Globalization, Growth and the Environment

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August 24, 2022

Danish Environmental Economics Coucils Conference

Late May: Canada vs Denmark

Canada falls 3-2 to Denmark in men's world hockey championship

Denmark's players celebrate beside Canada's Damon Severson, right, after winning the group A Hockey World Championship match between Canada and Denmark in Helsinki, Finland, Monday May 23 2022. THE CANADIAN PRESS/AP/Martin Meissner

First loss in 73 years

Mid June: The Whiskey War 1978-2022

Our new land border. Hans Island shared amicably!

Is Globalization Environmental Friendly?

Why is this an important question?

- International Trade accounts for one fourth to one third of global emissions - Stylized Fact 7. (Copeland, Shapiro, & Taylor, 2022)
- Rich countries are increasingly outsourcing pollution to lower income countries - Stylized Fact 8. (Copeland, Shapiro, & Taylor, 2022)
- Many Rich country environments have improved over the last 30 years; most growth in world pollution comes from the developing world - Stylized Fact 6 (Copeland, Shapiro, & Taylor, 2022).
- Moreover, no one can escape global pollutants nor biodiversity losses.

How am I going to answer it?

- Use arguments, data and materials from several recent papers and one or two older classics. A list of the papers is on the last slide of this talk. These slides will be made available on my website under What's New at `https://www.mstaylor1.org/`
- Show you some facts drawn from pollution data, and three conclusions often drawn from them about Globalization's effect.
- Reconsider these conclusions in the light of theory and empirical work.
- Conclude with Answer/s.
- Leave policy questions to the Q&A.

Start with Definitions

- Standard way to think about Globalization's impact on the environment is to decompose its potential effects into three different channels.

- These channels relate the Scale of output, its Composition, and the Techniques of production to overall emissions. For example:

$$E = \sum_{i=1}^{n} a_i s_i Y \qquad \sum_{i=1}^{n} s_i = 1$$

- E is emissions, Y is real GDP, s measures shares, and a is emission/output.

Globalization's Impact

$$\hat{E} = \sum_{i=1}^{n} \pi_i [\hat{a}_i + \hat{s}_i] + \hat{Y} \qquad \pi_i = E_i / E$$

$$\text{Technique Effect} = \hat{a}_i < 0$$

$$\text{Composition Effect} = \hat{s}_i$$

$$\text{Scale Effect} = \hat{Y} > 0$$

- The hope is to then estimate the impact of globalization's impact on the environment making sure to account for these potential impacts.

Accounting Based Approach

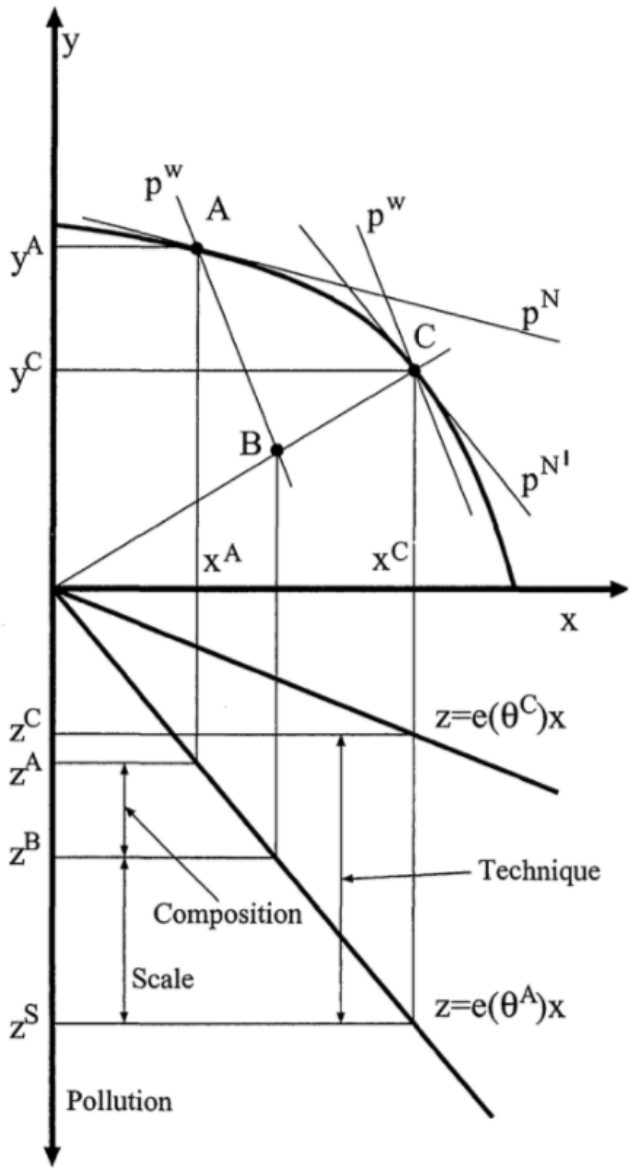
- One calculates, using accounting definitions, the size of Scale, Composition and Technique effects for various countries and pollutants.
- Look for the impact of Globalization in the entrails.
- Researchers sometimes compare different countries composition effects to argue for or against the Pollution Haven Hypothesis.
- Researchers sometime compare the magnitude of Scale and Technique effects to argue income growth is enough to drive pollution downward.

Alternative Theory Based Approach

- Develop a theory of how an economy or sector responds to a trade liberalization or similar globalization event.
- Identify changes in pollution caused by Globalization's impact on an economy's scale, composition and technique caused by Globalization;
- One estimates their magnitudes and adds them up. Is the net effect negative or positive? Conclude.
- Simple in theory - difficult in practice.

Trade Liberalization for a Dirty Good Exporter

Example Decomposition from: Antweiler, Copeland, & Taylor, 2001



Scale, Composition, and Technique Elasticities

	Estimation method	
	Random effects	Fixed effects
Scale elasticity	0.32	0.40
Composition elasticity	0.99	0.98
Technique elasticity	-1.58	-1.27
Trade intensity elasticity	-0.39	-0.88

Source: Table 1, Antweiler, Copeland, & Taylor, 2001

- Liberalized Trade? Income Gains of x% times Scale minus Technique (.4-1.27) = -.87 + Trade Composition effect (-.88) <0! Free Trade is good for the environment!
- Technological Progress? I.Gains of x% times -.87 $<$ 0 Growth is good!
- Capital accumulation? I. Gains of .3 times Scale minus Technique plus Composition created by Kapital accumulation = .3*(-.87)+1 $>$ 0. Capital accumulation is bad!

Is that it? Are we done?

- Start with the Facts created by the Accounting Approach
- Add in theory when necessary to correct, redirect, or qualify interpretations
- Using Pollution Data drawn from the World Input Output Database and OECD Stat.
- Focus on two heavily regulated local pollutants (SO2 and NOx) and one hardly regulated global pollutant (CO2).

