Checking China's pollution by satellite

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Air pollution has smothered China's cities in recent decades. In response, the Chinese government has implemented measures to clean up its skies. But are those policies effective? Now an innovative study co-authored by an MIT scholar shows that one of China's key antipollution laws is indeed working—but unevenly, with one particular set of polluters most readily adapting to it.

The study examines a Chinese law that has required coal-fired power

plants to significantly reduce emissions of sulfur dioxide, a pollutant associated with respiratory illnesses, starting in July 2014. Overall, the researchers found that with the policy in place, the concentration of these emissions at coal power plants fell by 13.9 percent.

"There is a significant drop in sulfur dioxide concentrations around the policy deadline," says Valerie Karplus, an assistant professor at the MIT Sloan School of Management and co-author of a newly published paper detailing the results. "That's really important. The stakes are really high in China."

However, that top-line result comes with some quirks. The law called for greater sulfur dioxide emissions reductions in regions that were more heavily polluted and are more populous, yet those places—known as "key" regions in policy terms—are precisely where plants have been least compliant, the researchers found.

"We see the lowest correspondence between sulfur dioxide reported by plants and in independent satellite measures in key regions," Karplus notes. That includes coal-fired plants in the areas around Beijing and Shanghai, among other populous, economically well-off places.

Indeed, the researchers discovered this precisely because the method they employed in the study compares satellite data measuring sulfur dioxide, on the one hand, to data from relatively new, on-the-ground emissions-monitoring systems—an approach that can pinpoint places where emissions exceed the law, even if audits and reports do not catch the excess pollution.

The paper, "Quantifying coal power plant responses to tighter SO2 emissions standards in China," is being published this week in *Proceedings of the National Academy of Sciences*.

The authors are Karplus, who is the Class of 1943 Career Development Professor and an assistant professor of global economics and management at MIT Sloan; Shuang Zhang, an assistant professor of economics at the University of Colorado at Boulder; and Douglas Almond, a professor in the School of International and Public Affairs and the Department of Economics at Columbia University.

To conduct the study, the researchers examined sulfur dioxide data from Continuous Emissions Monitoring Systems (CEMS), power-plant based sensor systems used to capture on-the-ground concentrations of pollution emitted in China. The team looked at data from 256 plants in four provinces. They also used NASA satellite data that measures sulfur dioxide concentration levels globally, and in geographic detail. This provided "an objective source for assessing changes in plant-level emitting behavior that is not susceptible to manipulation," as the researchers write in the paper.

That is, the CEMS data could be affected by actions at power plants that are designed to influence the results—from incomplete reporting to the manipulation of sensors. But the NASA data is not affected by attempts to influence ground-level readings.

Then, by evaluating the results of the two systems together, Karplus, Zhang, and Almond were able to see how much the data sets corresponded, and where, by focusing on isolated power plants.

"Because we're comparing patterns in the CEMS to a trusted and well-established data source, that helps make the case that what we're seeing here is real, and there's an explanation behind it," Karplus says.

Intriguingly, data from the two monitoring systems corresponded closely in what the researchers call "non-key" regions, where the maximum allowable concentration of sulfur dioxide was lowered from 400

milligrams per cubic meter to 200 milligrams per cubic meter. But in the heavily polluted and populated "key" regions, where the limit was placed at 50 milligrams per cubic meter, the research found no evidence of correspondence.

That tougher new standard may have been harder for power plants to meet. Thus one potential explanation for the varying results could be that the "stricter new standards and pressure to comply may have generated incentives for plant managers to falsify or selectively omit concentration data," as the researchers put it in the paper. The study further finds a drop in the reported compliance in key regions from 100 percent to around 50 percent, a further indication the new standard was tough for many plants to meet.

So in addition to the bottom line results indicating overall progress, the new study may contain a couple of policy lessons. In the first place, Karplus suggests, "Governments can and should use remote sensing data as a way of providing an independent check on the numbers they're getting from emitters who are subject to a particular policy. Satellite data could help to support central government ambitions to curb air pollution."

To be sure, she notes, the fact that China not only uses CEMS data but makes it available is "a sign of real progress in environmental management in China." But the satellite data is vital to accurate monitoring.

Moreover, Karplus adds, tightening pollution standards is necessary, but not sufficient to get emitters to make lasting reductions in pollution. New standards are likely to work best when accompanied by stronger implementing capabilities of firms and local governments, as well as rules and norms that support accurate reporting.

"Environmental policy doesn't exist in a vacuum," Karplus says. "It requires reshaping prevailing understanding of firms' environmental responsibility and establishing credible reporting systems. In China, there is still a long way to go, but recent progress is very encouraging."

More information: Valerie J. Karplus el al., "Quantifying coal power plant responses to tighter SO2 emissions standards in China," *PNAS* (2018). www.pnas.org/cgi/doi/10.1073/pnas.1800605115

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