Economic consequences of carbon abatement: some lessons from the past

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New US rules cap CO_2 emissions per MWh of electricity. Research based on historical experience in the US and EU suggests that the rules will not lead to a decline in manufacturing or a rise in imports. Worldwide, economic growth has outpaced declines in energy intensity, meaning that carbon abatement will require reducing the carbon content of energy, not just the energy intensity of the economy.

In a much anticipated announcement of June 2, the United States Environmental Protection Agency (EPA) released its proposal to cut CO_2 emissions at existing power plants. While the rule has some way to go before being finalized, including a public comment period and inevitable litigation, one remarkable feature of the plan is its flexibility. It gives each US state a target ratio of CO_2 emissions per megawatt hour of electricity generated, ranging from 215 pounds in Washington to 1783 pounds in North Dakota[4]. States must achieve their goals by 2030, but the EPA only offers suggestions for how they might get there: improving power plant heat rates, replacing coal with natural gas and renewables, and encouraging end-user energy efficiency. Depending on the strategies that states pursue, the EPA forecasts that CO_2 emissions from electricity generation will decline by about 30 percent relative to 2005 levels. Already, some have begun arguing that the US proposal doesn't go far enough, while others are claiming the new rules will devastate American manufacturing, increase imports, and slow down economic growth[5].

Most of the forecasts are speculative, especially given how little we know about the ways states and utilities will eventually choose to comply with the EPA's targets, but we do have historical experience to draw on. The EU and the US have been regulating industrial pollution for decades – not carbon pollution but certainly for other similar air pollutants – and the economic consequences

[4] For more information about the new U.S. rule, see here: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule.
[5] Landberg, Reed "EU Calls on Deeper U.S. Emissions Cuts to Protect Climate" [http://www.bloomberg.com/news/2014-06-02/eu-calls-on-deeper-u-s-emissions-cuts-to-protect-climate.html] Bloomberg News. June 2, 2014. U.S. Chamber of Commerce, "Assessing the Impact of Proposed New Carbon regulations in the U.S." [http://www.energyxxi.org/epa-regs] 2014.

should be comparable.

From 1995 to 2008 sulfur dioxide emissions from manufacturers fell 59 percent in the EU and 63 percent in the US. How was that cleanup achieved? Drastic declines in manufacturing output? An increase in imports of goods the manufacture of which creates pollution? New research by Claire Brunel at Georgetown shows that neither of those explanations holds[6]. The manufacturing sectors of the EU and the US didn't shrink at all during this period. They grew by 39 percent in the EU and 31 percent in the US. And imports into the regions did not shift towards more polluting products – if anything, imports shifted towards cleaner products, while in the EU the composition of domestic production shifted towards more polluting products, not less.

So how did the EU and the US reduce emissions from manufacturing without reducing manufacturing output and without importing proportionally more products made via pollution-intensive processes? According to Brunel, the biggest explanation must be technological changes to manufacturing production: cleaner fuels, more efficient use of those fuels, or end-of-pipe pollution abatement technologies. And she finds similar patterns for two other common air pollutants: nitrogen dioxides and volatile organic compounds.

Brunel's research, like my own work for an earlier period in the US, represents good news for the rest of the planet[7]. If the cleanup in the EU and the US had come from declines in manufacturing output, that might be a sacrifice too costly for lower-income countries to replicate. And if the cleanup had come from importing polluting goods previously manufactured domestically, that would not be a process that lower-income countries could replicate even if they wanted to, unless they could find ever-poorer countries with which to trade.

New research shows that air pollution from manufacturing has declined, while manufacturing output has increased

However, technological change can be mimicked worldwide, and in fact might be less expensive if other countries can adopt technologies already developed to meet regulations in the EU and US[8–9]. Of course, CO_2 is different from the pollutants that Brunel studies. It's a global pollutant, making it critical that regulation in the EU and US does not result in shifting carbon emissions to less-regulated countries. Brunel's research suggests that won't necessarily happen. And CO_2 also differs in that there are no working, economical, large-scale, end-of-pipe, abatement technologies. That means that meeting ambitious CO_2 emissions targets will require either switching to less carbon-intensive fuels or reducing the economic importance of energy generation. On that issue, again we have historical experience on which to draw.

World energy use per dollar of output has declined by 25 percent since 1980, but that decline masks considerable heterogeneity (Fig. 4). In the Middle East, energy consumption rose faster than economic

[6] Brunel, Claire (2014), "Pollution Offshoring and Emission Reductions in EU and US Manufacturing" [http://ssrn.com/abstract=2447679].

[7] Levinson, Arik (2009) "Technology, International Trade, and Pollution from US Manufacturing" [http://pubs.aeaweb.org/doi/pdfplus/10.1257/aer.99.5.2177] American Economic Review 99(5) pp. 2177-92.