The Facts

Decomposition of Scale, Composition, and Technique

Copeland, Shapiro, & Taylor, 2022

$$Scale = 100 \times \frac{(\sum_i Y_{it})}{(\sum_i Y_{i1995})}$$

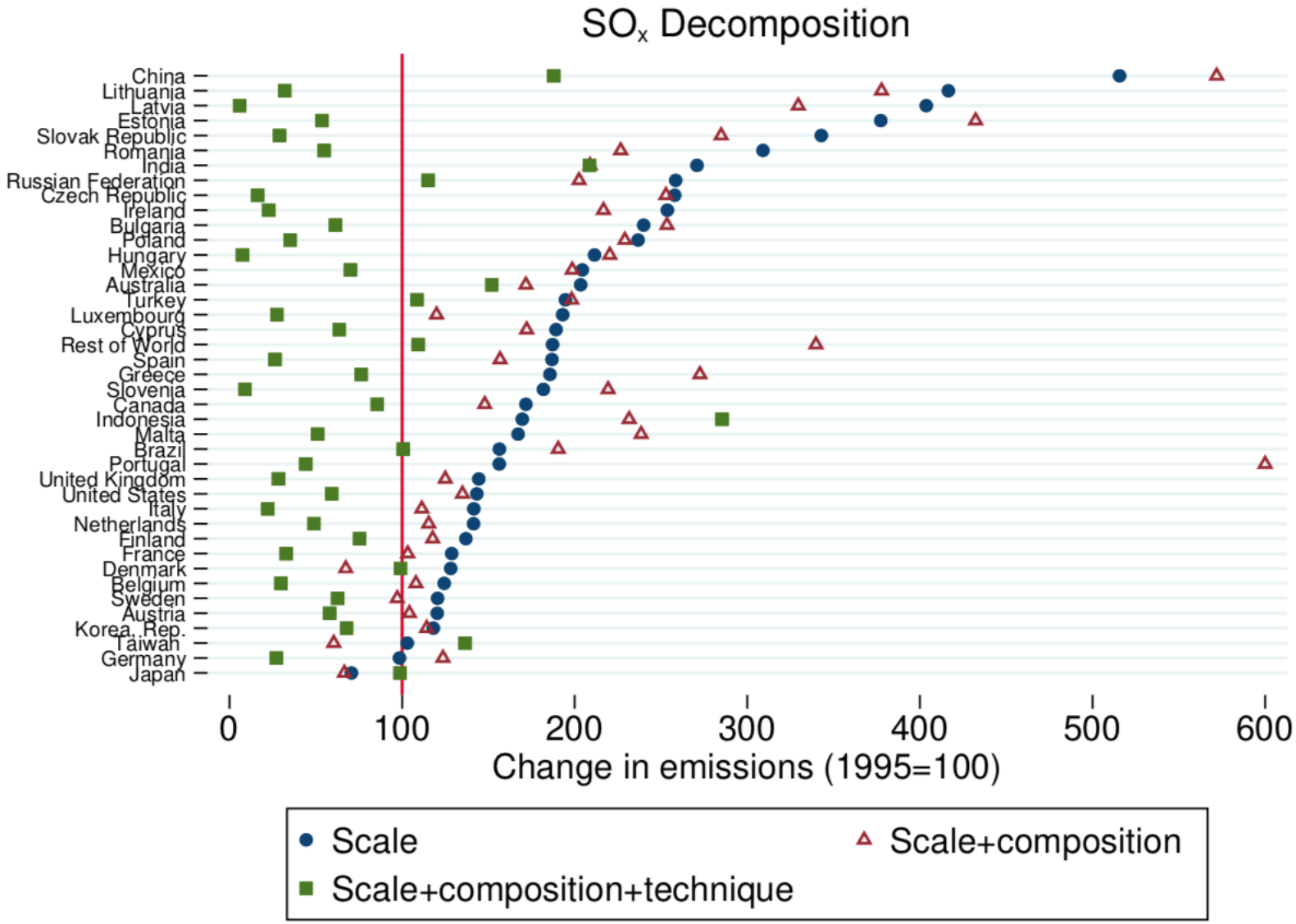
$$Scale, composition, \& \ technique = 100 \times \frac{(\sum_i Y_{it} e_{it})}{(\sum_i Y_{i1995} e_{i1995})}$$

$$Scale \ \& \ composition = 100 \times \frac{(\sum_i Y_{it} e_{i1995})}{(\sum_i Y_{i1995} e_{i1995})}$$

- e_{it} is the emission rate of industry i in year t, and Y_{it} is the real value added of industry i in year t.

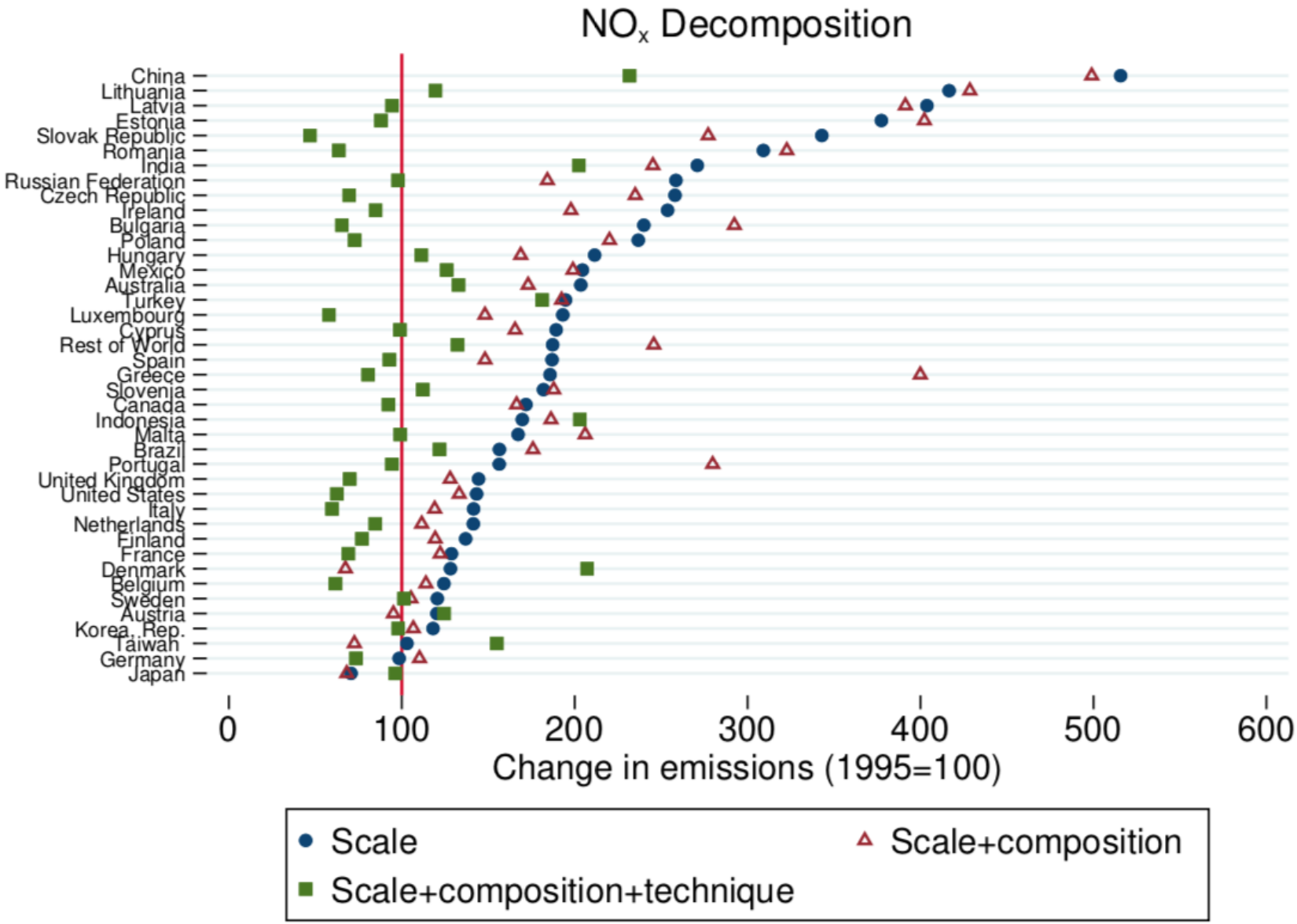
Scale, Composition, and Technique

Sulfur Oxides (SO_x) Decomposition (Copeland, Shapiro, & Taylor, 2022)



