

Responses to Anonymous Referee #3:

The authors estimate the air pollutants embodied in inter provincial and international trade for China using an input-output approach. The fraction of emissions embodied in inter provincial trade are similar in magnitude to the fraction in international trade. While the interprovincial results appear to be a new contribution, the manuscript should be rewritten to distinguish this study from previous work.

Response: Thanks for the suggestions. We have rewritten the abstract and introduction part of the manuscript, to clearly state that this work is the first study which quantified consumption-based air pollutant emissions for each province in China and tracked virtual emission flows of air pollutants embodied in Chinese interprovincial trade. Using the approaches developed in this work, we separated the relative contribution of local consumption and regional consumption to air pollutant emissions in each province, constructed a consumption-based emission inventory for each province, and tracked the emission flows embodied in interprovincial trade. To our best knowledge, all these results are presented for the first time for air pollutant emissions in China. We also added a conclusion section in the revised manuscript, to emphasize our unique contribution presented in this work.

Major Comments

The introduction in the manuscript does not identify the unique contribution of this study. In particular the Lin et al. (2014) study appears to have done something very similar. The present manuscript needs to identify the differences in approach from previous work and provide evidence as to why these differences are important and worth investigating. It seems that this might be that the study adds a province-level analysis... but this needs to be stated and its importance needs to be justified.

Response: Thanks for pointing out this. Lin et al. (2014) investigated air pollutant emissions embodied in China's international trade and their impact to the global environment with a focus on air quality in the United States. The objective of this work is to understand air pollutant emissions embodied in China's interprovincial trade, which is quite different from Lin et al. (2014). Lin et al. (2014) used a Single-Region Input-Output (SRIO) model, which is able to quantify emissions embodied in trade, but not able to track the trade-embodied emission flows from different regions. In this work, we used a Multi-region Input-Output (MRIO) model framework, to track the emission flows embodied in interprovincial trade. This is of great importance because developed regions always consumed more products but transferred emissions to developing regions through trade. As China is an uneven developed country, rich regions could avoid producer emissions by offshoring productions to poor regions, resulting redistribution of emissions and pollution in the country. The results from this work will help the community to reveal the social-economic drivers behind the air pollutant emission growth in China and aid the policy makers to better understand their responsibilities to air pollution by identifying emissions induced by their consumption activities. In the revised manuscript, we have rewritten the abstract and introduction part and added a conclusion section, to identify the importance and unique contribution of this study. We also revised the Sect. 3.4 to avoid redundant discussions on international trade, which is

thought to be a minor contribution of this work.

The results that 15-23% of emissions are embodied in foreign trade is very similar to the 17-36% reported in Lin et al. (2014) so perhaps this is not a new results and should not be highlighted in the abstract.

Response: Agree. This sentence has been removed from the abstract.

“However, if the response is to shift industry out of these cities without changing consumption patterns, the result of the regulations may be an increase in the total amount of pollution emissions and little or no improvement in air quality, since there will be an increase in emissions through transportation along the geographically extended supply chains and also because that the general low efficient production in less regulated areas.” This sounds like a critical motivation for this study but the opposite may be true. If consumption stays the same but emissions are shifted out of megacities then that would have two effects to reduce the impact of air quality. First, the emissions might be more dispersed in space which would dilute the concentrations. Second, the emissions would be further from the high population densities which would result in dilution from atmospheric mixing and reduce exposure impacts. It’s not clear to me if the increase in transportation of goods and the less efficient production in less regulated areas would be more important or less important than the factors that I mention above. To investigate this trade-off you would need to include a health assessment model (e.g. BENMAP).

Response: Thanks for the comment. We agree that the impact of emission transfer on human health could be positive or negative, as pointed out by the reviewer. In the revised manuscript, we have changed the statement as follows. *“However, if the response is to shift industry out of these cities without changing consumption patterns, the result of the regulations may be an increase in the total amount of pollution emissions, since there will be an increase in emissions through transportation along the geographically extended supply chains and also because that the general low efficient production in less regulated areas. The redistribution in emissions could have potential significant effects on regional air quality.”* We further discussed this issue in the conclusion section of the revised manuscript. Investigating the air pollution and health impact caused by cross-regional industry transfer is a very interesting and important topic, but we believe that it is beyond the scope of current paper, and the results and policy implications presented in this work is worthy for publication in ACP. The consumption-based emission inventory developed in this work provides a good basis for consumption-based health benefit evaluation, and we will extend this work in the future.

Minor Comments

"These particles are known..." Previous sentence is talking about gases and particles so might need to rewrite in this sentence "The primary PM2.5 particles..."

Response: Corrected.

The results that 15-23% of emissions are embodied in foreign trade is a bit lower than the 17-36% reported in Lin et al. (2014). The discussion section should include some reasons for this difference

Response: The differences between Lin et al. (2014) and this work are mainly due to differences in methodologies. As mentioned above, Lin et al. (2014) used a Single-Region Input-Output (SRIO) model, while we used a Multi-Region Input-Output (MRIO) model framework. SRIO used national average emission intensity when calculating export embodied emissions, which will overestimate emissions in coastal provinces where emission intensities are lower than national average. In MRIO framework, embodied emissions were calculated for each province using its own emission intensity. Estimates in Lin et al. (2014) would be then higher than ours, as export embodied emissions are dominant by coastal provinces. We explained the reasons of differences in Sect. 3.4 of the revised manuscript.

"Allow for the embodied emission from other regions, the pollution embodied in these regions' products exports accounts more (68–75 %)." Please rewrite.

Response: Thanks for pointing out this. It is an improper statement and has been removed in the revised manuscript.

Reference:

Lin, J., Pan, D., Davis, S. J., Zhang, Q., He, K., Wang, C., Streets, D. G., Wuebbles, D. J., and Guan, D.: China's international trade and air pollution in the United States, *P. Natl. Acad. Sci. USA*, 44,7771-7776, doi:10.1021/es101094t, 2014.