How significant is the ~~carbon~~ pollution content of trade?

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McKibbin and Wilcoxen's analysis in this volume is prospective. It predicts future trade patterns after developed countries unilaterally impose hypothetical carbon taxes that disproportionately affect carbon-intensive industries. Their analysis is sophisticated, state-of-the art, and probably the best conceivable approximation to the true future effect of carbon taxes on trade, but it remains in the end a forecast, arguably not something economists are best at.

My point, then, is that the question posed by the title of this session can just as well be answered by a *retrospective* analysis, so long as we are willing to replace as-yet-unregulated carbon for a pollutant developed countries began regulating 30 years ago. The idea is that it is easier to say what happened 30 years ago than to predict what will happen thirty years from now.

Thirty years ago the United States unilaterally imposed strict pollution regulations that disproportionately affected pollution-intensive industries, raising fears that those industries would relocate to "pollution havens," a process now being called "leakage." Manufacturing sector pollution abatement operating costs in the U.S. doubled as a fraction of value shipped between 1974 and 1991, but this doubling was spread unevenly across industries. For some (petroleum refining, primary metals, pulp and paper), costs tripled or even quadrupled. For other industries, pollution abatement costs remained small or even declined. Did this change in comparative advantage across manufacturing industries lead to leakage in the past? For evidence of that, begin with U.S. manufacturing output depicted in figure 1.

The top line in figure 1 plots the real value shipped by U.S. manufacturers, from 1972 to 2001, indexed so the 1972 value equals 100. Real manufacturing output rose 71 percent. If over this period there were no change in the technology of abatement or production, and no change in the mix of industries comprising US manufacturing, then we would expect pollution emitted by US manufacturers to also have risen 71 percent over this period. (Manufacturers would be producing 71 percent more of the same goods using the same methods.) But of course we know that the composition US manufacturing output has changed. We produce different goods today than we did 30 years ago – and one of the reasons might be "leakage" caused by polluting industries avoiding U.S. environmental regulations.

The bottom line in figure 1 calculates the extent of the change in composition of U.S. industries as it affects one particular pollutant, sulfur dioxide (SO2). It uses the 1997 emissions intensities of each of the 470 industries that make up the manufacturing sector, as calculated by the U.S. Environmental Protection Agency. For every year, I multiply each industry's output by its corresponding 1997 emissions intensity, and then sum the predicted SO2 emissions across all industries. The result is the predicted amount of SO2 that would have been emitted by US manufacturing, using the 1997 technologies,

but the concurrent scale and mix of industries. The bottom line rises 19 percent, and is lower than the 71 percent manufacturing growth for one reason – U.S. manufacturing has shifted towards industries that emit less SO2. This "green shift" of the US manufacturing composition resulted in SO2 emissions that were 30 percent lower than they would have been had the mix of industries remained the same. Where did this extra SO2 pollution go? If the SO2-intensive industries fled to pollution havens and imported their products to the U.S., we would call that leakage.

To examine whether the green shift of US manufacturing might be explained by leakage, figure 2 conducts exactly the same analysis, but with imported manufactured goods instead of domestically produced goods. Here I am careful to account for pollution caused by intermediate inputs to the final imports, using a Leontief-style input-output calculation similar to that used by McKibbin and Wilcoxen. The top line in figure 2 depicts the real value of imports, which increased 641 percent from 1972 to 2001. The bottom line depicts the SO2 that would have been emitted as a consequence of manufacturing those imports, had they been produced in the US using 1997 technologies.

Figure 2 depicts two noteworthy results. First, the composition of imports became cleaner over time, not dirtier. The 30 percent green shift of US manufacturing was not accompanied by a corresponding "brown shift" on the part of imported goods. Instead, the composition of imports also shifted towards less pollution-intensive goods. Second, and perhaps more startling, imports shifted towards less polluting goods *faster* than domestic goods. The SO2 content of imported goods was 43 percent lower that it would have been if the mix of goods being imported had remained constant.

Now, some might look at figure 2 and note that US imports are dominated by trade with other developed economies that were themselves enacting strict environmental regulations during this period: Canada, Japan, and Europe. If there was leakage, perhaps the SO2 moved to developing countries more likely to be pollution havens. That shift might not be apparent in aggregate imports data composed mostly of imports from developed economies.

To address that concern, figure 3 conducts exactly the same analysis but limited to imports from non-OECD countries. The figure rebuts the conjecture that leakage will be apparent in import data from less-developed countries. In fact, the green shift in imports from non-OECD countries (50 percent) was even larger than the green shift in aggregate imports (43 percent), which was itself larger than the green shift in domestic production (30 percent).