[8] Hilton, F. G. (2001), "Later Abatement, Faster Abatement: Evidence and Explanations from the Global Phase-Out of Leaded Gasoline" [http://jed.sagepub.com/content/10/3/246.full.pdf+html] *Journal of Environment and Development* 10(3) pp.246-265.

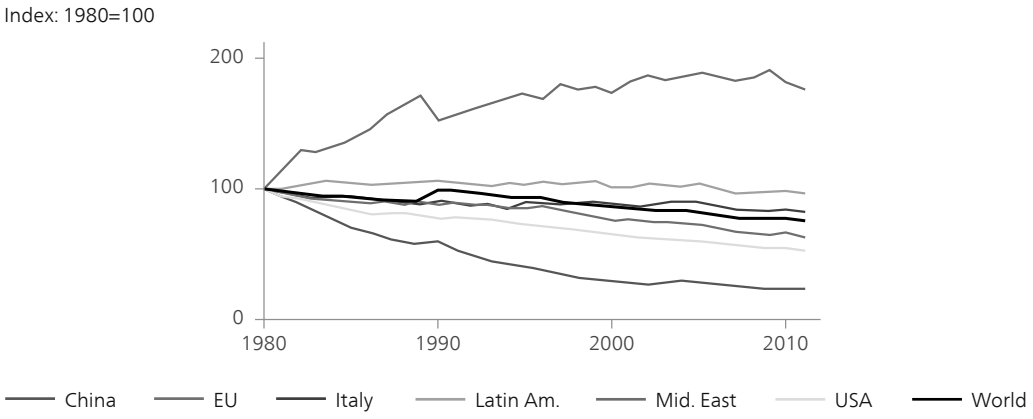
[9] In fact, the export rate of greenhouse gas mitigation technologies is over 40 percent in the US and up to 90 percent in the Netherlands. Dechezlepretre, Antoine, Matthiew Glachant, Ivan Hascic, Nick Johnstone, and Yann Meniere. (2011). "Invention and Transfer of Climate Change-Mitigation Technologies: A Global Analysis" [http://reep.oxfordjournals.org/content/5/1/109.abstract?sid=a1e4b085-d5d9-4391-9fcb-c15057543163] Review of Environmental Economics and Policy 5 (1) 109-130.

growth. In China, where rapid economic growth has been the lead story, energy intensity fell.

Looking across US States, we can see a similar pattern (Fig. 5). National energy use per dollar of output has declined by 45 percent since 1980, with similar heterogeneity. In states with abundant energy resources – Alaska, North Dakota, Wyoming – energy intensities rose, or fell less rapidly. Western states like Oregon and California have seen their energy intensities fall.

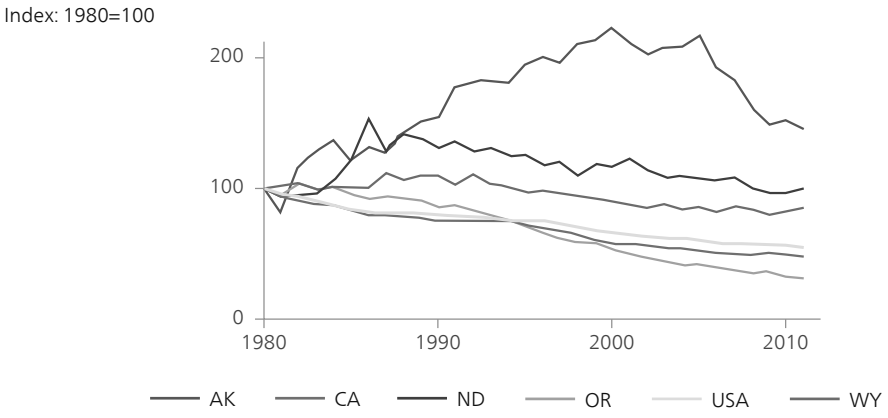
If the world is to reduce CO_2 emissions while continuing to grow, we are going to have to follow paths more like China's and Oregon's, and less like those of the Middle East and Alaska. My own research in progress examines the determinants of US State energy intensities to see if there are lessons that can be extrapolated to the rest of the world. But it won't be enough to merely ensure that energy intensities decline, because even though Oregon's energy intensity has declined by 69 percent in the last 30 years, its state economy has grown by 240 percent. Overall energy use by Oregonians therefore grew. And even though China's energy intensity fell by 76 percent, its economy grew by a factor of 37, so overall energy use in China grew by a factor of 9. Just reducing energy intensities won't be enough – the world needs to reduce the carbon intensity of that energy or reduce total energy consumption.

FIGURE 4 – World Energy Use per Dollar of GDP



Source: World Bank World Development Indicators, kg oil equivalent, constant 2005 PPP $

FIGURE 5 – US State Energy Use per Dollar of Gross State Product



Source: US Energy Information Administrator, 1000 BTU per chained 2005 $