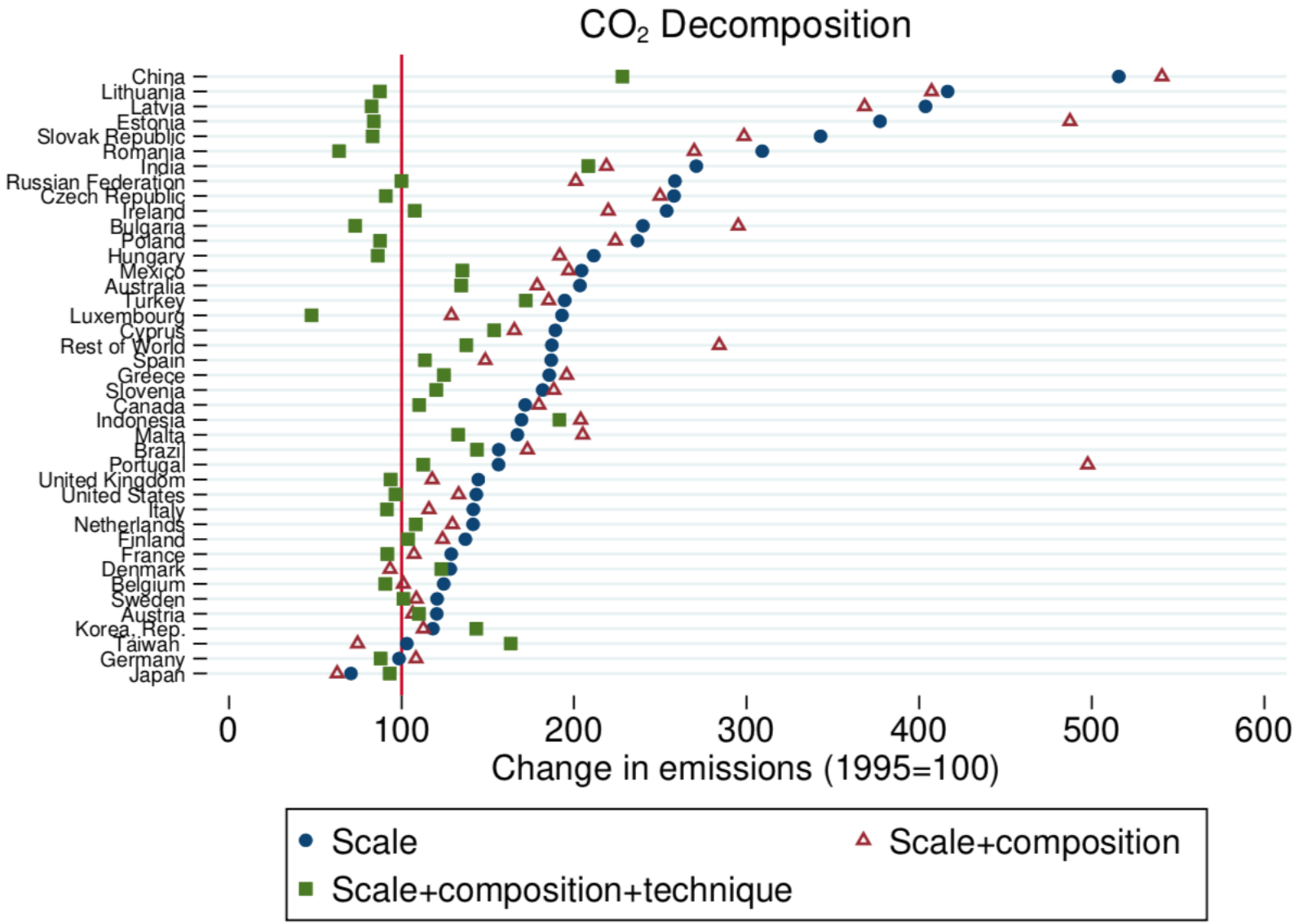
Scale, Composition, and Technique

Nitrogen Oxides (NO_x) Decomposition (Copeland, Shapiro, & Taylor, 2022)



Scale, Composition, and Technique

Carbon Dioxide (CO_2) Decomposition (Copeland, Shapiro, & Taylor, 2022)



Observations from the Data

- Overall SOx has fallen a lot; NOx fallen a little; CO2 has however grown quite a bit especially for economically large countries.
- Composition effects are fairly small. There is some evidence that Rich countries are producing a cleaner set of goods over time.
- Scale effects which are driven by economic growth are large. Looking across countries, there is a fairly strong negative relationship between income per capita and economic growth.
- Technique effects are very large (even for the largely unregulated pollutant CO2). Since there is no abatement technology for CO2, we know something other than abatement is at play.

Three Problematic Conclusions

- Composition effects are small. No simple pattern of Rich countries getting cleaner and Poor countries getting dirtier via changes in the composition of output.
- Does this imply that differences in regulations - that are at the heart of the Pollution Haven Hypothesis and all other theories - have only a minor impact on costs and international competitiveness?
- Technique effects are huge, and this is true for CO2 as well.
- Does this mean that large beneficial changes in emission intensities can be achieved relatively easily, and that governments have responded strongly to demands for cleaner environments?

Why are measured composition effects quite small?

Prior to 2010: Environmental Regulation doesn't matter!

- Early literature found no evidence that more stringent regulation was lowering domestic production and raising imports or lowering exports.
- Measures of pollution stringency were often of the wrong sign - tighter regulation was associated with greater exports!
- Often the weakest results were found in natural resource intensive industries which tend to be the most pollution intensive.
- Researchers claimed the small share of pollution control costs in firm total costs explained the finding
- Confirmed the belief that international trade could not be affected by regulatory differences, and hence pollution havens were unlikely because the competitiveness consequences of tighter regulation were zero.

Post 2010: Environmental Regulations do matter!

- Problem: environmental regulation is not randomly assigned across industries, and it may be determined with trade policy.

- Natural resource industries were both dirty and very export oriented, creating a positive cross-sectional association between pollution control costs and trade flows. OVB
- Large, successful industries drew regulation onto themselves given their scale, but these same attributes often meant they did well in trade. Endogeneity.
- Less successful industries are often shielded from competition via high tariffs (small imports) and lax regulation (lax regulation). Endogenous with trade policy.

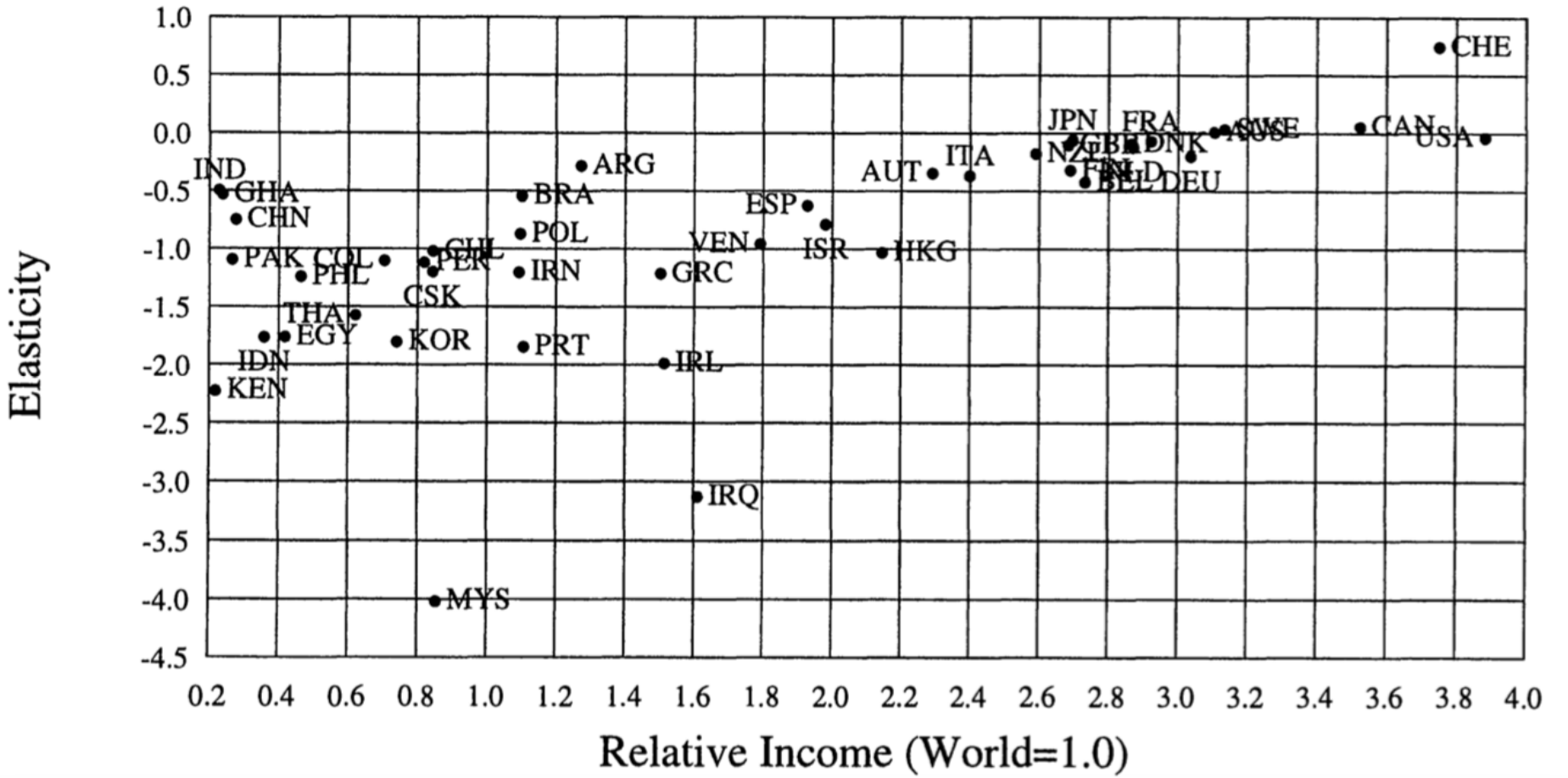
- Fixed effects estimations using panel data sets largely solved the OVB problem; sometimes aided with instrumenting for endogenous pollution policy policy.

If Regulation is costly, why are Composition effects small?

- Environmental regulation has competitiveness consequences: exports fall, imports rise with more stringent regulation.
- Environmental regulation PLUS other factors determine comparative advantage; Rich developed countries seem to be abundant in these factors;
- Therefore trade liberalization will shift only a small fraction of dirty production elsewhere (holding constant foreign direct investment, growth, etc.).

Country-Specific Trade Intensity Elasticities

More than Regulation Matters (Antweiler, Copeland, & Taylor, 2001)



Why are Technique effects so big?

The Technique Effect

Cherniwchan, Copeland, & Taylor, 2017

- Industry level Technique effects are hiding within industry adjustments if firms are heterogenous.
- Let E_i be industry i emissions intensity, $e_i(n)$ the emission intensity of firm n, φ is the share of firm n in industry i output.
- Industry level emission intensity can be rewritten as the weighted sum of firm level intensities.

$$E_i = \frac{Z_i}{X_i} = \int_0^{n_i} e_i(n)\varphi_i(n)dn$$

Unbundling the Technique effect

Cherniwchan, Copeland, & Taylor, 2017

$$\hat{E}_i = \int_0^{n_i} \hat{e}_i(n)\theta_i(n)dn + \int_0^{n_i} \hat{\varphi}_i(n)\theta_i(n)dn + n_i[\theta_i(n_i) - \varphi_i(n_i)]\hat{n}_i$$

- Firms could get cleaner - firm level technique effect - but it could be from active abatement, or it could be ongoing technological progress.
- Cleaner firms could get a larger/smaller share of industry output
- Entry/Exit could alter the distribution of clean and dirty firms.
- Turns out that cleaner firms also tend to be the most productive - energy use could be lower/different, managerial expertise, wastage is low, etc.

