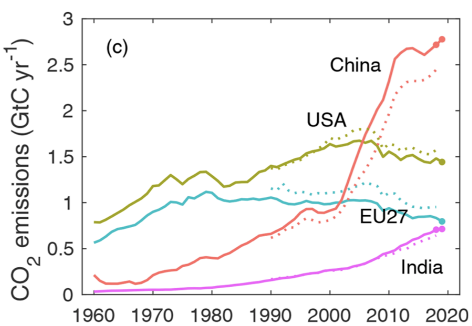
Carbon Trading Pilot Programs in China and Local Air Quality

By Douglas Almond and Shuang Zhang*

China emits twice as much CO_2 as the US. China's embrace of market-based CO_2 policies is an encouraging step to reigning in global greenhouse gas (GHG) emissions and thereby slowing the pace of climate change. Such policies offer the promise of reducing carbon emissions at the lowest cost. While the EU has had a carbon trading platform since 2005, President Obama's attempt to implement one for the US failed in 2009. US efforts to implement market-based reductions in GHG have been confined to the regional level.



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China's national emissions 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_2 equivalent in any year from 2013 to 2018. China's power generation sector accounts for one third of its CO_2 emissions (Goulder and Morgenstern, 2018) and about 8% of global emissions (Jotzo et al., 2018). National emissions 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 the carbon-trading: air quality. In so doing, we will leverage the fact that "most local pollutants are coproduced with greenhouse gases, so many of the policies to reduce GHGs also reduce local pollutants" (Fullterton and Wolfram, 2016), which may be particularly important given 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, e.g. running pollution control equipment typically requires more energy and thereby increases carbon emissions (Holland, 2011).[2] Pizer and Zhang (2018) also note the benchmarking

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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.

[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).

[2] We thank Catherine Wolfram for mentioning this reference out to us.

of China's incipient national program could assign emissions 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 emissions caps: more output allows more carbon emissions.

I. Background

China announced its emissions 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. Emissions intensity was benchmarked against GDP and called for a roughly 20% reduction by June 2016. Phase II began in July 2016; in general permits cannot be traded across phases. Emissions permits were allocated to firms based on estimates of historical emissions, though Guangdong auctioned 10% 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% of China's total carbon emissions (Zhang et al., 2014).

II. Data

We downloaded data on cap and trade programs data from each regional program's website. These include daily carbon prices and trading volumes by regional market as well as a 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 US's 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 and not 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 used subsequently).

III. Results

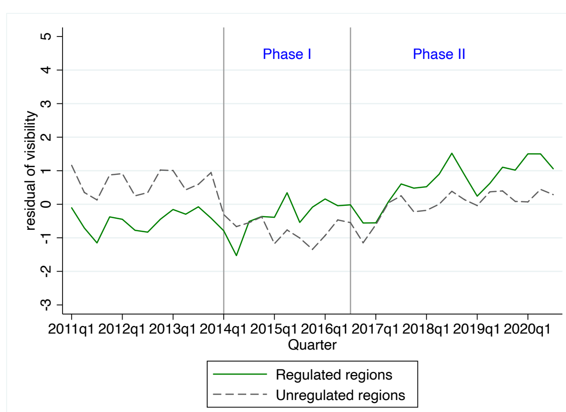
Previous work has tracked trading activity and carbon prices. The general price pattern is U-shaped: higher initial prices in 2013 and 2014 of between \$5 and \$13 per ton, followed by a prolonged period of lower prices, then a return to the initial price range in 2019 and 2020.

We know of no systematic, design-based empirical evidence on the emissions 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 non-pilot 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 non-pilot areas:



This could reflect a longer-term trend of worsening air quality in China, but is also consistent with leakage, whereby emissions shifted to unregulated regions. In Phase II, both regulated and unregulated regions have improved visibility.

The difference-in-difference (DD) comparison indicates that visibility improved more in areas regulated by the pilot programs. In specifications controlling for weather station FE, quarter FE, weather controls, and station specific time trends, trading areas experienced a 7.6% increase in visibility in the post-adoption period (p-value<0.01).

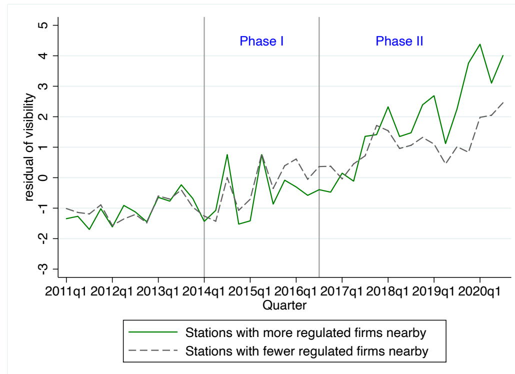
B. *Guangdong*

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 above in any year from 2010 to 2012.

We observe which firms had coal usage above 5 kilotonnes (kt) ($\sim$13 kt of CO_2) for both regulated and exempted industries. Exempted industries include chemicals, non-ferrous 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 20kt. Thus, our control firms include unregulated firms in regulated industries and firms in unregulated industries (all with baseline CO_2 emission>13kt).

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%. We consider weather stations as treated if they have more than 40% regulated firms within 33 km.

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:



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 DD specifications include controls for weather station FE, quarter FE, weather controls, and regulatory status-specific time trends. Our point estimate is a 4% increase in visibility in Phase II (p-value<0.01).

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", e.g. He et al. (2012); Karplus, Zhang and Almond (2018). It is therefore encouraging – and to some extent surprising[3]– that we find the pilot programs

[3]For example, Yang, Li and Zhang (2016) surveyed firms in 2015 and concluded that: "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..."

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 DD 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 DD analysis is consistent with air quality having deteriorated in non-pilot regions due to carbon trading, i.e. 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 emissions 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-CO2 GHG emissions are exempted. These account for 17% 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% of China's massive Belt and Road Initiative (BRI) financing has been to the power sector and 43% of BRI power generation projects use coal for fuel, making coal the BRI's 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.

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