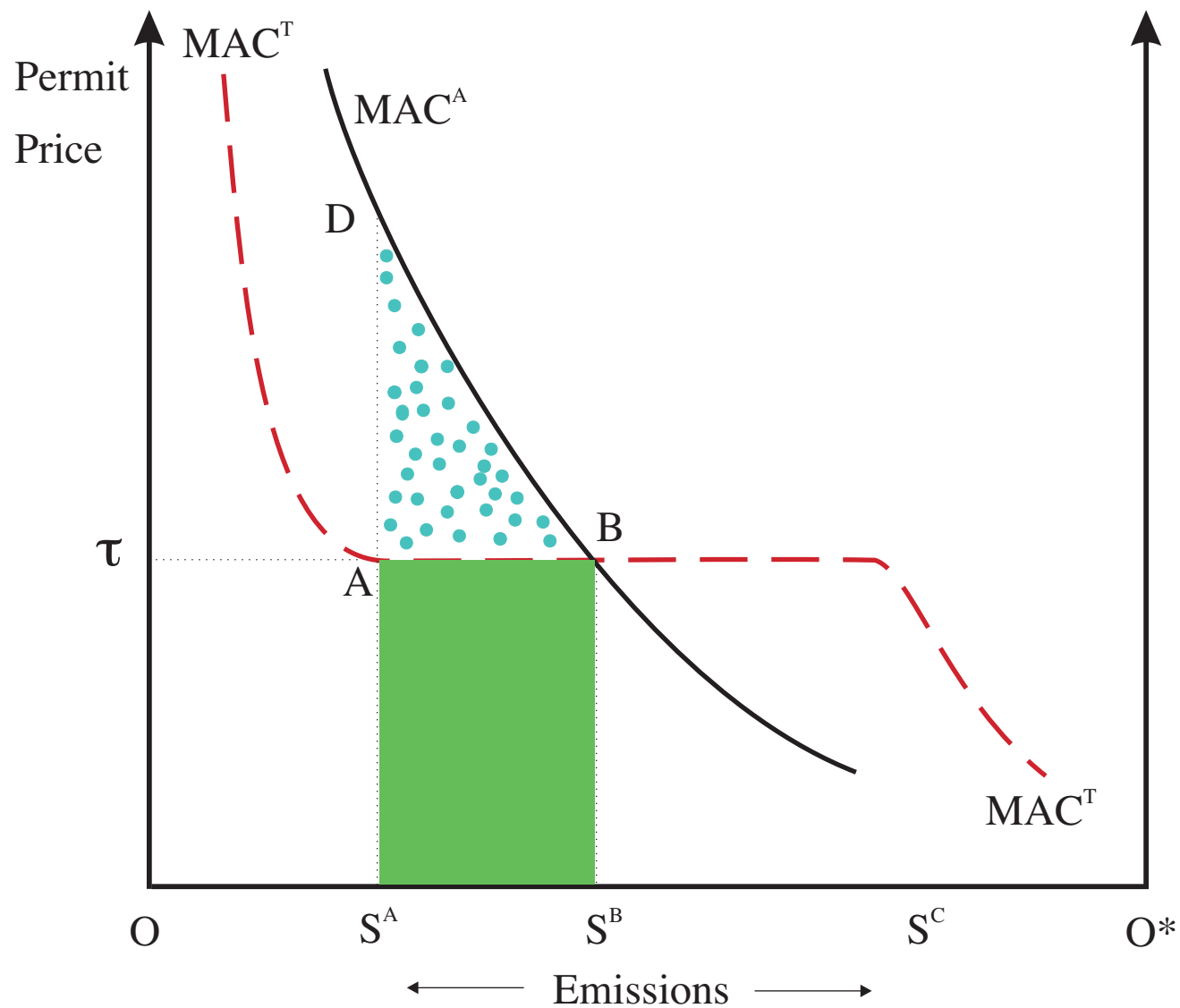
**There exists a continuum of efficient allocations
of emission permits in free trade**

Implications

1. Arbitrary allocations of emission permits across countries can be efficient even without permit trade
2. Permit allocation can target income distribution without an efficiency cost (even with no permit trade)
3. Marginal abatement cost curves are flatter in free trade than in autarky; that is trade yields a reduction in abatement costs. Trade is a channel for global pollution abatement

Intuition:

Trade in goods and factors are perfect substitutes in some cases (Mundell). Emission permit prices are unaffected by changes in the allocation of permits across countries. Instead all of the adjustment takes place via changes in outputs.



