



REPLY TO QI AND DONG:

# Policy clarification and robustness of effects

Valerie J. Karplus<sup>a,1</sup>, Shuang Zhang<sup>b,1,2</sup>, and Douglas Almond<sup>c</sup>

The central concern in ref. 1 that the “timing of the policy shock is incorrect for key regions” is false. We received confirmation from the Ministry of Environmental Protection’s representative who authored the policy document issued on February 27, 2013. We confirmed that by July 1, 2014, in the key regions power plants in the central districts were bound by stricter standards (50 mg/m<sup>3</sup>), while power plants in the noncentral districts faced less-strict standards (200 mg/m<sup>3</sup>). We agree with the authors on the distinction between the central districts and noncentral districts within the key regions. When we take this distinction into account, our results remain robust. We repeat the analysis in table 3 of ref. 2 for central districts and noncentral districts in key regions separately. Fig. 1 shows that plants in the central districts report large reductions in SO<sub>2</sub> concentrations after July 2014, while the changes in the satellite data are much smaller. Table 1 shows that plants in central districts report a reduction in SO<sub>2</sub> concentrations of 62.5% (statistically significant at the 1% level). By contrast, in the satellite data, the point estimate is close to 0 and is statistically insignificant. In the noncentral districts, we observe smaller changes in the SO<sub>2</sub> measures, consistent with less-tough standards.

Additional concerns expressed in the last two paragraphs of ref. 1 were already addressed in the paper. In equation 1 of ref. 2 our covariates are chosen to isolate the effect of the policy deadline on SO<sub>2</sub>

emissions. We include plant-by-year fixed effects to absorb plant or surrounding area characteristics that change by year, as well as calendar-month fixed effects. These fixed effects already addressed the authors’ concerns that SO<sub>2</sub> emissions have been broadly declining, which by design are not ascribed to the policy. Furthermore, in a placebo test we do not find a decline in SO<sub>2</sub> concentrations using the hypothetical policy timing of July 1, 2015, in table 2 of ref. 2, suggesting that the concerns posited were already addressed by our regression. We also clearly state in the paper that we are only estimating the effect of the policy deadline on July 1, 2014. Finally, in ref. 2 we compare estimated plant responses as measured by ground and satellite sources. Following a large literature in atmospheric science, we focus on relatively isolated plants. Note that the point estimate using the satellite data is close to 0 in the key regions. Essentially, the authors’ last question is whether the estimates from the ground and satellite are significantly different. In the key regions (first two columns), the *t* statistic for the difference between the two estimates is 1.98, significant at the 5% level. By contrast, in the nonkey regions (first two columns), the *t* statistic for the difference is 1.17, not statistically significant. These *t* tests are consistent with our conclusion that the correspondence between the ground and satellite measures is weak in areas facing the toughest standards.

- 1 Qi Y, Dong C (2018) Incorrect policy interpretation affects conclusion on SO<sub>2</sub> emissions by coal-fired power plants in China. *Proc Natl Acad Sci USA* 115:E11429.
- 2 Karplus VJ, Zhang S, Almond D (2018) Quantifying coal power plant responses to tighter SO<sub>2</sub> emissions standards in China. *Proc Natl Acad Sci USA* 115:7004–7009.

<sup>a</sup>Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA 02139; <sup>b</sup>Department of Economics, University of Colorado Boulder, Boulder, CO 80309; and <sup>c</sup>School of International and Public Affairs, Columbia University, New York, NY 10027

Author contributions: V.J.K., S.Z., and D.A. designed research, performed research, contributed new reagents/analytic tools, analyzed data, and wrote the paper.

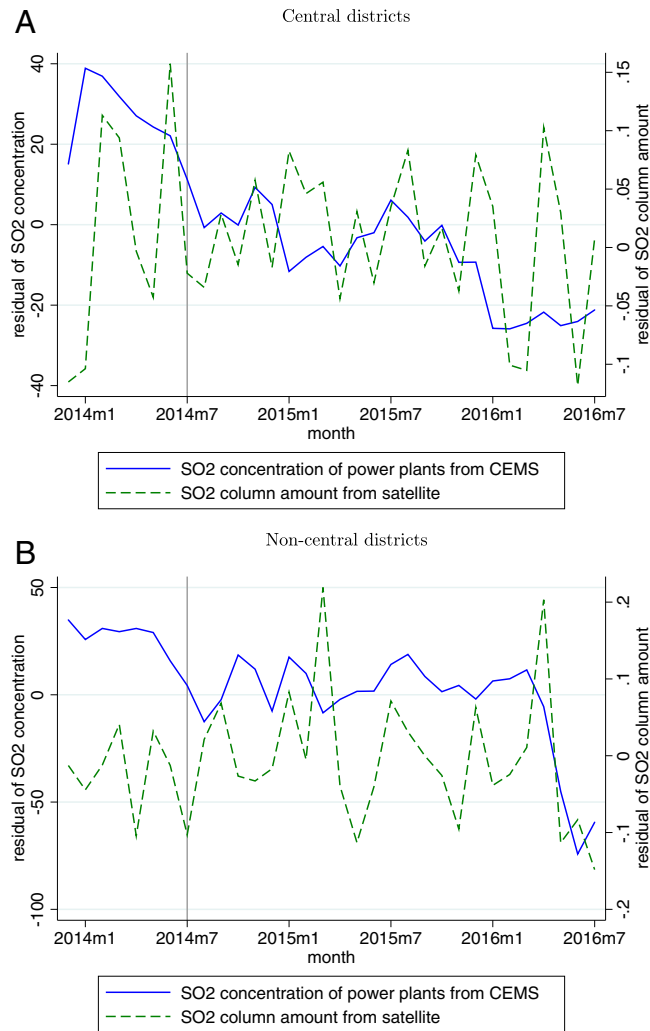
The authors declare no conflict of interest.

Published under the [PNAS license](#).

<sup>1</sup>V.J.K. and S.Z. contributed equally to this work.

<sup>2</sup>To whom correspondence should be addressed. Email: shuang.zhang@colorado.edu.

Published online November 16, 2018.



**Fig. 1. Satellite and continuous emission monitoring systems (CEMS) SO<sub>2</sub> measures for the (A) central districts and (B) noncentral districts in key regions.**

**Table 1. Estimated declines in CEMS and satellite data around the July 2014 policy deadline in central districts (panel A) and noncentral districts (panel B) in the key regions**

Measure	(1)	(2)
	ln(plant SO <sub>2</sub> )	ln(satellite SO <sub>2</sub> )
Panel A: Central districts in key regions		
Post-July 2014	−0.625*** (0.182)	0.062 (0.228)
Observations	119	119
R <sup>2</sup>	0.83	0.69
Panel B: Noncentral districts in key regions		
Post-July 2014	−0.395** (0.150)	−0.188 (0.163)
Observations	71	71
R <sup>2</sup>	0.94	0.81
Plant/area × year fixed effects	Y	Y
Month fixed effects	Y	Y
Additional controls		Y

Y, yes. Standard errors are clustered at the plant level. \*\* $P < 0.05$ ; \*\*\* $P < 0.01$ .