Emission Rates and Firm Productivity, Other Pollutants

Copeland, Shapiro, & Taylor, 2022

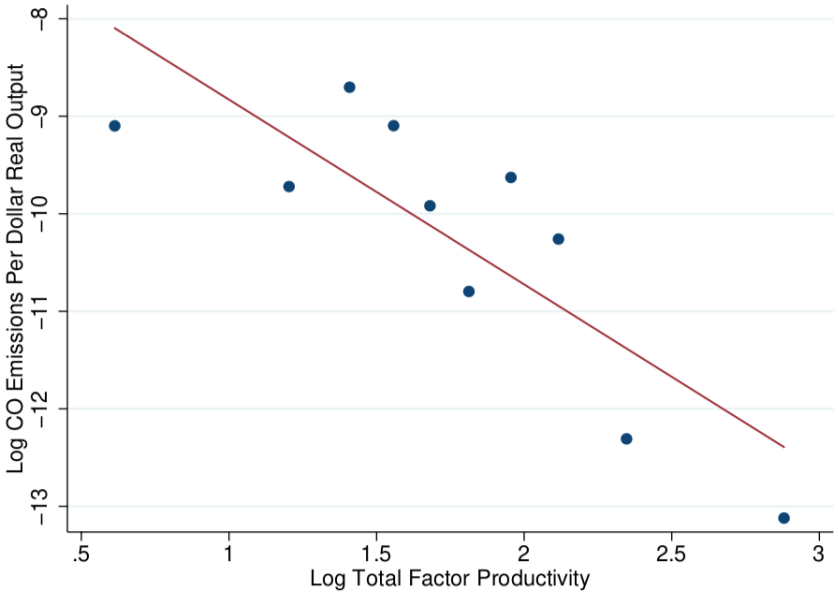


Figure a: Carbon monoxide (CO)

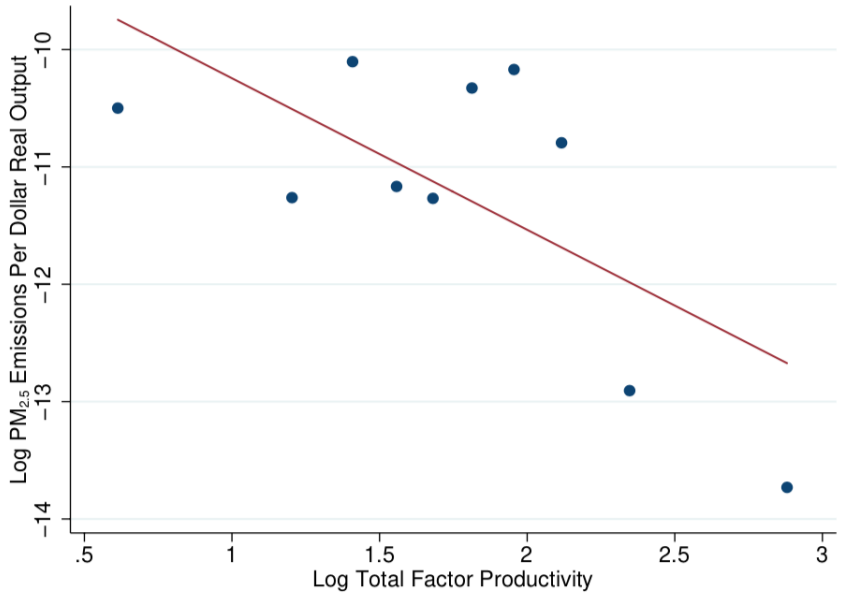


Figure b: Particulate matter smaller than 2.5 micrometers ($PM_{2.5}$)

Emission Rates and Firm Productivity, Other Pollutants

Copeland, Shapiro, & Taylor, 2022

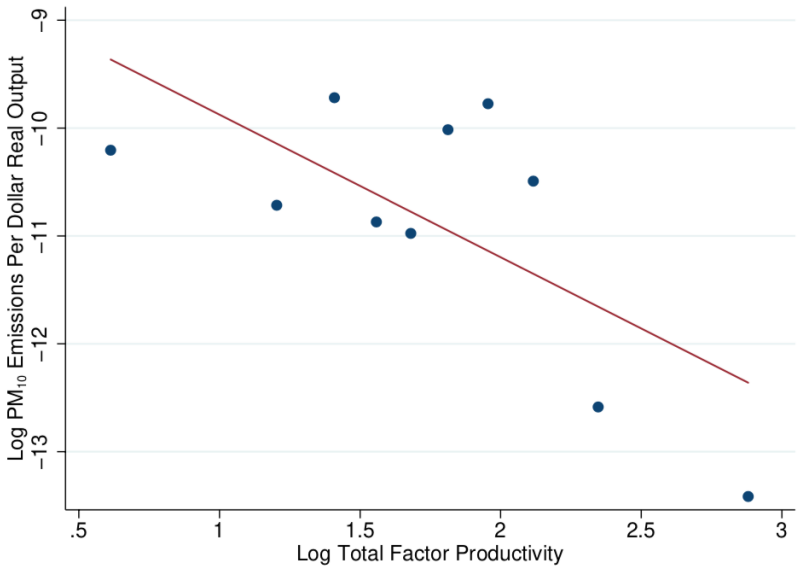


Figure c: Particulate matter smaller than 10 micrometers (PM_{10})

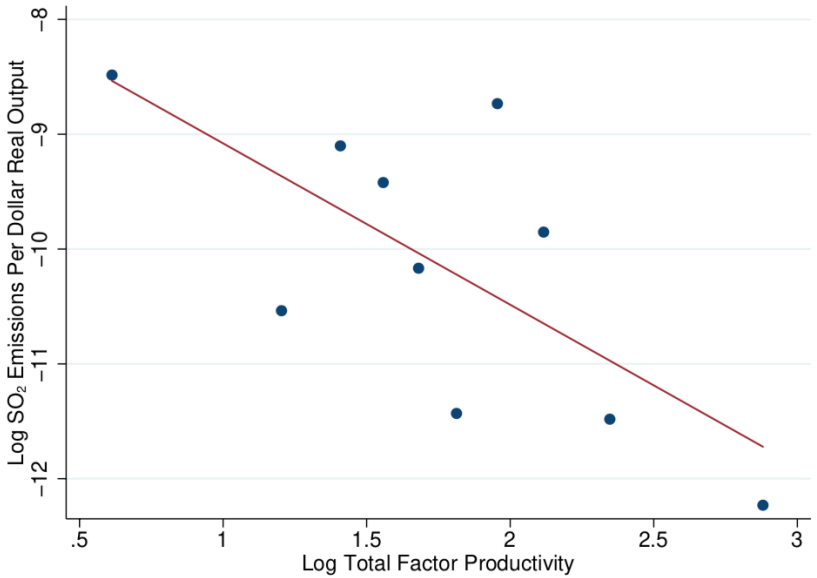


Figure d: Sulfur dioxide (SO_2)

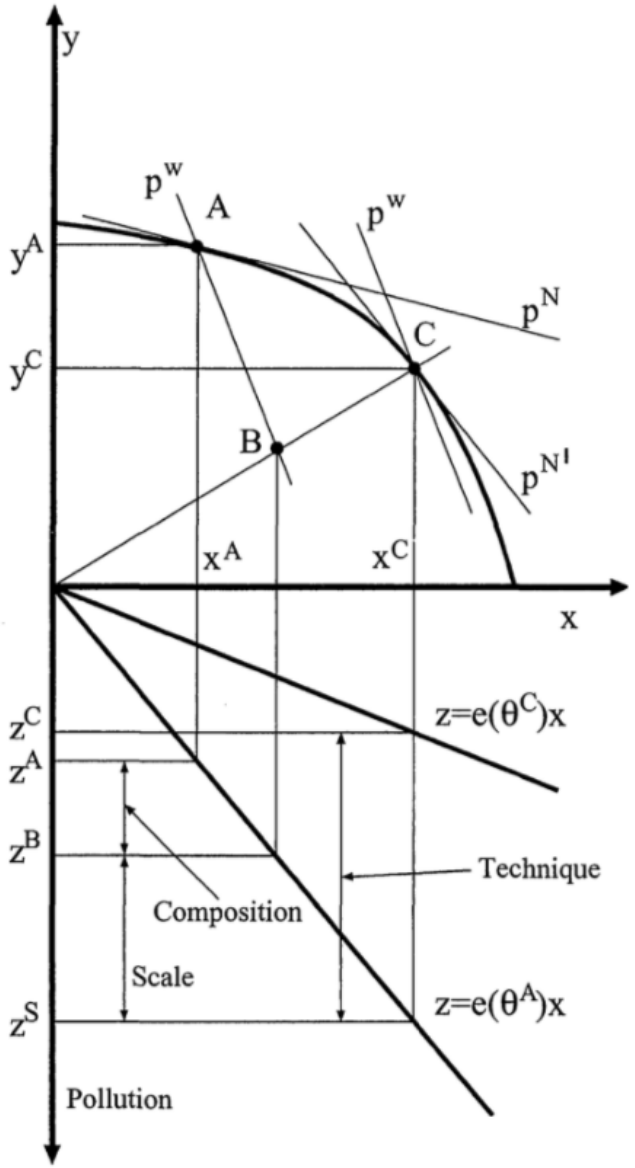
Why are Technique effects so large?