Thirty years ago the US began seriously regulating industrial emissions of common air pollutants such as SO2. In the ensuing years, the US manufacturing base has shifted away from production of goods that emit SO2. But at the same time, imports to the US, in general and from non-OECD countries in particular, have also shifted away from SO2-intensive goods.

Note that these trends do not mean there was no leakage of SO2 emissions from the US to importing countries. It could be that there was leakage, and as a consequence, the US manufacturing green shift was larger than it otherwise would have been, and the imported goods' green shift was smaller. To assess that possibility, we need a general equilibrium analysis like that of McKibbin and Wilcoxen. All this analysis shows is that if there was leakage, it is not apparent in aggregate data and was swamped by other

changes in the past 30 years: trade liberalization, oil prices, labor costs, and changing preferences.

My forecast, then, based on this retrospective analysis, is that any carbon leakage in the future will also be swamped by as-yet-unforeseen forces affecting the composition of trade.

Figure 1

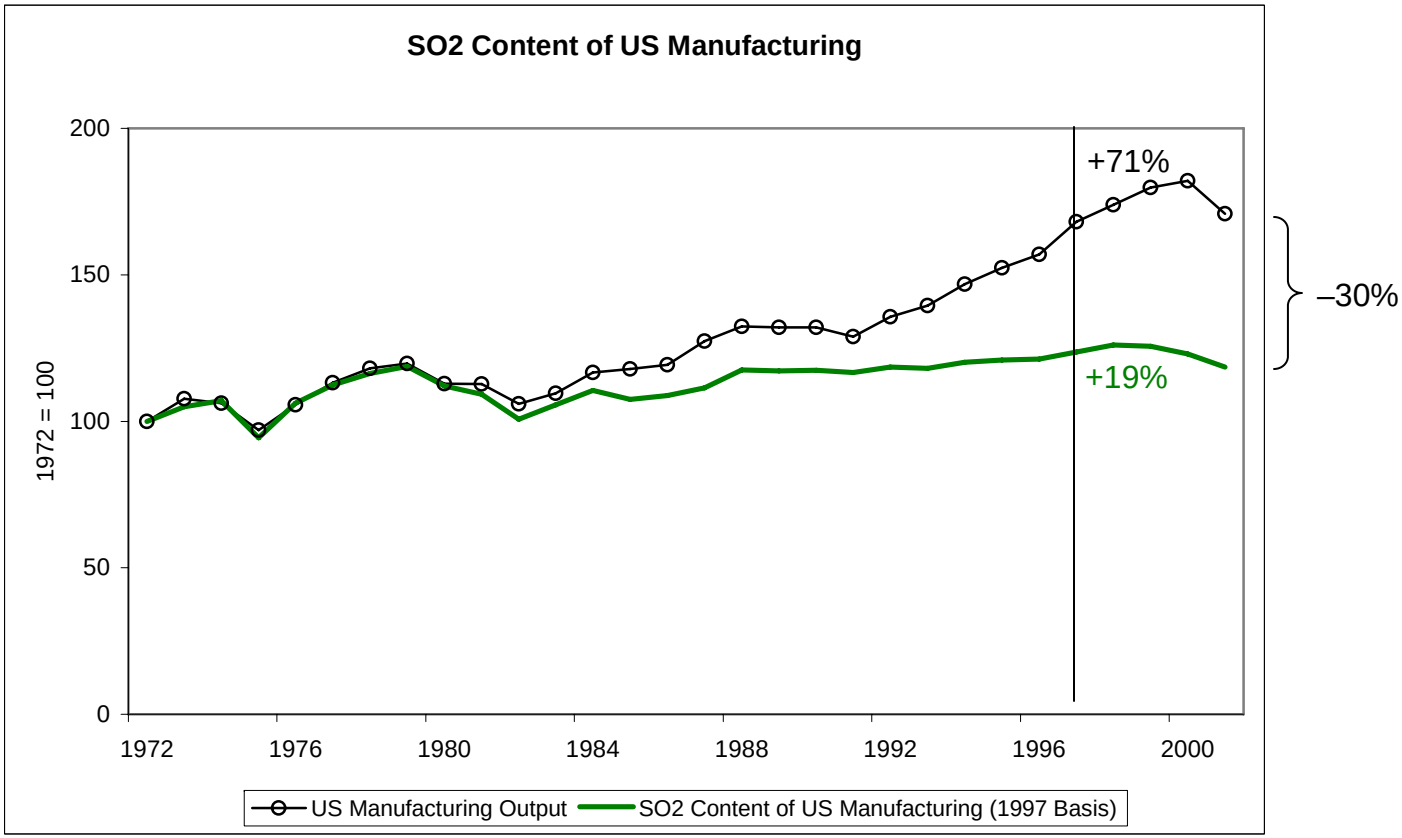

SO2 Content of US Manufacturing
200
150
100
50
0
1972 = 100
1972
1976
1980
1984
1988
1992
1996
2000
+71%
+19%
–30%
US Manufacturing Output
SO2 Content of US Manufacturing (1997 Basis)

