

One shape does not fit all: A nonparametric instrumental variable approach to estimating the income-pollution relationship at the global Level

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ABSTRACT

We examine the relationships among water pollution, income, and political institutions using country-level global water quality data over the period 1980 to 2012. In order to address concerns about the highly nonlinear relationship between pollution and income, the endogeneity of income, and the discrete nature of political variables, we use a nonparametric instrumental variable approach that allows for the inclusion of continuous and discrete variables to identify these relationships. Results indicate an inverted-U shaped relationship between pollution and income consistent with an environmental Kuznets curve for one pollutant (lead), a cubic shape for three pollutants (nickel, mercury, and fecal coliform), and more highly nonlinear relationships for many of the other pollutants. For several stock pollutants (nickel, mercury, and arsenic), we find that pollution levels may continue to increase at higher levels of income, suggesting that stock pollutants may continue to accumulate in productive high-income countries even when marginal emissions have been reduced. We also find suggestive evidence that levels of pollutants resulting from industrial activity (e.g., chemical oxygen demand) may increase with income while those that are more driven by residential activity and population levels (e.g., fecal coliform) do not. By estimating a nonparametric relationship between pollution and political institutions and by accounting for the categorical nature of the political variables, we are able to detect a nonlinear relationship between pollution and political institutions as well, which for some pollutants is an inverted-U shaped curve.

1. Introduction

The environmental Kuznets curve (EKC) is a relationship between income and pollution which is hypothesized to have an inverted-U shape. The EKC hypothesis stems from Kuznets' famous work in income equality and poverty [1]. The EKC hypothesis states that as income increases, pollution goes up initially but when income is high enough, pollution eventually declines. The income level at which pollution level is the highest is called a turning point.

There are numerous papers on the validity, application, and measurement of the EKC [2,3]. This is evident from the seminal work of [4], as well as from papers focusing specifically on air pollution (e.g., [5–12]), water pollution (e.g., [13–16]), deforestation (e.g.,

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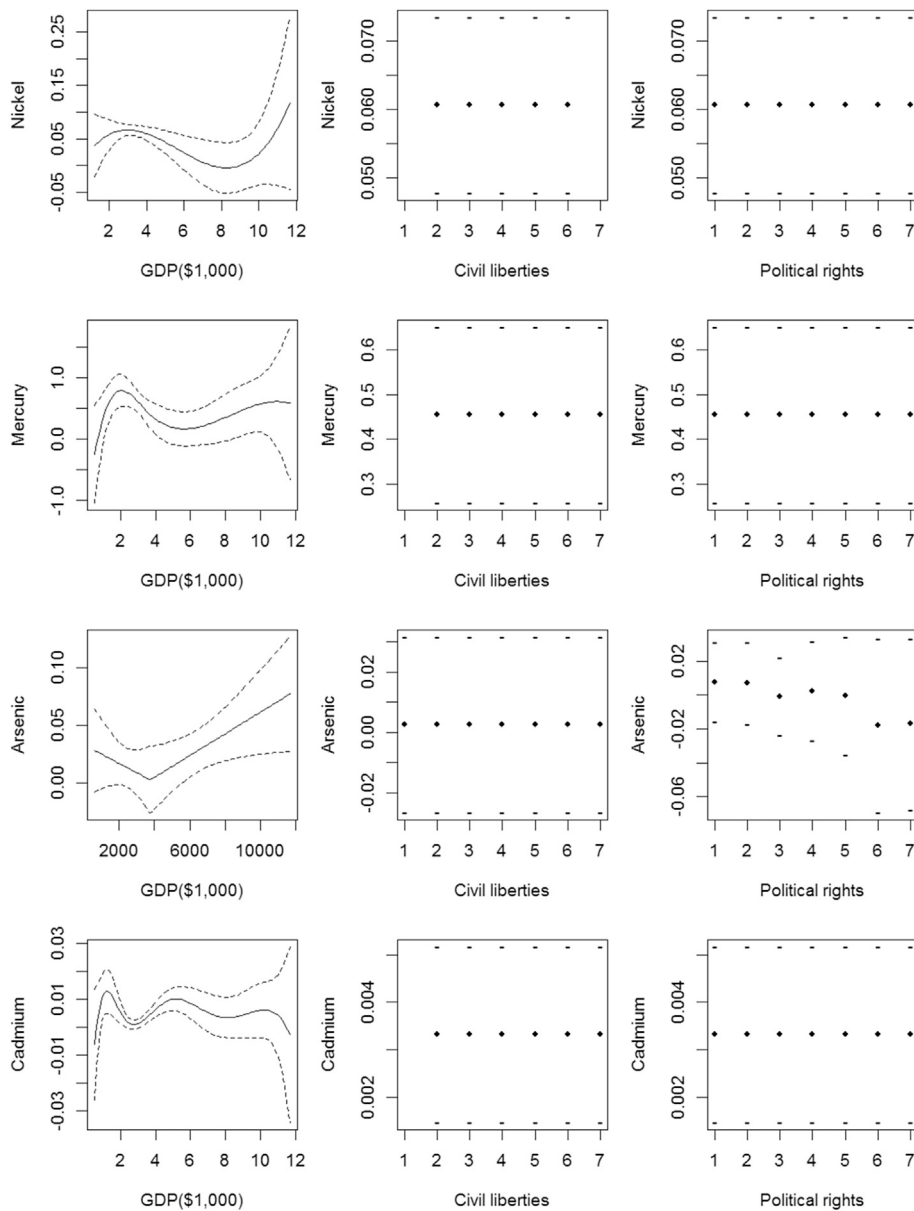


Fig. 1. Relationships between pollution and per capita GDP; pollution and civil liberties; and pollution and political rights obtained from using a nonparametric instrumental variable estimation.

Notes: Dotted lines in the GDP-pollutant relationship are 95% confidence interval bands. The lightly dotted points in civil liberties and political rights are confidence interval bands. All water pollutant data are in the form of concentrations of mg/l except for the mercury data, which is in the form of $\mu\text{g/l}$; and the coliform data, which is in the form of measured count/100 ml. Per capita GDP is in thousand constant 2005 international dollars. The political rights and civil liberties variables each vary from 1 to 7, with 1 meaning the most political rights or civil liberties. In plotting the GDP-pollutant relationship, the ordinal categorical variables are fixed at their middle value of 4.

[7,17–19]), hazardous waste and toxins (e.g., [20,21]), and carbon dioxide (e.g., [2,22–24]). However, critics have challenged both the findings and policy implications of these studies [25,26]. Some suggest that the pollutant-income relationship differs depending on the choice of the pollutant, study area, and time period [27].

One strand in the EKC literature posits that there may be a political mechanism underlying the EKC relationship. These papers suggest that what cleaned up the environment was not rising income, but rather political institutions responding to public demand [28]. For example Ref. [4] speculates that the strongest link between income and pollution in fact is via an induced policy response, and that these policies are in turn induced by popular demand. According to this line of reasoning, poor countries, at first, have so little development that they have high environmental quality. Then, countries' environments degrade as they develop and become richer. Finally, they reach a point at which environmental quality is poor enough and the people are rich enough that they desire to pay for

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