- Free market competition between firms reallocates output to the most productive (and often cleaner) firms. Cleaner firms expand output; less efficient, dirtier firms contract.
- New entrants are cleaner on average (perhaps a vintage effect); older exiting firms are dirtier. If International trade causes industry rationalization and exit, it could be making industries cleaner.
- While this sounds great, the evidence for it is currently minimal. And it needs to carry a heavy burden.
- Instead we need to acknowledge that a lot of what we call a Technique effect is probably exogenous technological progress driving energy intensity down.

Is Globalization Benign?
What's missing?

The Ceteris Paribus: Short Run Effects

Trade Liberalization for a Dirty Good Exporter



Growth is missing

How Big are the impacts of Trade-inspired Growth?

- A difficult inference problem to solve because in theory, trade raises incomes, but incomes raise trade.
- Researchers look for exogenous variation in trade flows unrelated to country income levels
- Typically isolate this variation via an instrumental variable approach.
- Frankel and Romer (1999) were the first to suggest using geography as an instrument for trade. Dani Rodrik and co-authors showed this result was premature.

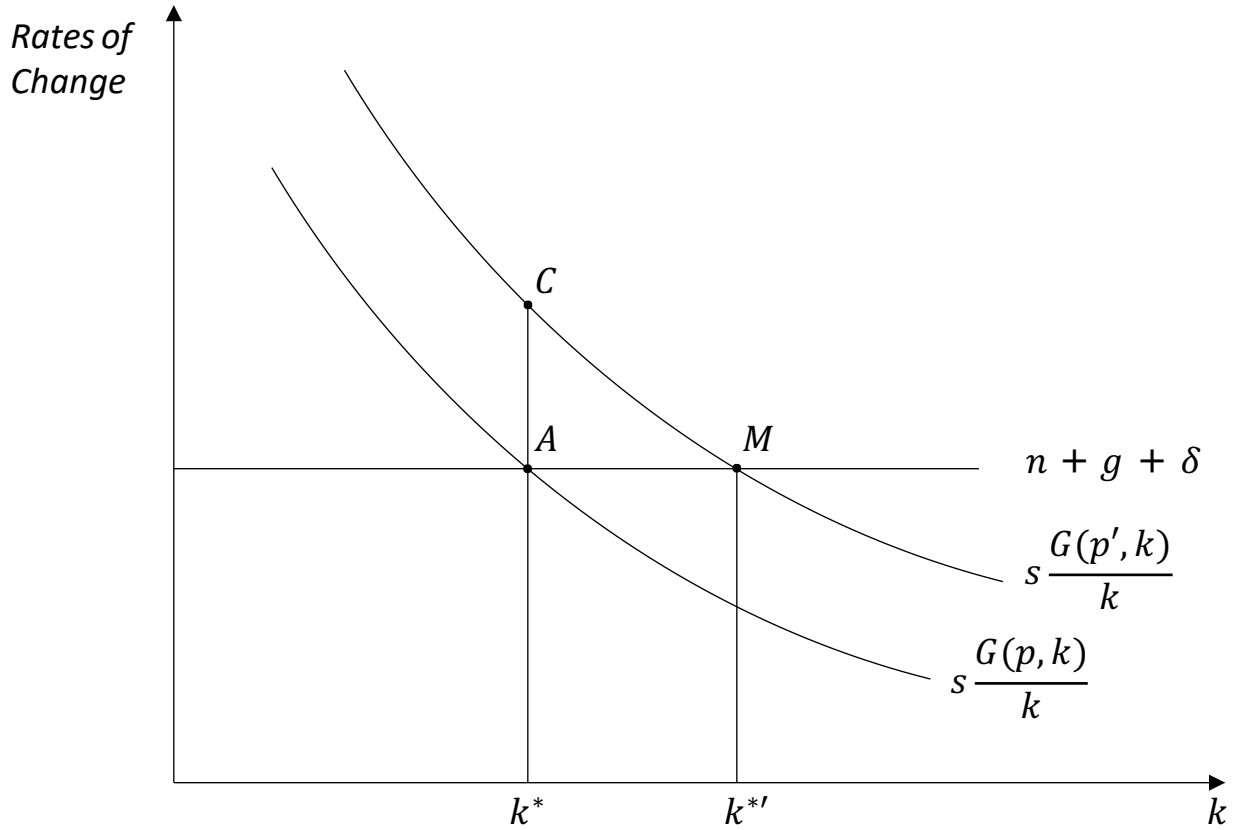
More Recent Evidence

Does Trade cause Growth? (Feyrer 2019, 2021)

- First establishes that distance has a strong bearing on trade flows.
- Shows that minimum distance trade routes changed during the 8 year closure, and this lowered trade for affected parties.
- Finds a doubling of trade would create approximately a 25% increase in real income.
- Feyrer (2019) suggests a larger impact if we take into account other aspects of globalization: movement of people and capital in addition to physical goods. In this case, a doubling of trade increases real income 50%.

How would this work in our Context?

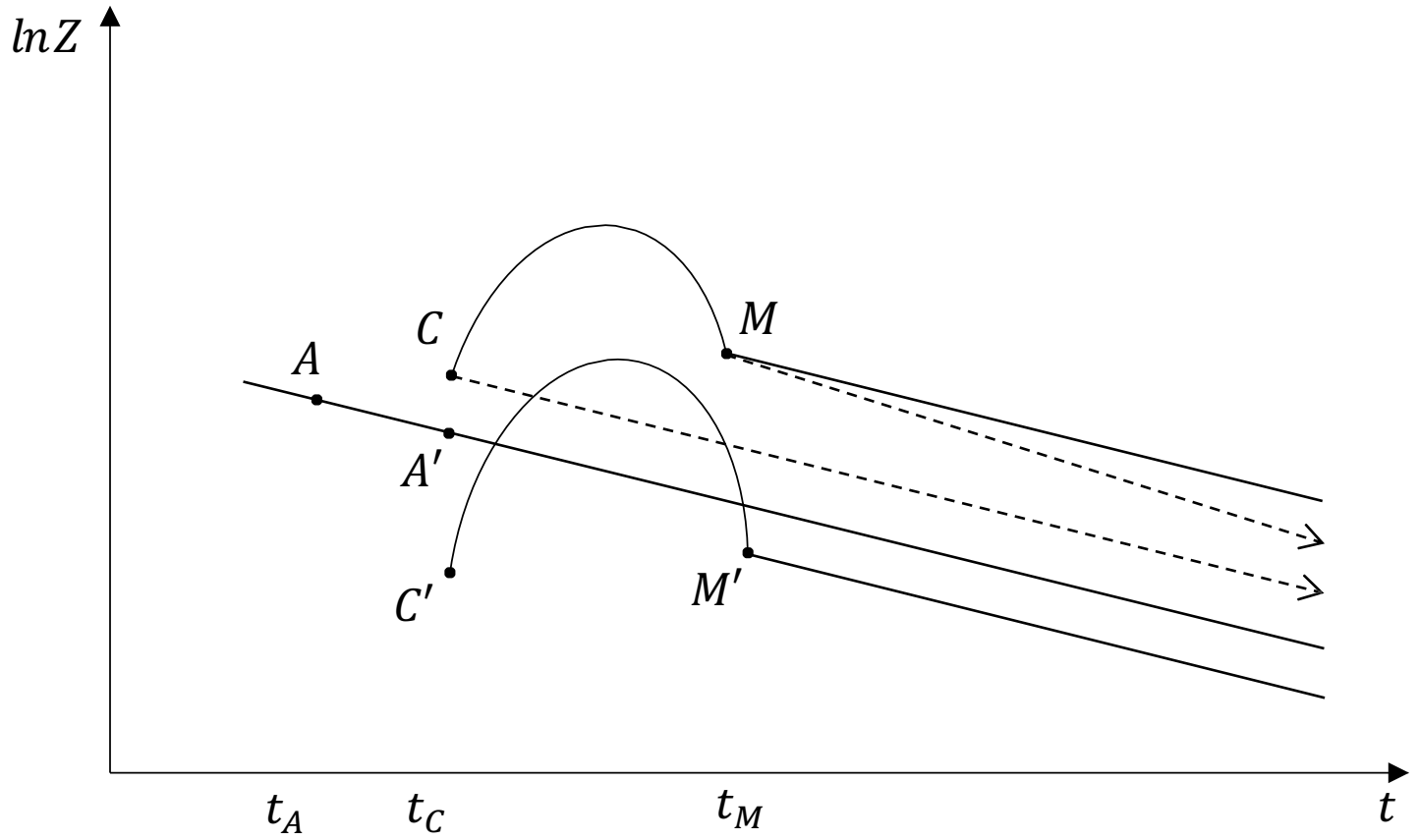
The Impacts of Trade Liberalization in the Green Solow Model (Brock&Taylor 2010)



