Clearer Skies Over China – Coping with Dirty Air and Climate Change*

Key Points

- A U.S.-Chinese team led by the Harvard China Project has developed a comprehensive framework for evaluating the economic and environmental costs and benefits of national policies to control air pollution and CO_2 emissions in China.
- Contrary to some perceptions of Chinese inaction on air pollution, China's SO_2 control policy of 2006-2010 may have been one of the most swiftly successful air pollution policies on record judged by key criteria: sulfur emissions fell sharply and prevented as many as 74,000 premature deaths from fine particle ($PM_{2.5}$) air pollution in 2010 alone, all at little economic cost.
- Looking to the future, a modest tax on carbon dioxide, starting small and rising to about $6.50 per ton in 2020 (in 2007 dollars), could lead to a 19% reduction in China's CO_2 emissions in 2020 compared to a scenario with no tax, with little effect on GDP growth and consumption over the long run.
- Such a carbon tax would also deliver powerful ancillary benefits: reduced concentrations of an array of domestic air pollutants and prevention of as many as 89,000 premature deaths a year by 2020.

Background: Past Success and New Opportunities

In January 2013 air pollution levels in Beijing were 25 times higher than what is considered safe in the U.S. This so-called 'airpocalypse' event shined a spotlight onto China's air pollution challenges, and there has been a noticeable increase in the discontent of urban Chinese with current environmental quality. The Chinese government has taken notice and in July of 2013 announced it would invest $275 billion over the next five years to improve air quality. This number is equivalent to the GDP of Hong Kong and is twice the size of China's annual defense budget.[4] In September China announced a new 'Clean Air Action Plan' which aims to dramatically clean up China's air using measures such as limiting coal usage as a percentage of total energy and promoting quicker adoption of non-fossil energy sources.[5]

Clearly, China is taking this problem seriously, and in its search for ways to clean up the air, China also has an opportunity to reduce its carbon dioxide emissions. In fact it has been attempting to address air pollution for decades, launching particularly aggressive efforts in recent years that have successfully reduced some pollutants although growth of the economy and of emissions of other pollutants have kept air quality poor overall. One of the most ambitious policies was initiated during the 11th Five Year Plan (11FYP) of 2006-2010, when China attempted to improve air quality by widespread deployment of scrubbers to remove sulfur from power plant emissions and by closing down small, inefficient, highly polluting plants.

Although we hear more about China's air quality problems now than we did in 2010, groundbreaking analysis by a U.S.-Chinese research team led by the Harvard China Project[6] shows that China's policies during the 11FYP actually did improve air quality, and did so at negligible cost to economic growth and consumption (see boxes below). The team also applies its research tools to evaluation of future policy options, finding that a carbon tax would not only effectively reduce carbon emissions but also be powerfully effective in bringing down air pollution in China, again with a minimal effect on economic growth.

Controlling Sulfur in the 11th Five Year Plan:

During the 11FYP, two national targets served China's air pollution goals. One target sought to reduce national emissions of sulfur dioxide (SO_2) by

** This fact sheet is largely based on Chapter 2, "Summary: Sulfur Mandates and Carbon Taxes for 2006–2010" and Chapter 3, "Summary: Carbon Taxes for 2013–2020," authored by a U.S.-Chinese research team based at the Harvard China Project[1] in Clearer Skies Over China: Reconciling Air Quality, Climate, and Economic Goals (2013, MIT Press).[2] A New York Times op-ed on October 25, 2013 by Chris P. Nielsen and Mun S. Ho of the Harvard China Project highlights some of the same research.[3]*

10% from 2005 to 2010. It was pursued in part by mandated installation of scrubbers to remove SO_2 emissions on new and existing power plants, raising the share of coal-fired capacity that includes desulfurization technology to more than 80% by 2010.

The second target sought to reduce China's national energy consumption per unit of GDP (the "energy intensity") by 20% in 2010 compared to its 2005 level. A major element of the effort to achieve this target was the forced early retirement of an estimated 59GW of small, inefficient power plants, replacing the lost electricity supply with power generated by newer, cleaner plants.[7] Because the retired small plants were highly polluting, their closures also played an important role in reducing SO_2 emissions.

To study the effectiveness of these policies, the Harvard China Project team evaluated two scenarios:

1. A policy case representing what actually transpired during 2006-2010, including economic and environmental conditions and the full desulfurization mandates and small-plant closures of the 11FYP SO_2 control strategy.

2. A base case identical to the first case except that it hypothetically assumes that the 11FYP target-based measures that reduced SO_2 emissions were not enacted — specifically, that no existing coal-fired power plants were retrofitted with desulfurization technology and that no small, inefficient plants were forced to close down.[8]

By comparing conditions under the two cases, the research team estimated the effects that the 11FYP policies had on CO_2, the economy, air quality, and public health.

