Economic impacts from PM2.5 pollution-related health effects in China: A provincial-level analysis

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Background

- China has faced with severe challenges relating to its environment, particularly air pollution in recent years.
- Bad air quality poses a significant threat to human health, increases health expenditure and decreases labor attendance and labor supply.
- Air pollution obviously has negative impact on the economy. We aim to use CGE model combined with health module to forecast and evaluate the long-term economic impacts caused by air pollution in 30 Chinese provinces.

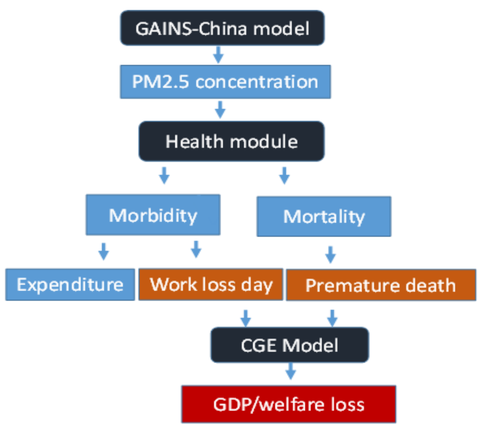

Fig.1 Research Framework.

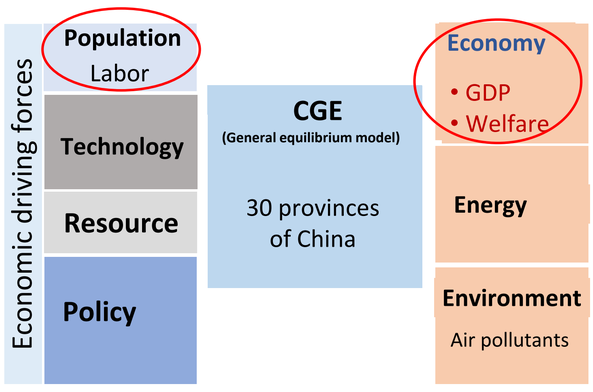

Fig.2 CGE -Health Impact

Methods

1. Combining AIM/CGE, Health module and GAINS model

- GAINS-China model provided PM2.5 annual average concentration data in 30 provinces (**Fig. 1**).
- Health module quantifies the health impacts and converts to work time loss.

Receptor	Impact category	ER functions
Mortality	Chronic mortality	0.4%
Morbidity	Respiratory hospital admissions	1.17E-05
	Cerebrovascular hospital admissions	8.40E-06
	Cardiovascular hospital admissions	7.23E-06
	Chronic bronchitis	4.42E-05
	Work loss day	2.07E-02

$$case_{r,t}^{mortality} = \sum_{n} ER^{Mortality} * C_{r,t} * M_{r,n,t} * P_{r,n,t}$$

$$case_{r,t}^{morbidity} = \sum_{n} ER^{\text{Morbidity}} * C_{r,t} * P_{r,n,t}$$

n: cohort
C: PM2.5 concentration
M: all-cause mortality, equal to 0.715% in China
P: Population
t: year
r: region or province

- AIM/CGE-China model estimated GDP loss and welfare loss from per capita work time loss due to PM2.5 pollution.

2. Scenario

- **WoAir scenario**: without any intensive air-pollution-control technology. The bad air quality increases outpatient visits, hospital admissions and work loss day. Additional health expenditure and work time loss lead to adverse effects on the economy.
- **WAir scenario** assumes the existence of intensive air-pollution-control technologies are used to reduce PM2.5 concentration to levels much lower than those in reference and WoAir scenario.

Results

PM2.5 concentration in 30 provinces

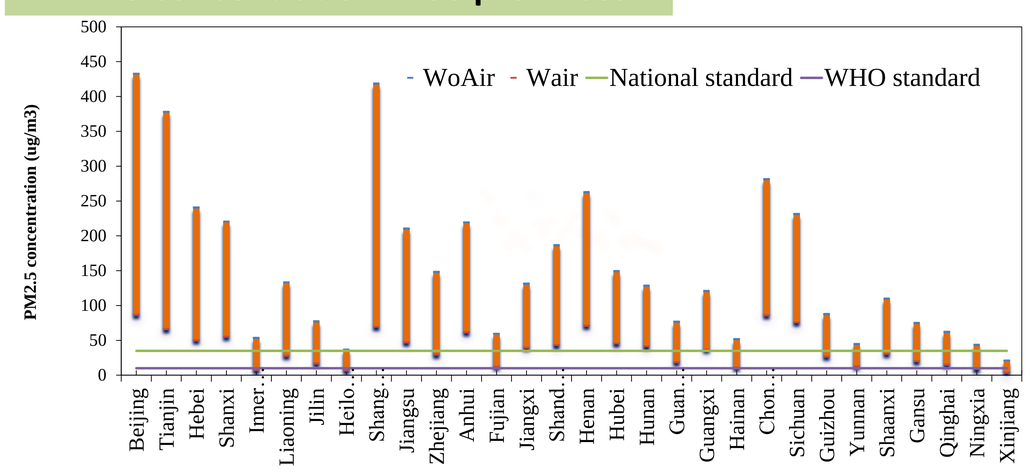

Fig. 3: Annual average $PM_{2.5}$ concentration in 2030 in 30 provinces

- $PM_{2.5}$ concentration is higher in the east of China, especially on the North China Plain, a populous region with more industry.
- In the WoAir scenario, the $PM_{2.5}$ concentration far exceeds the national standard of 35 ug/m^3.
- Even in the WAir scenario, the $PM_{2.5}$ concentration in most provinces exceeds the national standard and the WHO standard of 10 ug/m^3.(**Fig.3**)