Figure 2

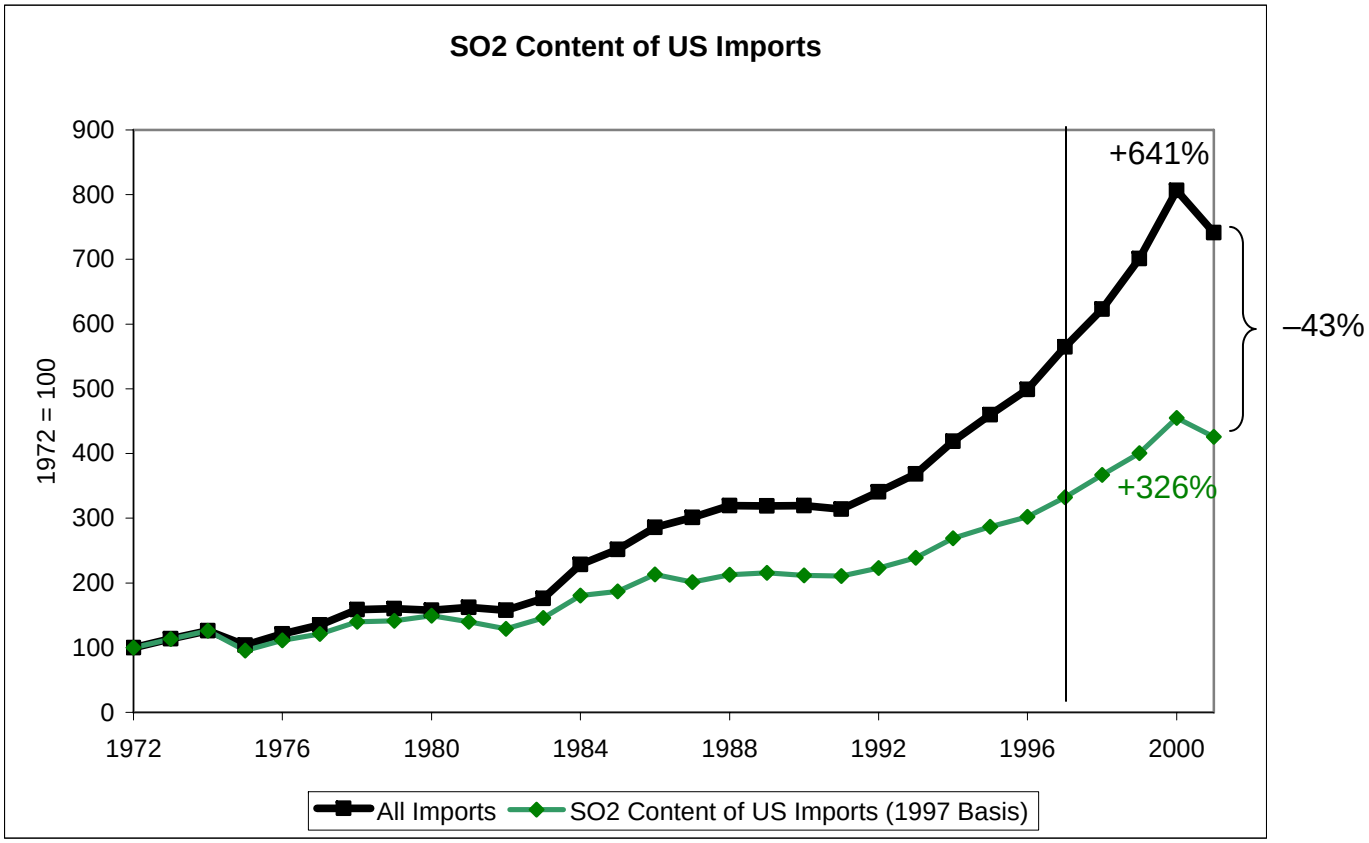
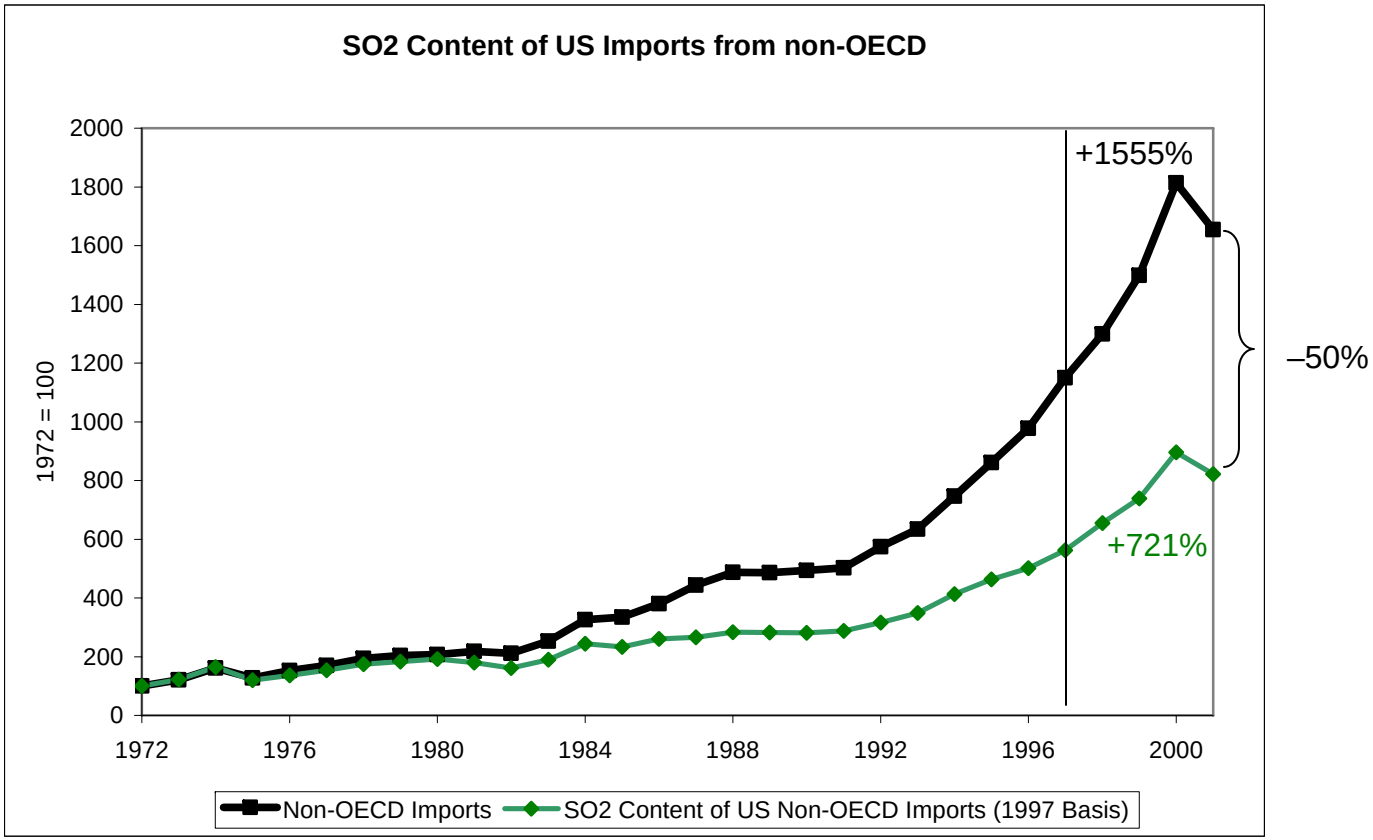

SO2 Content of US Imports
900
800
700
600
500
400
300
200
100
0
1972 = 100
1972
1976
1980
1984
1988
1992
1996
2000
+641%
–43%
+326%
All Imports
SO2 Content of US Imports (1997 Basis)

Figure 3


SO2 Content of US Imports from non-OECD
1972 = 100
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1972
1976
1980
1984
1988
1992
1996
2000
+1555%
+721%
–50%
Non-OECD Imports
SO2 Content of US Non-OECD Imports (1997 Basis)