Effects on CO_2, Air Quality, Health, and the Economy

The study found that the 11FYP policies did improve air quality, resulting in as many as 74,000 fewer deaths from air pollution-related causes in 2010 alone than otherwise would have occurred. The policies also resulted in a 4.6% reduction in CO_2 emissions in 2010 compared to the base case, attributed to the closures of small plants.[9] Interestingly, the 11FYP policies had a negligible (and possibly even positive) effect on 2010 GDP, compared to the base case without the policies. This is attributed to the closures of inefficient power plants that were costly to run, which in turn reduced implicit subsidies and freed capital for investment in the economy. In both scenarios, GDP growth is in excess of 7% per year.

A Future Carbon Tax in China:

The Harvard-based team's interdisciplinary research framework was developed not only to evaluate past emission control policies but also potential future policies, including carbon taxes. China's 12th Five Year Plan (12FYP), which covers policy for the years 2011-2015, includes a mandate to initiate environmental taxes to reduce pollution, and many experts indicate this mandate was designed for possible extension to carbon. In the summer of 2013, Lou Jiwei, China's Minister of Finance, became the highest-ranking official to date to explicitly promote future use of carbon taxes, as part of broader fiscal reform.[10] And November 2013 decisions at the Third Plenary Session of the 18th Central Committee of the Communist Party to improve market pricing of energy and broaden resource taxes are also consistent with prospective use of carbon taxes in China.[11]

To examine the effects a future carbon tax in China would have on air quality, public health, economic growth and carbon emissions, the research team developed a number of scenarios from 2013 to 2020 reflecting a range of carbon tax rates and structures. Here we focus on two of those scenarios, and a base case for judging their effects.

1. In the first scenario, the base case, the policies that China has previously announced or put into effect are continued, and the Chinese economy will continue to grow as guided by projections of current market trends and policies.

2. In the second scenario, a carbon tax is implemented starting in 2013 at 10 yuan (in constant 2007 yuan, approximately $1.30) per ton of CO_2. The tax is then progressively scaled up to a rate of 50 yuan (approximately $6.50) per ton of CO_2 by 2020. The revenue from the tax is redistributed to households directly in lump sums.

3. The third scenario has the same features as the second scenario, except that the revenue from a carbon tax is used to cut existing tax rates rather than rebated directly to households.

Effects on CO_2, Air Quality, Health, Agriculture, and the Economy

The effects of the carbon tax on the environment are nearly the same regardless of how the tax revenue is used, i.e., under scenarios 2 and 3. In both policy cases a carbon tax would decrease emissions of CO_2 in 2020 by about 19% compared to a scenario with no tax. This would be equivalent to just a 3% rise in CO_2 emissions between 2012 and 2020. Without a tax, CO_2 emissions would rise by about 26.8% over the same period.

This alone might justify adoption of a carbon tax, but the research shows that the tax would deliver an enormous ancillary benefit: comprehensive reduction of a range of domestic air pollutants at the same time. Compared to business-as-usual with no tax, a carbon tax (regardless of what is done with revenue) would reduce estimated 2020 emissions of SO_2 by 21%, nitrogen oxides (NO_x) by 17%, primary PM_{10} by 16%, and primary $PM_{2.5}$ by 14%. (PM_{10} and $PM_{2.5}$ refer to particle matter under 10 and 2.5 microns in diameter, respectively, and "primary" refers to direct emission of those particles from combustion sources.) These reductions would occur because a carbon tax would reduce combustion of fossil fuels, especially coal, the primary source of many air pollutants as well as CO_2. By reducing SO_2 and NO_x, moreover, the tax would also reduce levels of "secondary" $PM_{2.5}$, fine particle matter that is not directly emitted but rather formed in the air by chemical reactions of precursor gases. Another secondary pollutant, ozone, would also decline on a national basis.

Overall the carbon taxes would reduce $PM_{2.5}$ substantially throughout China, especially in the densely populated urban areas where air pollution problems are severe. By 2020, the improvements in air quality would lead to as many as 89,000 fewer deaths each year from $PM_{2.5}$ and ozone exposures. Along with the health benefits, the ozone reductions would also lead to improved grain production overall, with increased yields reaching 10% in some areas.

Although one might think that all of these health, crop, and CO_2 benefits would come at a cost to economic growth, in fact the efficiencies of tax-based emission control limit their economic effects. Under scenario 2, with the tax revenues rebated to consumers, GDP in 2020 would be only 0.14% less than in the business-as-usual case; consumption would actually rise 0.27%, consistent with the goal of Chinese economic planning to shift towards consumption-led growth. Under scenario 3, with the carbon tax revenue used instead to cut existing taxes, a resulting higher level of investment by business would effectively negate all effects on aggregate GDP, and possibly even raise it slightly. Annual GDP growth for all three scenarios averages over 7% between 2012 and 2020.