More Details

The Short and Long Run Implications

Cherniwchan & Taylor, 2022



The Developed World is Along the A to A' path

Pollution Emissions by Country, Cherniwchan & Taylor, 2022

Peak Emissions in 32 Countries: 1990-2019

Country	NO_X	SO_X	VOC	CO
Australia	2018	2002	1994	1997
Austria	2005	$\leq$1990	$\leq$1990	1991
Belgium	1992	1991	$\leq$1990	$\leq$1990
Canada	1999	$\leq$1990	1994	$\leq$1990
Czech Republic	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
Denmark	1991	1991	1991	1991
Estonia	$\leq$1990	$\leq$1990	$\leq$1990	1996
Finland	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
France	1991	1991	1991	1991
Germany	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
Greece	2005	2005	2004	$\leq$1990
Hungary	$\leq$1990	1991	$\leq$1990	$\leq$1990
Iceland	1996	2012	1992	2014
Ireland	2000	1991	1991	$\leq$1990
Italy	1992	$\leq$1990	1992	1993
Japan	1997	$\leq$1990	$\leq$1990	$\leq$1990
Latvia	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990

The Developed World is Along the A to A' path

Pollution Emissions by Country, Cherniwchan & Taylor, 2022

Peak Emissions in 32 Countries: 1990-2019

Country	NO_X	SO_X	VOC	CO
Lithuania	1991	1991	1991	1991
Luxembourg	2005	1993	1991	$\leq$1990
Netherlands	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
New Zealand	2019	2005	2019	2007
Norway	1998	$\leq$1990	2001	$\leq$1990
Poland	$\leq$1990	$\leq$1990	1996	1996
Portugal	1999	1992	1992	1992
Slovak Republic	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
Slovenia	1997	$\leq$1990	1996	1996
Spain	1992	1991	1991	1991
Sweden	1991	$\leq$1990	$\leq$1990	1991
Switzerland	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990
Turkey	1998	2012	2000	2000
United Kingdom	$\leq$1990	$\leq$1990	$\leq$1990	1991
United States	$\leq$1990	$\leq$1990	$\leq$1990	$\leq$1990

Emissions peaks constructed using data on air emissions taken from OECD Stat Database (2022). Dates listed under each heading indicate the year when emissions of the corresponding pollutant peaked, with $\leq$1990 implying that the peak occurred in 1990 or earlier.

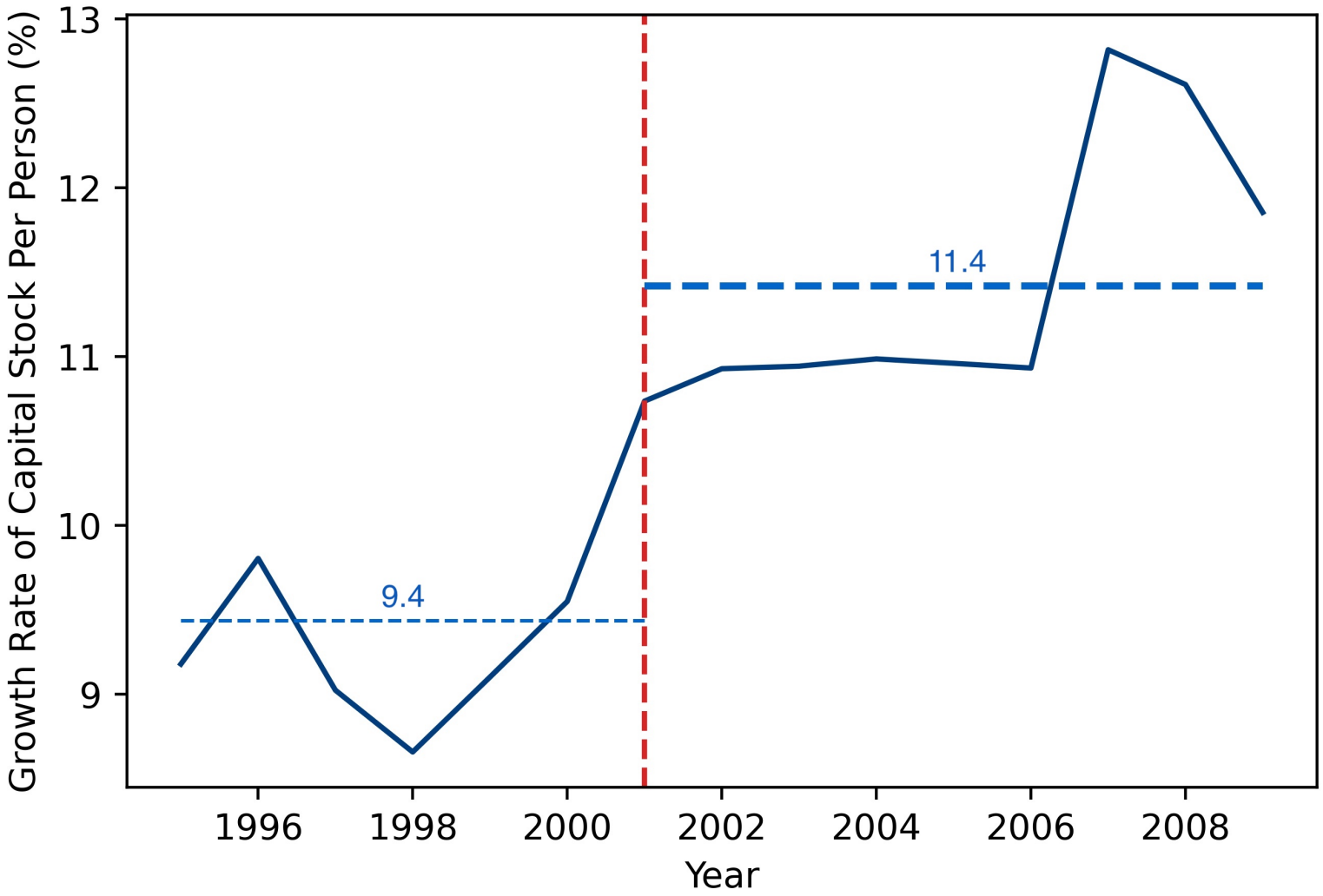
The Developing World is Not

A Back of the Envelope Example

- China's real income grew 5 fold from 1995 to 2009.
- China's exports plus imports grew 6.5 fold
- China's trade growth caused somewhere between 30-60% of the growth in China's Scale (Feyrer (2019,2021)).
- A mid-way estimate of 45%, implies little less than half of its 5 fold Scale effect was created by trade.
- This will have a huge effect on pollution - if this trade inspired capital accumulation created the scale effect.