GDP loss and Welfare loss in 30 provinces

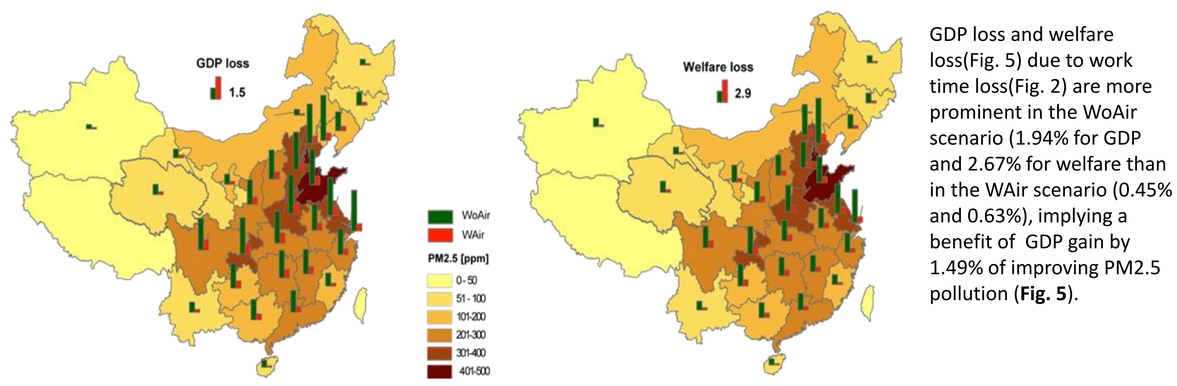

Fig. 5 GDP loss (left) and Welfare loss (right) in 2030

GDP loss and welfare loss(Fig. 5) due to work time loss(Fig. 2) are more prominent in the WoAir scenario (1.94% for GDP and 2.67% for welfare than in the WAir scenario (0.45% and 0.63%), implying a benefit of GDP gain by 1.49% of improving PM2.5 pollution (**Fig. 5**).

Health impact of air pollution in 2030

- **Health endpoints:** Respiratory symptoms are the most frequent health problem induced by PM2.5 pollution, followed by asthma attacks and chronic bronchitis. measures to control PM2.5 emissions in WAir scenario could reduce the numbers of patients by about 75% (**Fig. 4 upper**)
- **Total health expenditure**: national total is 141 billion CNY in woAir scenario, Henan (18.0 bil.CNY), Sichuan (14.1), Shandong (12.4), Hebei (11.8), and Jiangsu (11.2) are the top five provinces. In wAir scenario, national total expenditure could be reduced by 75% to 36 billion CNY.

- **Per capita health expenditure:** Top-spending provinces with most per capita health expenditure are Beijing (432.6 CNY), Shanghai (418.2 CNY), and Tianjin (377.9 CNY) in the WoAir scenario in 2030, each bearing more than double the national average of 151.6 CNY (**Fig. 4 middle**).
- **Per capita work loss time**: Annual national per capita work loss time is 52.6 hours (2.5% of annual total annual work hours) in the WoAir scenario, and falls to 13.3 hours (0.64% of annual work hours) in 2030 (**Fig. 4 bottom**).