Conclusion:

China's air pollution and the world's CO_2 challenges are closely linked. China's experience with SO_2 in the 11FYP shows its commitment to addressing pollution and its capacity to undertake aggressive control measures, although further work is needed on sulfur and other pollutants that have not been similarly addressed. China can benefit from linking its effort to reduce air pollution, which is currently one of its top priorities, to its carbon control effort. Imposition of a carbon tax, one of the most potent tools for addressing climate change, would not only benefit China and the rest of the world by limiting China's carbon emission but also provide a huge net benefit for China in comprehensive air pollution control.[12] As this set of China assessments shows, such progress might be achieved at a lower cost than many expect and with substantial co-benefits, especially in the form of improved air quality and environmental health of the Chinese people.

At the same time the U.S. has announced its own Climate Action Plan that outlines measures it can take using the Clean Air Act and other existing legal authority that, with strong implementation, can help the U.S. meet its 2020 emission reduction target.[13] Together the U.S. and China account for over 40% of global carbon emissions. Thus, the two countries have the power to galvanize global action and avert dangerous climate impacts.[14]

Box 1: Why is this work groundbreaking?

The central methodological breakthrough from this study is merging state of the art models of the atmosphere and China's economy, both featuring high levels of detail. Previous work has generally emphasized either the economic or scientific dimensions of emission control, relying on relatively simplified representations of other aspects. Linking the models is now possible due to advances in the resolution of emission inventories for China, both by sector and geographical location. Such inventories are developed "bottom-up" using independent scientific (i.e., not official) data, including plant-by-plant representations of key industries such as electric power generation. Combining advanced approaches from science and economics allows for a more complete and accurate picture of the policy tradeoffs behind air pollution and carbon control in China.

Box 2: How Can Success with SO_2 be Reconciled with Recent Air Pollution Episodes in China?

The episodes of very high levels of $PM_{2.5}$ observed in some Chinese cities in 2013 are not inconsistent with these results. Even if the sulfur controls reduced levels of $PM_{2.5}$ by 2010, other factors can cause them to rise. It is as important to appreciate less obvious scientific complexities of fine particle formation and control. $PM_{2.5}$ is defined only by physical size and can have any chemical composition at all; it can also be emitted directly or formed chemically in the air from diverse precursor gases. This means that successful restriction of one pathway of $PM_{2.5}$ formation (in this case the production of sulfate particles from gaseous SO_2 emissions) does not prevent $PM_{2.5}$ from rising via a variety of other pathways (such as the production of nitrate $PM_{2.5}$ from growing nitrogen oxide emissions).[15]

It is also essential to recognize the role of meteorology in severe pollution episodes, which generally occur during periods of unusual atmospheric stagnancy, including in Beijing in January of 2013. Such episodes are obviously a serious concern but should be differentiated from average pollution concentrations during a year, as used to judge health impacts in the study.

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Notes

[1] See: www.chinaproject.harvard.edu
[2] See: www.mitpress.mit.edu/books/clearer-skies-over-china
[3] See: www.nytimes.com/2013/10/26/opinion/international/clearing-the-air-in-china.html?ref=opinion&_r=0
[4] http://www.economist.com/news/leaders/21583277-worlds-biggest-polluter-going-green-it-needs-speed-up-transition-can-china
[5] http://www.gov.cn/zwgk/2013-09/12/content_2486773.htm (in Chinese)
[6] The lead authors include ChinaFAQs expert Chris P. Nielsen and Mun S. Ho of the Harvard China Project, Yu Zhao (Nanjing University School of Environment), Yu Lei (Chinese Academy of Environmental Planning), Yuxuan Wang (Tsinghua University Center for Earth System Science), Jing Cao (Tsinghua University School of Economics and Management), and Dale W. Jorgenson (Harvard Department of Economics).
[7] Official estimates range from 62GW to more than 70GW of closed small plants during the 11FYP; the research team's lower, independently derived estimates may therefore be conservative.
[8] The base case assumes that desulfurization would have still been required for newly constructed plants, under preexisting policy expectations; this assumption is thus also conservative.
[9] This effect more than compensated for the small CO2 penalty due to the energy demands of desulfurization equipment.
[10] https://www.chinadialogue.net/article/show/single/en/6242-No-timetable-for-carbon-tax-say-Chinese-officials. See also: http://wjb.mof.gov.cn/pindaoliebiao/ldjh/201307/t20130716_966665.html (in Chinese)
[11] http://www.chinafaqs.org/blog-posts/high-level-chinese-policy-initiative-shows-new-momentum-environment
[12] Although this study looked at a carbon tax, putting a price on carbon can also take the form of carbon cap-and-trade. For more on China's carbon trading pilots see: http://www.chinafaqs.org/blog-posts/emissions-trading-china-first-reports-field
[13] http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf. See also: http://www.wri.org/publication/can-us-get-there-from-here
[14] For more see: http://www.chinafaqs.org/library/chinafaqsus-china-collaboration-can-they-inspire-world
[15] In fact under some wintertime conditions in Northern China it is believed that reduction of sulfate production can even increase nitrate production, due to complex chemical interactions beyond the scope of this fact sheet; taking account of such chemical mechanisms is one of the strengths of the atmospheric model used in the study.

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