China emits twice as much CO\textsubscript{2} as the United States. China’s embrace of market-based CO\textsubscript{2} policies is an encouraging step to reigning in global greenhouse gas (GHG) emissions, thereby slowing the pace of climate change. Such policies offer the promise of reducing carbon emissions at the lowest cost. While the European Union has had a carbon-trading platform since 2005, President Barack Obama’s attempt to implement one for the United States failed in 2009. US efforts to implement market-based reductions in GHG have been confined to the regional level.

China’s national emission-trading program is expected to start this year and cover 2,225 large power plants—those that emitted 26,000 tonnes or more of CO\textsubscript{2} equivalent in any year from 2013 to 2018. China’s power generation sector accounts for one-third of its CO\textsubscript{2} emissions (Goulder and Morgenstern 2018) and about 8 percent of global emissions (Jotzo et al. 2018). National emission trading is anticipated to expand to additional sectors and is a key mechanism by which China intends to peak carbon emissions by 2030.

China’s pilot carbon-trading programs provide the best extant evidence as to how effective the national carbon-trading program will be. Although significant features will differ, China has a history of initiating pilot projects (or shidian) that are subsequently scaled up to a national level (Jotzo et al. 2018).

Surprisingly, pilot program “downstream” impacts are relatively unstudied, likely due to data constraints for the adoption period.\(^1\) Here, we aim to provide some initial design-based evidence on the effect of pilot programs. That said, we will only focus on a very specific potential co-benefit of carbon trading: air quality. In so doing, we will leverage the fact that “most local pollutants are coproduced with GHGs, so many of the policies to reduce GHGs also reduce local pollutants” (Fullerton and Wolfram 2016), which may be particularly important given

\(^{\text{‡}}\)Discussants: Hanming Fang, University of Pennsylvania; Shaoda Wang, University of Chicago; James Bushnell, University of California-Davis; Matthew Kahn, Johns Hopkins University.

*Almond: Columbia University (email: da2152@columbia.edu); Zhang: University of Colorado Boulder and CEIBS (email: Shuang.Zhang@colorado.edu). We thank the National Science Foundation for support through Award SES-1658888: “Collaborative Research: Market Based Emissions Policies” in China. We thank Hanming Fang and Catherine Wolfram for helpful comments and Solveig Asplund for proofreading.

\(^{\dag}\)Go to https://doi.org/10.1257/pandp.20211071 to visit the article page for additional materials and author disclosure statement(s).

\(^{1}\)An exception is the empirical literature on innovations in low-carbon technologies and whether they increased due to the pilot programs, e.g Cui, Zhang, and Zheng (2018).
coal’s dominance as a fuel source for Chinese power plants. Indeed, improved air quality was a key motivation for President Xi Jinping to adopt carbon cap and trade.

Still, it is not obvious that the pilot programs would actually reduce emissions. Pilot carbon prices started relatively high but soon dropped for a prolonged period. In some cases, pollution and carbon abatement may be substitutes, for example, running pollution-control equipment typically requires more energy and thereby increases carbon emissions (Holland 2011). Pizer and Zhang (2018) also note that the benchmarking of China’s incipient national program could assign emission standards in a way that could lower the cost of using dirtier technologies and thereby raise emissions (if production increases substantially in the dirtier technologies). Finally, China’s cap-and-trade system was and continues to be built around carbon intensity targets, not absolute emission caps: more output allows more carbon emissions.

I. Background

China announced its emission-trading pilots in 2010, and Shenzhen initiated trading in June 2013. Shanghai and Beijing followed in November 2013, and by June 2014, Chongqing, Guangdong, Hubei, and Tianjin began carbon trading. Emission intensity was benchmarked against GDP and called for a roughly 20 percent reduction by June 2016. Phase II began in July 2016; in general, permits cannot be traded across phases. Emission permits were allocated to firms based on estimates of historical emissions, though Guangdong auctioned 10 percent of its allowances. In covering 408 million metric tonnes of carbon emissions, Guangdong was also the largest of the pilots (Munnings et al. 2016). Altogether, the pilots covered about 7 percent of China’s total carbon emissions (Zhang et al. 2014).

II. Data

We downloaded data on cap-and-trade programs from each regional program’s website. These include daily carbon prices and trading volumes by regional market as well as geo-identified information on 2,041 regulated firms across the seven pilot programs. In Guangdong province, we obtained a list of large coal-using firms that were not covered.

We use visibility to proxy for air quality using weather station data provided by the US National Climate Data Center. Visibility is defined as the greatest distance at which an observer with normal eyesight can discern a dark object near the horizon during daytime (Che et al. 2007). These data are relatively objective because they are not disclosed to the public or used in the evaluation of government officials (Chen et al. 2012). Furthermore, horizontal visibility has been successfully benchmarked against conventional pollution measures (Che et al. 2007). Unfortunately, how pollution is measured by China’s official pollution monitors changes during our analysis period (PM$_{2.5}$ was not recorded before 2013 but was subsequently).

III. Results

Previous work has tracked trading activity and carbon prices. The general price pattern is U shaped: higher initial prices between $5 and $13 per ton in 2013 and 2014, followed by a prolonged period of lower prices, then a return to the initial price range in 2019 and 2020.

We know of no systematic, design-based empirical evidence on the emission impacts of the pilot programs. We take a modest step in that direction here by analyzing the patterns of air quality following implementation of regional carbon trading.