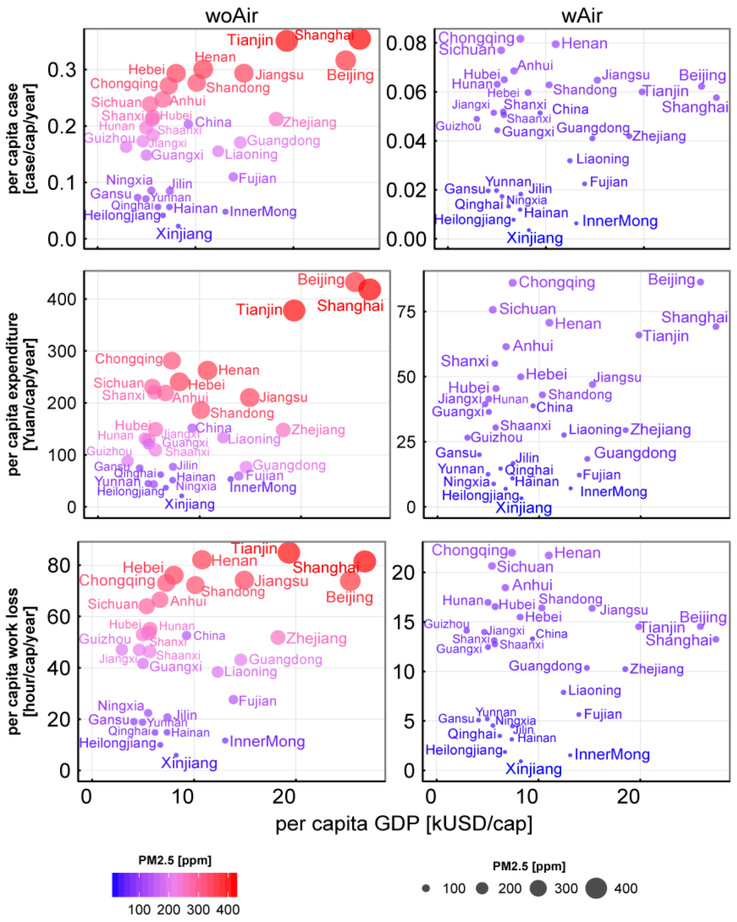

Fig. 4 Annual per capita case (upper), expenditure (middle) and work hour loss (lower) in 2030

Net benefit of PM2.5 control technology in 2030

Net benefit in China

- The air pollution control cost reaches 833.6 billion Yuan, or about 0.79% of GDP. The net benefit (**Fig. 6**) from PM2.5 control technology is 0.80% in GDP., investment on such technology is quite beneficial in China as a whole.

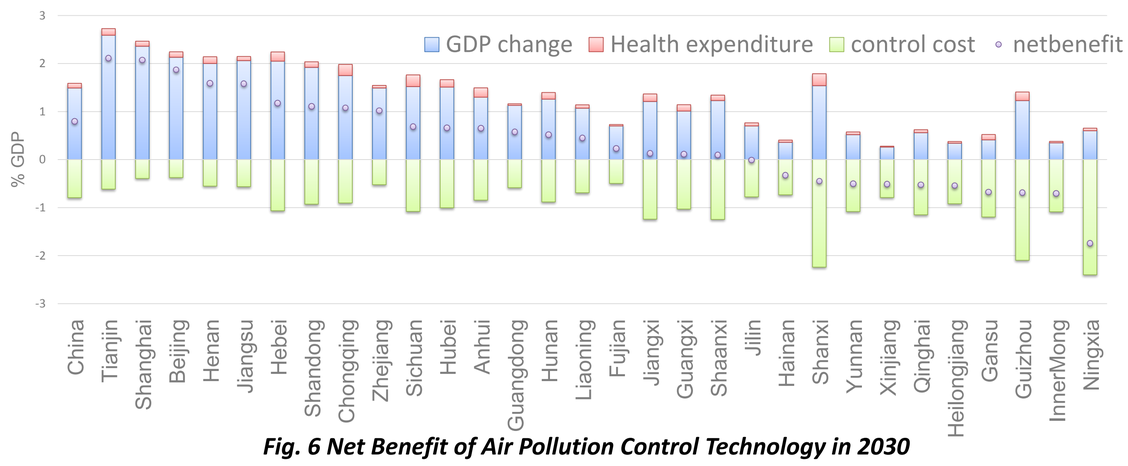

Fig. 6 Net Benefit of Air Pollution Control Technology in 2030

Net benefit at provincial level

- The net benefit (**Fig. 6**) is high in provinces with larger economies and higher PM2.5 concentrations, such as Tianjin (2.1%), Shanghai (2.07%), Beijing (1.9%), Henan (1.6%), Jiangsu (1.6%), and Hebei (1.2%).
- By contrast, the PM2.5 control technology incurs a big burden on less developed western provinces and ultimately leads to negative net impacts, such as Ningxia (-1.7%), Inner Mongolia (-0.7%), Guizhou (-0.69%), Gansu (-0.67%), Heilongjiang (-0.54%), Qinghai (-0.53%) and XinJiang (-0.51%).
- Policymakers should consider the differences and tailor suitable policies for different regions. The Chinese government should institute a suitable policy and provide necessary financial aid in these underdeveloped provinces. Developed regions can provide technologic and financial aid to undeveloped regions, since air pollution concentration depends not only on emissions in one region, but also on transboundary emissions from neighboring regions..

Summary & Conclusion

- PM2.5 pollution is very serious in China and leads to a large number of health, resulting in additional health expenditure, work loss time and premature death.
- The economic impact of PM2.5 pollution is significant in China. In 2030, GDP loss is 1.89% in the WoAir scenario and 0.45% in the WAir scenario, while welfare loss is 2.67% in the WoAir scenario and 0.63% in the WAir scenario.
- The economic impact differs markedly in different provinces. Beijing, Tianjin, Shanghai provinces have higher GDP loss and welfare loss in the WoAir scenario.
- Air-pollution-control technology brings more net benefit in Tianjin , Beijing , Shanghai , compared to the rest of the country. Undeveloped provinces, such as Ningxia, Inner Mongolia, Guizhou have negative impact from air pollution control technology.

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