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ECONOMIC Synopses

Measures of Pollution

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Pollution caused by economic activity can both affect health and motivate policymaking decisions. According to the Environmental Protection Agency (EPA), air pollution, for example, "can affect the heart and lungs and create serious health effects." Pollution in the form of greenhouse gas emissions causes concerns about climate change and global warming.

In this essay, we propose to relate pollution to the economic activity that generated it. Our point is not to dispute the quantity of pollution, nor is it to argue about the effects of pollution on people's health or the climate. Instead, we suggest that the costs of pollution should be assessed relative to the benefit of said economic activity. If both economic activity and pollution are rising, one ought to ask whether the costs are rising faster than the benefit...or the opposite.

We find that pollution in the United States, measured by particulate matter or CO_2 emissions, rises with economic activity, but at a noticeably slower pace. According to the EPA, CO_2 emissions—the most abundant greenhouse gas—increased by 10 percent between 1990 and 2014, or an average annual rate of 0.4 percent.[1] During the same period, U.S. gross domestic product (GDP) increased at an average annual rate of 2.4 percent. The difference between these two figures indicates that the United States produced less CO_2 per unit of output each year.

Another indicator of economic growth—often of greater interest to economists—is GDP per capita, which is GDP divided by the population. During the 1990-2014 period, the U.S. population grew by 1 percent per year. Thus, GDP per capita increased at an average annual rate of 2.4 – 1 = 1.4 percent.[2] That is, each year, the United States produced 1.4 percent more goods and services per person, on average, as well as 0.4 percent more CO_2. Thus, the average person in the United States has benefited from relatively "cleaner" goods and services produced with fewer emissions of CO_2. The United States still produced more CO_2 in 2014 than in 1990, and that rise is likely to have detrimental effects on climate that are not discussed here. The point here is that the increasing level of CO_2, which is detrimental to well-being, coincides with an even greater increase in GDP per capita, which advances well-being.[3]

The patterns of overall greenhouse gas emissions (shown in the table) are similar to that of CO_2. Greenhouse gas emissions increased by 7 percent between 1990 and 2014. This average annual increase of 0.28 percent is, again, noticeably lower than the 1.4 percent average annual increase in GDP per capita during the same period.

> Pollution in the United States rises with economic activity, but at a noticeably lower pace.

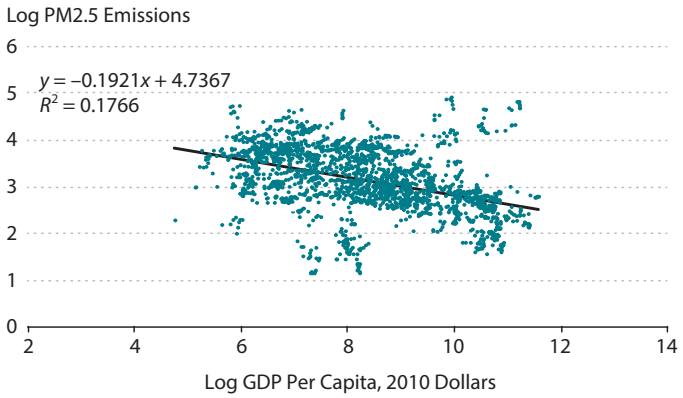
This pattern also holds when the economy slows down. From 2005 to 2011, the era around the Great Recession of 2007-09, greenhouse gas emissions *declined* at an average annual rate of 1.2 percent. At the same time, both GDP and population increased at an average annual rate of 0.9 percent. Thus, GDP per capita was stagnant, while total

The Evolution of Greenhouse Gas Emissions, U.S. GDP, and Population

Indexes (1990 = 100)	1990	2005	2010	2011	2012	2013	2014
Greenhouse gas emissions	100	115	109	107	104	106	107
GDP	100	159	165	168	171	174	178
Population	100	118	124	125	126	126	127

SOURCE: EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014." EPA 430-R-16-002, April 15, 2016, Table 2-14.

GDP Per Capita and Air Pollution



SOURCE: World Bank.

greenhouse gas emissions decreased. Again, GDP per unit of CO_2 was increasing, albeit at a slow pace, with fewer emissions every year.

Consider now another form of pollution: particulate matter, which consists of small particles generated by either a chemical process or the mechanical deterioration of matter, such as organic dust or the dust released by construction. One measure of particulate matter emission, known as PM2.5, measures the concentration of particles less than 2.5 micrometers in size (about 1/40th the width of a human hair) in a given volume of air. The figure shows the relationship between PM2.5 and GDP per capita across countries from 1990 to 2015, where each data point corresponds to a particular country and year.

As the figure shows, a negative correlation exists between PM2.5 and GDP per capita. The relation is similar to that between CO_2 emissions and GDP per capita in the United States. Namely, there is a tendency for emissions to decrease as GDP per capita increases. In other words, one unit of GDP per capita can be produced with fewer particulate matter emissions in countries with high GDP per capita. Why? Although all countries desire clean air, wealthy countries can better afford cleanup technologies (filters, clean-energy devices, etc.) that prevent emissions. Poorer countries prefer to spend their resources on food and shelter; anti-pollution technologies are a luxury. In other words, clean air is what economists call a "normal good." Normal goods are those that people consume more of as they get richer.

There exists a vast literature on the relationship between pollution and economic activity. An old hypothesis in this literature is the so-called "environmental Kuznets curve" (EKC). The EKC is the description of a non-monotonic, theoretical relationship between economic activity and pollution. The idea is that, in the early stages of development, pollution increases with economic growth. But, beyond a certain level of development, the trend reverses and economic growth improves environmental conditions by creating the resources to do so. David I. Stern disputes the existence of the EKC, arguing that empirical investigations of the EKC are weak. He finds, as we do, that pollution rises monotonically with economic activity. Stern writes that "emissions of most pollutants and flows of waste are monotonically rising with income, though the 'income elasticity' is less than one."[4] Stern's view is consistent with ours: A 1 percent increase in economic activity raises pollution but at a slower pace. That is, pollution is increasing more slowly than GDP. ■

NOTES

[1] EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014." EPA 430-R-16-002, April 15, 2016, Table 3-1.

[2] This is a frequently used approximation of the rate of growth of GDP per capita.

[3] This statement does not imply that welfare increases just because GDP per capita increases faster than CO_2 emissions. That is, welfare can either increase or decrease, depending on how the GDP and CO_2 increases affect it.

[4] See Stern, David I. "The Rise and Fall of the Environmental Kuznets Curve." *World Development*, August 2004, *32*(8), pp. 1419-39; http://doi.org/10.1016/j.worlddev.2004.03.004.

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