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U.S. state-level carbon dioxide emissions: Does it affect health care expenditure?

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ABSTRACT

This paper is the first to provide an empirical analysis of the short run and long run effects of carbon dioxide (CO_2) emissions on health care spending across U.S. states. Accounting for the possibility of non-linearity in the data and the relationship among the variables, the analysis estimated various statistical models to demonstrate that CO_2 emissions led to increases in health care expenditures across U.S states between 1966 and 2009. Using quantile regressions, the analysis displayed that the effect of CO_2 emissions was stronger at the upper-end of the conditional distribution of health care expenditures. Results indicate the effect of CO_2 emissions on health care was relatively stronger for states that spend higher amounts in health care expenditures. The primary policy message of the paper is that there can be tangible health related benefits associated with policies that aim to reduce carbon emissions across U.S. states.

1. Introduction

The relationship between environmental quality and healthcare has long been an area of interest among scholars. Studies from medical science provide evidence that air pollution affects all types of mortality. An early study, Ostro and Rothchild [23] use Health Interview Surveys to find that the association with small particulate matter can lead to work loss and even bed disability in adults. Schwartz and Dockery [32] use data over the period 1973–1980 for Philadelphia air pollutants, such as total suspended particulate (TSP) and sulfur dioxide increased daily mortality rates. Spix and Wichmann [33] show that in Koln, sulfur dioxide leads to 3–4% increase in mortality and particulates to a 2% increase in mortality. Wordly et al. [37] find that in the U.K., ambient outdoor concentrations of particulate matter (PM10) significantly affect numerous health indicators. While there has been several scholarly attempts to find scientific evidence on the relationship between environmental quality and health care, identifying both the short term and long-run effects of pollutants on health is often very challenging for various reasons. For example, given the lack of effective monitoring systems, the levels of exposure to pollutants are often unknown. Also, the length of exposure to air pollutants, multiple exposures to different pollutants, and the cumulative effects of exposures all pose difficulties in fully understanding the impact of each pollutant on human health [4].

From an economic perspective, a key issue of both academic and policy interest is the potential spatial and temporal effects of different environmental quality indicators on healthcare expenditures. Economists have long been interested in identifying the factors that determine an individual's healthcare expenditures. Early studies, such as Abel-Smith [1], show that income is a key driver of healthcare spending. Murthy and Ukpolo [21] find evidence that U.S. per capita health expenditure is cointegrated with its determinants. Using data from 1960 to 1987, they identify key explanatory factors such as per capita income, health services and Medicare prices, age, and practicing physicians that explain the variation in health care spending across the U.S. population. Focusing on Canada, Matteo and Matteo [20] find that both income and age have a positive effect on per capita provincial healthcare expenditure.

While a relatively large body of literature exists on the determinants of healthcare expenditure, the empirical literature on the relationship between environmental quality indicators and health care expenditure is still limited in spite of the associated economic and social implications. For example, the externalities generated by air pollution can have potentially negative consequences for labor productivity, which has direct implications for industrial performances and economic growth. The nature and extent of these effects essentially depend on the pollutant. For example, using data from Oslo, Hansen and Selte [14] found

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that an increase in small particulate matter (PM) leads to a rise in sick leaves, which negatively affects output and trade in the city of Oslo. However, they also find that the effects of nitrogen dioxide and sulfur dioxide on sick leaves of employees are rather ambiguous. Jerrett et al. [13] make use of data for 49 counties in Ontario and a sequential two-stage regression model to find that counties with higher pollution tend to experience higher health expenses, while counties that spend more on protecting environmental quality have lower expenditures on health care. Jacobson [12] is the first paper that specifically isolated the human health effect of carbon dioxide from other global warming agents. The paper used a high-resolution model to show that chemical and meteorological changes due to carbon dioxide may increase U.S. annual air pollution deaths anywhere between 350 and 1800 as increases in fossil-fuel CO2 increases can lead to increase in U.S. surface ozone, carcinogens, and particulate matter, which in turn can increase hospitalization and death rates. Allen et al. [2] simulated indoor environmental quality conditions in “green” and “conventional” buildings. They found office workers who worked in environments with lower exposure to carbon dioxide had significantly higher cognitive functioning score.

In a 2008 publication, Narayan and Narayan examined the role of environmental quality in explaining per capita health expenditure for a sample of OECD countries. They adopted a panel cointegration approach to obtain estimates of short-run and long-run effects of environmental quality on health care expenditure for eight OECD countries. Their results indicate that carbon monoxide emissions, sulfur oxide emissions, per capita income and per capita health expenditure are panel cointegrated. Interestingly, they find that in the short-run, both carbon monoxide emissions and income and carbon monoxide emissions have a statistically significant positive effect on health expenditure. Income has an elastic and positive effect in the long run while carbon monoxide and sulfur oxide have an inelastic and positive impact on health expenditure. Assadzadeh et al. [3] focus specifically on the linkage between carbon dioxide emissions and health care expenses. They use a panel dataset for eight oil exporting countries that cover the years 2000 through 2010. Their findings reveal that short-run elasticities for carbon dioxide and income are positive and statistically significant, while the impact of life expectancy on health expenditures turns out to be negative.