China Accession to WTO in 2001

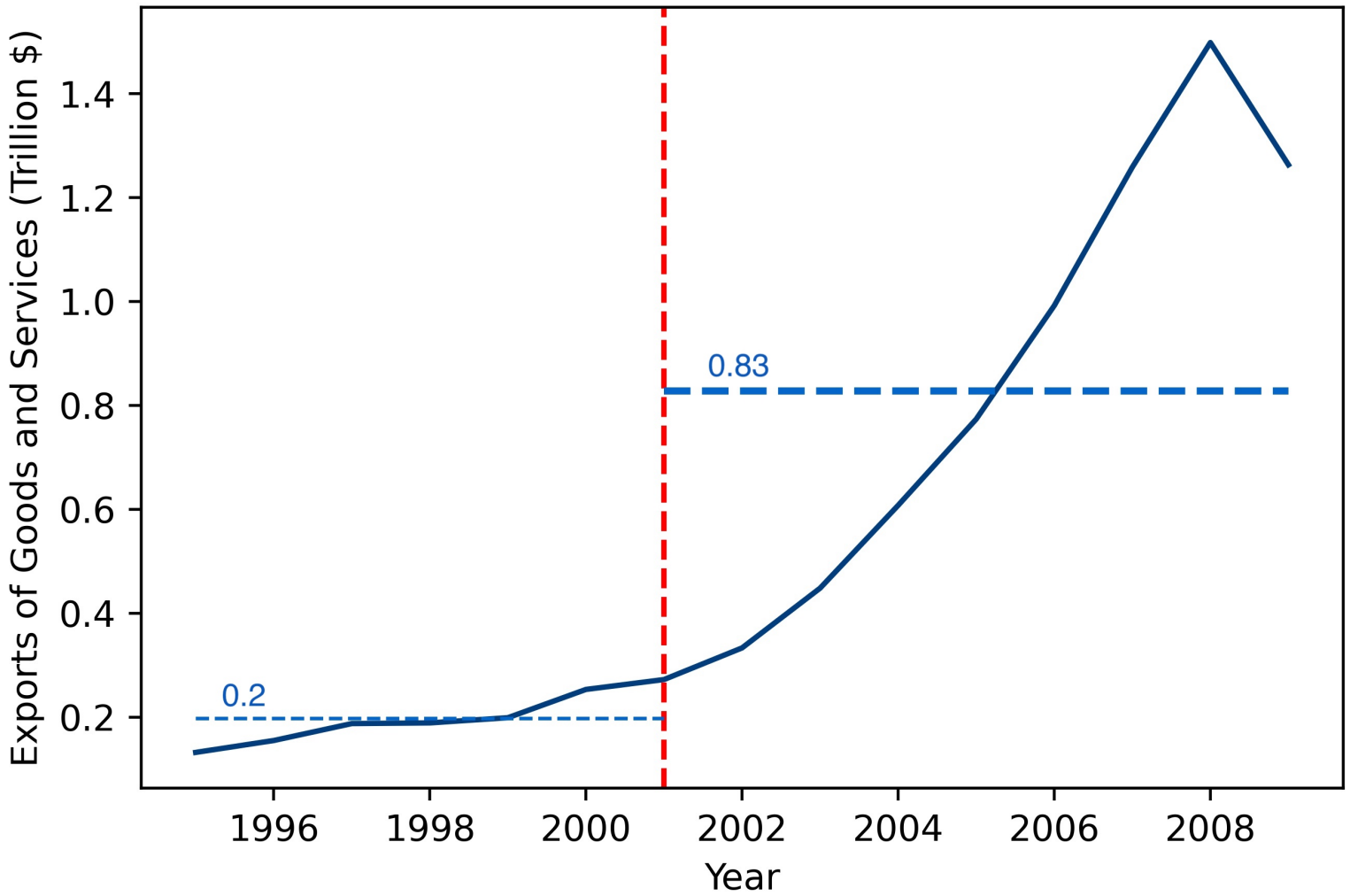
Growth Rate of Capital Stock Per Person in China



Data Source: Federal Reserve Bank of St. Louis

Evidence in Favour: China Accession to WTO in 2001

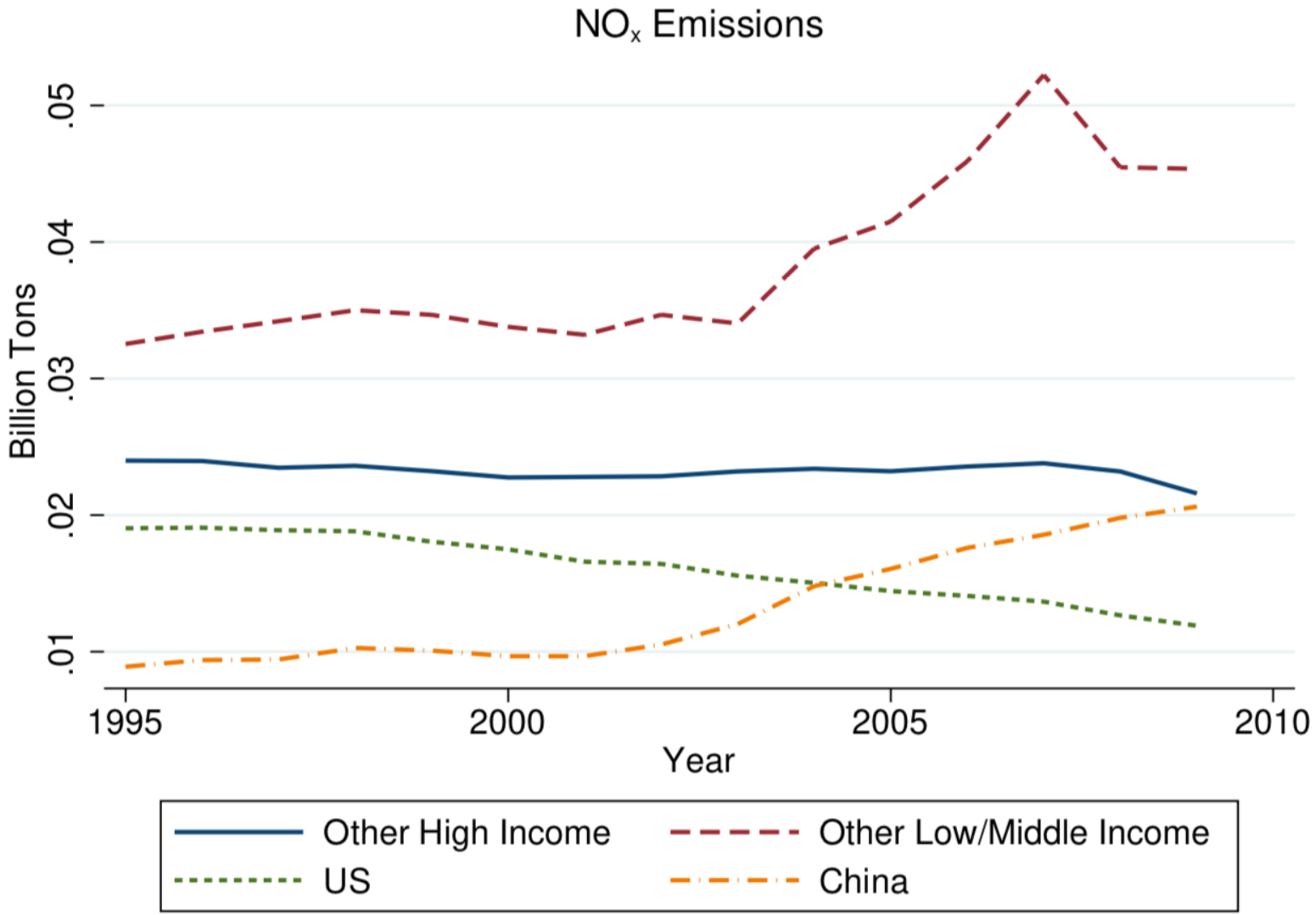
Exports of Goods and Services in China



Data Source: World Bank national accounts data

Evidence in Favour?

China Accession to WTO in 2001 (Copeland, Shapiro, & Taylor, 2022)



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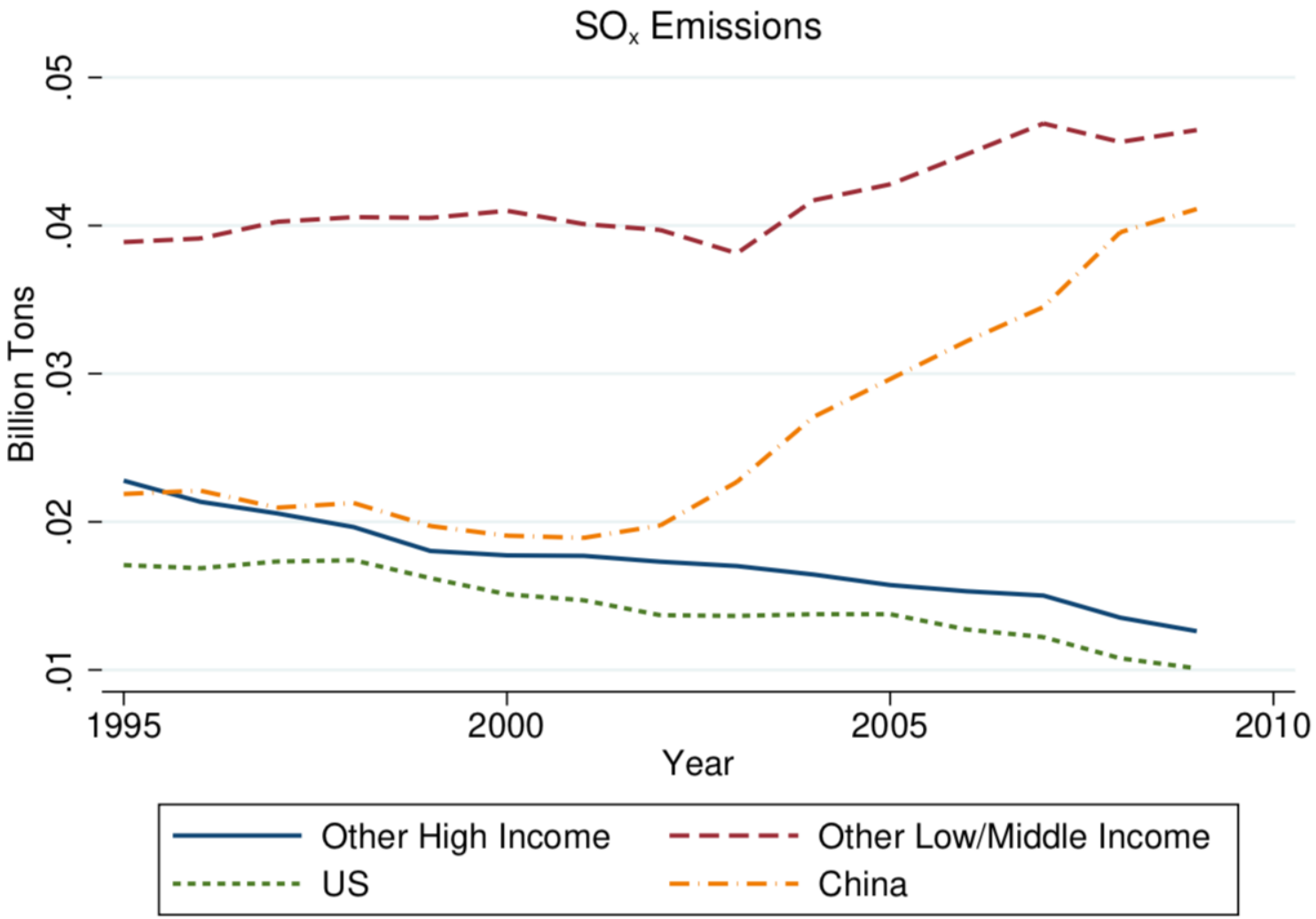