**Cutting emissions from S^B to S^A is less costly
in free trade than in autarky**

Spatial aspects of Climate Change

Demet and Rossi-Hansberg (2012) focus on role of labour mobility in adapting to climate change

Spatial model with global migration and endogenous temperature.

Emissions from production affect temperature.

Temperature affects the two industries - agriculture and manufacturing - differently.

Only effect on climate change is on productivity.

Endogenous innovation with spillovers dampened by distance.

Simulate for 200 years for various scenarios about how pollution affects temperature.

Results

Temperature increase makes places closer to equator less productive. Northern areas tend to benefit while places closer to equator lose.

With costless labour mobility and free trade, climate change has little effect on utility except in extreme temperature scenarios - people optimally relocate in response to productivity change

Restrictions on mobility hurt South, benefit North and reduce average global utility.

Linkage between Trade and Environmental agreements

Montreal Protocol on ozone-depleting gases contains provisions that restrict trade in products using certain chemicals. In practice, compliance was high and trade instruments were not used.

International agreements on biodiversity and endangered species contain provisions that constrain trade.

Basel Convention on transboundary movement of hazardous waste explicitly restricts trade in toxic substances between OECD and developing countries.

Why link trade and global environmental agreements?

Limao, Journal of International Economics 2005

Ederington, *Review of Environmental Economics and Policy*," 2010

Efficiency gains from linking agreements on trade and global pollution:

- Trade-offs across issues - more scope for bargaining
- Enforcement - wider range of incentives and punishments
- Limao finds that linkage may result in less enforcement leverage for the trade component of the agreement.
- Although global efficiency is increased, trade may be less free than it would be without linkage.

Experience with trade agreements: Implications for Climate Agreements

Trade agreements are incomplete contracts because of policy substitution

An agreement to restrict the use of trade policy instruments creates incentives to manipulate domestic policy instruments left unconstrained.

Trade offs between flexibility on domestic policy and loopholes in trade agreement

Solutions

Anticipate future strategic interaction over unconstrained instruments when choosing levels of constrained instruments (Copeland, 1990)

Think of trade agreements not as restrictions on tariffs alone but as agreements on market access (Bagwell and Staiger, 2001)

Expand the range of constrained instruments taking into account tradeoffs between flexibility and benefits of freer trade (Horn, Staiger and Maggi, 2010)

Implications for Climate Agreements:

Carbon Taxes vs Quotas

- Countries such as China and India are unlikely to accept an emission cap because it could constrain their growth
- A carbon tax would allow shifts in relative GDP and comparative advantage to lead to shifts in carbon emissions across countries
- Prices vs. quantities approach suggests carbon tax is more efficient in the face of uncertainty about compliance costs and damages

Policy substitution

Suppose a carbon tax is in place (and actual implementation of the tax could be enforced). Raises costs for carbon intensive industries and could lead to a contraction of output and employment in that sector.

Governments could introduce policies such as output subsidies, preferential corporate tax treatment, infrastructure investments, etc. aimed at preventing the decline in output.

These policies could undermine the effects of the carbon tax.

International agreements on emission quotas

Bagwell /Staiger (2001) point out that if market access agreements are binding, then there is no incentive to use domestic policy to undermine a trade agreement. (Targetting rule)

- Disadvantage is inflexibility of market access targets.

In the context of climate agreements, an agreement on access to global commons (implemented via country-level emission quotas) eliminates incentive to use domestic policy to undermine climate agreement.

- Disadvantage is inflexibility of emission targets and transactions costs of setting up international markets in emission permits

Conclusion

Circumstantial evidence suggests that trade is likely contributing to higher carbon emissions

Trade can help in reducing mitigation costs

Labour mobility may be more important than trade in adapting to productivity effects of climate change

Experience with trade agreements may provide some insights for design of climate agreements

- Need both carrots and sticks
- Need to manage loopholes