A. Average Visibility by Province/Subregion

Prior to the start of pilot programs, we observe similarly flat trends in average visibility over time. Jotzo et al. (2018) observe that pilot areas tended to have lower carbon intensities and higher incomes than nonpilot areas. Consistent with this, we see that pilot areas had better visibility prior to the start of carbon trading.

During phase I of carbon trading, differences emerge. In particular, visibility deteriorates in nonpilot areas as shown in Figure 2.

This could reflect a longer-term trend of worsening air quality in China, but it is also consistent with leakage, whereby emissions shifted to

---

2 We thank Catherine Wolfram for mentioning this reference to us.
unregulated regions. In phase II, both regulated and unregulated regions have improved visibility.

The difference-in-difference (DiD) comparison indicates that visibility improved more in areas regulated by the pilot programs. In specifications controlling for weather station fixed effects, quarter fixed effects, weather controls, and station-specific time trends, trading areas experienced a 7.6 percent increase in visibility in the postadoption period (standard error: 0.023).

**B. Guangdong**

Guangdong’s pilot covers four industries: coal-fired power generation, petrochemical, steel, and cement. Covered firms in these industries emitted 20,000 tonnes of CO$_2$ equivalent or more in any year from 2010 to 2012.

We observe which firms had coal usage above 5 kilotonnes (~13 kilotonnes of CO$_2$) for both regulated and exempted industries. Exempted industries include chemicals, nonferrous metals, building materials, textiles, rubber, paper, automobiles, electronics, etc. Additionally, about half of firms in regulated industries are not regulated because their baseline CO$_2$ emissions (unobserved to us) fall below 20 kilotonnes. Thus, our control firms include unregulated firms in regulated industries and firms in unregulated industries (all with baseline CO$_2$ emission > 13 kilotonnes).

Carbon-trading volumes in Guangdong spiked in 2019. For visibility, we match weather stations geographically to the concentration of regulated firms under the pilot. The median fraction of regulated firms within 33 kilometers is 40 percent. We consider weather stations as treated if they have more than 40 percent regulated firms within 33 kilometers.

Prior to the adoption of carbon trading in Guangdong, average visibility at monitors close to firms that would become regulated was quite similar to that at monitors close to firms that would not be regulated. The pre-trends also appear identical, presumably assisted by the fact that unregulated firms can still be large users of coal, as shown in Figure 3.

In phase I, we see that the similarity of visibility persists. Phase II, by contrast, shows improved visibility at monitors near more regulated firms. Moreover, the divergence in visibility occurs near the spike in trading of carbon permits in 2019.

Our DiD specifications include controls for weather station fixed effects, quarter fixed effects, weather controls, and regulatory status–specific time trends. Our point estimate is a 4 percent increase in visibility in phase II (standard error: 0.015).

**IV. Discussion**

More than any other single nation, the policies that China adopts over the next few years will impact global GHG emissions and thereby global climate change. Unfortunately (and much like the United States), it remains unclear whether China will work aggressively to reduce GHG emissions.
On the encouraging side, China is adopting market-based carbon abatement policies at a national scale. As has been widely noted, China’s environmental performance is sometimes only loosely related to policies “on the books,” for example, He et al. (2012) and Karplus, Zhang and Almond (2018). It is therefore encouraging—and to some extent surprising—that we find that the pilot programs do seem to have achieved something observable “on the ground.” Specifically, we find that the pilot programs have significantly improved local air quality—presumably a co-benefit of local reductions in carbon emissions. Our identification strategy within Guangdong of comparing areas with varying intensities of regulated firms is arguably stronger and returns a similar finding as the more aggregated DiD across regions. To the extent that leakages are minimal and the national program likewise appears to reduce pollution, the new carbon-trading market could generate tremendous benefits.

On the discouraging side, the national carbon market has been delayed from 2017 to 2021 and scaled back to start with the power sector alone. The across-area DiD analysis is consistent with air quality having deteriorated in nonpilot regions due to carbon trading, that is, leakage. Additionally, it remains to be seen how aggressively national intensity caps for the power sector will be set and enforced and, moreover, how quickly additional sectors will join the national carbon market. Unlike the European or California emission-trading system, China’s system will be built around carbon-intensity targets (relative to end-of-period output) rather than an absolute carbon cap (Goulder and Morgenstern 2018), which is what will temper climate change.

Finally, non-CO$_2$ GHG emissions are exempted. These account for 17 percent of China’s total GHG emissions (Pizer and Zhang 2018) and may grow as China relies more on natural gas.

More dispiriting is the discordance across China’s climate policies. China continues to build large coal-fired power plants in western China. Nearly 40 percent of China’s massive Belt and Road Initiative financing has been to the power sector, and 43 percent of Belt and Road Initiative power-generation projects use coal for fuel, making coal its largest energy source (Li and Gallagher 2019). To reign in carbon emissions, China will need to find ways to close many of these newly built coal-fired power plants and stop constructing additional ones. Whether the world’s leading emitter of CO$_2$ is committed to reducing emissions is unclear.

REFERENCES


Footnote 3 For example, Yang, Li, and Zhang (2016) surveyed firms in 2015 and concluded, “The carbon price fails to stimulate companies to upgrade mitigation technologies. The majority of companies treat participation in the ETS only as a means of improving ties with governments, as well as of earning a good social reputation.”