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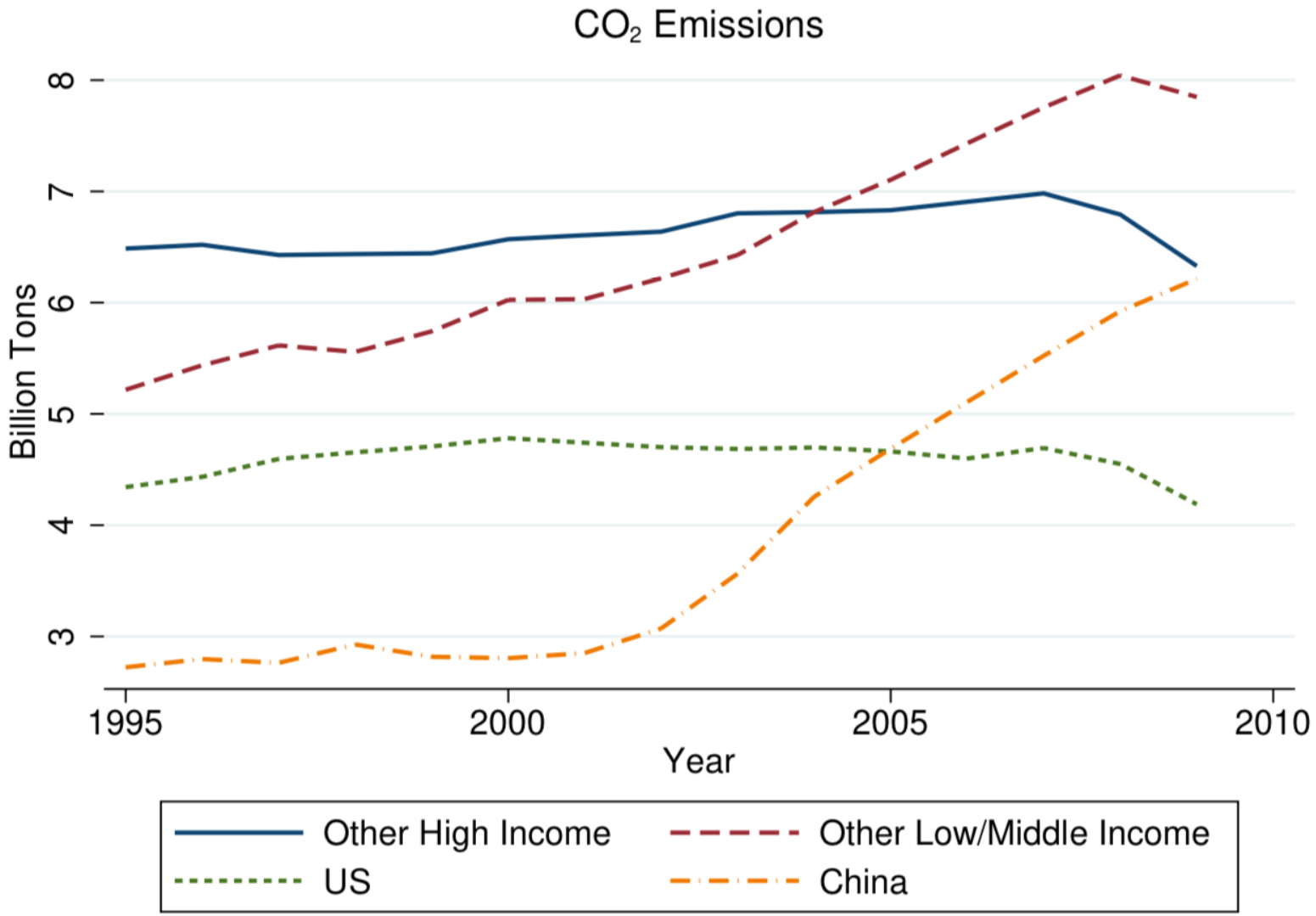


Conclusions

- Globalization may raise or lower pollution in the short or long run because of potentially offsetting effects. There will be trade-offs, but globalization brings large benefits to hundreds of million people.
- It is most likely to be Environmentally friendly when pollution is local and governments responsive to the demands of citizens.
- Globalization is unlikely to be Environmentally friendly when pollution is global, governments undemocratic, and trade inspires capital accumulation led growth.
- Many recent liberalizations have occurred in developing countries where capital accumulation led growth dominates - This growth has not been Environmentally Friendly.

Thank You

Questions?

Appendix

Green Solow

$$y = [1 - \theta]k^{\alpha}$$

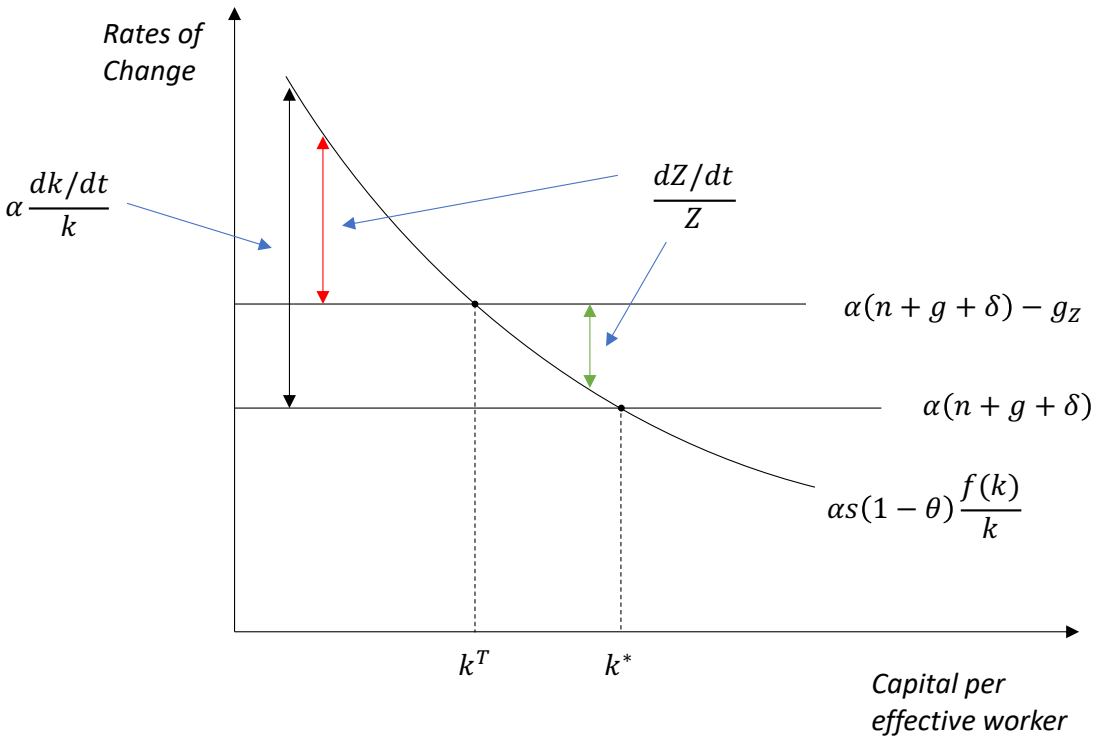
$$\dot{k} = s[1 - \theta]k^{\alpha} - [n + g + \delta]k$$

$$Z = \Gamma A(\theta)k^{\alpha}BL$$

$$\frac{\dot{B}}{B} = g \quad \text{and} \quad \frac{\dot{\Gamma}}{\Gamma} = -g^{*}$$

Green Solow

Convergence and the EKC



$$\frac{\dot{Z}}{Z} = \alpha \frac{\dot{k}}{k} + [g + n - g^*]$$

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Further Reading

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