



Understanding the industrial contribution to pollution offers opportunities to further improve air quality in the United States

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The quality of the air in the United States has improved substantially (1). The risks, however, remain high for several populations, and there is still much to learn about the sources and impacts of air pollution. Increasing our understanding of the sources of environmental damage can help us design policies and take preventative actions to further reduce the impacts of air pollution (2). In ref. 3, Tschofen et al. study the industrial composition of air pollution in the United States and how it has changed in recent years. To describe their findings, Tschofen et al. calculated the ratio between the gross external damage (GED) created by industrial emissions and the value added (VA) of the same industry's output to the economy. An important caveat is that GED in this context captures damages to the economy caused by air quality alone. It does not account for other types of pollution that could impact the economy (e.g., water pollution). Similarly, GED does not capture impacts to ecosystems services losses created by air pollution. Thus, GED should be interpreted as a lower bound on impacts of industrial activity on well-being. As a concept, the GED/VA ratio provides relevant information required for the design of efficient environmental and industrial policies. Industries with a GED/VA ratio less than 1 produce more VA to the economy than the damages they inflict and are thus positive net contributors to the economy.

Tschofen et al. (3) find that damages to the economy caused by air pollution have fallen, but not all sectors of the economy have contributed equally to this process. In fact, the authors find that different industries contribute to pollution in different ways in terms of pollution intensity (GED/VA) and type of pollutant. Moreover, the GED/VA trends are very different across industries. The reduction in air pollution is mostly driven by the cleaning up of electricity generation and utilities. Utilities emissions have decreased substantially for a multiplicity of reasons (4), a feature not

easily translated to other industries. Transportation is steadily becoming cleaner, but a substantial amount of work is still needed to reduce emissions even further (5). Agriculture emissions remain stubbornly high and exhibit a flat trend, making agriculture one of the most polluting industries per dollar in the United States right now. Manufacturing is also flatlining, but the aggregate emissions are relatively low (see figure 2 in ref. 3).

Questions Raised by the Study

The analysis presented in ref. 3, by incorporating the industrial composition of emissions, raises several questions and introduces avenues of research. First, while improvements in local air quality have been driven by local authorities (6), industrial emissions expand across several jurisdictions, and dealing with them will require a broader understanding of how economic production is distributed across space and time. We can observe damages at a local level, but they are the by-product of consumption that is not necessarily happening in the same place that emissions took place. In fact, recent research shows the burden of emissions is larger in underrepresented communities (7). In principle, understanding how different industries' production contributes to pollution can also help illuminate how to better allocate, via interstate trade and commodity flows, the sources of those emissions across jurisdictions. In this sense, the current results suggest a complementary role between industrial policy and environmental policy.

There is an important caveat to the analysis. The change in the production structure away from agriculture and manufacturing toward a more service-oriented economy has been one of the main reasons why the United States enjoys clean air now. In ref. 3, the authors treat industrial outcomes as independent of each other. That is, the GED and VA of agriculture are contained within that same industry, but they are not affected by,

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