Given the serious implications of rise in atmospheric greenhouse gas (GHG) concentrations on life on earth, an important area of research involves identifying the linkages between greenhouse gases emissions and expenditures on health care. Carbon dioxide (CO_2), water vapor, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons and chlorofluorocarbons are among the most abundantly found greenhouse gases in the earth’s atmosphere [22] website, *retrieved October 10, 2017*). Larger emissions of greenhouse gases lead to higher concentrations of pollutants in the atmosphere, which lead to excess heat trapped on the earth’s surface that would have otherwise radiated back to the atmosphere. In this paper, we focuses on the relationship between carbon dioxide and health care expenditures. Carbon dioxide emissions that stem from various anthropogenic causes such as fossil fuel combustion, soil erosion, and deforestation is likely to play a critical role in defining current and long-term global environmental quality. Scientific evidence shows that carbon dioxide can stay trapped in the earth atmosphere for a very long time. The negative externalities that stem from carbon dioxide emissions have long last adverse effects on both economic growth and human welfare. This makes it critically important to develop our understanding of the role of carbon dioxide emissions in human health over time. Therefore, this paper contributes to the existing environmental and health economics literature by providing an empirical analysis of the impact of per capita CO_2 emissions on real per capita health care expenditure across all the 50 U.S. states. We control for a measure of output, *i.e.,* real per capita personal disposable income, given the widespread evidence of the latter being a strong predictor of health care expenditures [10,11,6].

The United States is the second largest emitter of carbon dioxide in the world behind China and ahead of the European Union (EU) and India (Union of Concerned Scientist website, *retrieved October 10, 2017*). Within the U.S., there is a considerable variation in CO_2 emissions across states. For example, in 2013, aggregate CO_2 emissions in Texas for all five sectors, i.e. commercial, industrial, residential, transportation, electric power, was 712.86 million metric tons, whereas for Vermont was 5.97 million metric tons (U.S. EPA website, retrieved October 10, 2017). There is also some variation in per capita health care spending across these states. For example, in 2009, the per capita health care spending in the District of Columbia (D.C.), Alaska, and Massachusetts were $10348.85, $9127.63, and $9277.89, respectively, indicating the highest spending per capita across all U.S. states. In comparison, per capita health care spending for Utah, Georgia and Idaho were $5030.94, $5467.46, and $5657.99, respectively, three states with the lowest per capita spending in the country [15], *retrieved October 10, 2017*).

The novelties of this paper are twofold. First, it is the first paper to provide an empirical analysis of the short- and long-run effects of CO_2 emissions of healthcare spending across U.S. states using a panel dataset. The results can be useful in the context of designing and evaluating U.S. health care and environmental policies, particularly, those that account for cross-state variation. Second, the paper makes a methodological contribution as well. To account for the possibility of non-linearity in the data of the individual variables as well as in the relationship amongst the variables, we estimate various conditional mean-based statistical models. We also conduct quantile regressions to account for the variability of the results across the US states, conditioned on their level of health care expenditures.

The remainder of the paper is organized as follows: In Section 2, the data set and the econometrics methodologies are detailed. Section 3 discusses the empirical findings. Finally, Section 4 provides discusses some policy implications and provides a few concluding remarks.

2. Data and method

For the empirical analysis, the study makes use of annual data on healthcare expenditures for all 50 US states for the period 1966–2009. We obtained the data on health care spending by state of residence from the Center for Medicare and Medicaid Services Health Expenditure. The data on nominal personal disposable income were obtained from the regional database of the U.S. Bureau of Economic Analysis (BEA). Per capita values were obtained for both variables by dividing the data with the population data, which was also obtained from the BEA regional database. We obtained the data on per capita carbon dioxide from the Carbon Dioxide Information Analysis Center. The data was obtained from sectoral accounting, which reflects human/economic activity during a certain period of time. The CO_2 data are measured in thousand metric tons of carbon.

Because the state level consumer price index (CPI) levels are not available for the sample period, we converted the per capita nominal personal disposable income and the nominal per capita health care expenditure data into their real values by deflating with the aggregate US CPI. Freeman [11] is our source for the data on real per capita health expenditures (H) and personal disposable income (INCOME) for the 50 US states. The data on income inequality (Gini coefficient) is obtained from Mark W. Frank’s website.[1] The paper provides a complete description of the dataset. For the analysis, the data are transformed into their natural logarithmic values.[2]

As is standard practice in panel data econometrics (N = 50) with a long time series component (T = 44), we start off by conducting unit root testing on the data. Given the evidence of non-linearity in the three

[1] Source: http://www.shsu.edu/eco_mwf/inequality.html.

[2] The dataset is available upon request.