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Communication

A dynamic state-level analysis of carbon dioxide emissions in the United States

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HIGHLIGHTS

- State-level analysis of carbon dioxide emissions.
- Dynamic panel estimation to account for time series properties.
- Feasible environmental Kuznets curve for carbon dioxide emissions.
- Implications for state environmental policy discussed.

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ABSTRACT

As climate change and the regulation of carbon dioxide emissions play an increasingly important role in the global policy debate, careful consideration of the state-level determinants driving emissions must be considered. The importance of state-level determinants in the transmission of carbon dioxide matters especially for a country that differs from coast to coast in energy use and industry makeup like the United States. To add to the policy debate this paper estimates two models that account for the dynamic nature of emissions of carbon dioxide emissions at the state-level from 1980–2010 while taking account of scale, technique, and composition effects. When stochastic trends are taken account of, an environmental Kuznets curve relationship with a feasible turning point is found for carbon dioxide emissions.

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1. Introduction

The regulation of carbon dioxide (CO_2) and other greenhouse gases has come to the forefront of policy debates taking place on the international and state-level alike. Although there is a robust literature on CO_2 emissions from an international perspective, very few authors have considered CO_2 emissions at a sub-national level for the United States. Many states are in fact larger than some developed countries and thus produce more emissions through the scale effect alone. There are many underlying factors in aggregate reported data that matter when it comes to CO_2 emissions. As Stanton et al. (2010) point out, if per capita CO_2 emissions were equal across the United States to that of California, global emissions would fall by 8%. If per capita emissions were equal to Texas, however, global emissions would increase by 7%. Furthermore, state-level analyses of emissions are important because many states have begun to pursue more stringent environmental standards unilaterally than they are required by Federal law (Prasad and Munch, 2012). As a policy tool, some states have implemented renewable portfolio standards that dictate the amount of electricity generated by renewable means. More stringent policies have been adapted, though, such as the cap-and-trade program for CO_2 emissions in California and the Regional Greenhouse Gas Initiative (RGGI). RGGI (2012) is in fact a perfect example of states going beyond Federal regulations to limit CO_2 emissions because it is a coalition of nine Northeast and Mid-Atlantic states that are trying to reduce carbon emissions from electricity by 10% in 2018.

This paper adds to the diminutive literature on state CO_2 emissions by estimating a dynamic state-level model of the determinants of CO_2 emissions while accounting for effects due to the scale, technique, and composition of economic activity that stem from the literature on free trade and the environment. Understanding the determinants of CO_2 emissions from a state-level is certainly important in the crafting of future legislation, and reconsideration of current policies. This paper also contributes to the wider literature on estimating carbon dioxide emissions because it explicitly takes into account the time series properties of emissions, which are seldom addressed. Continuing on, Section 2 briefly discusses the scale, composition, and technique effects that will be used to add structure to the model as well as discusses papers that specifically account for the time-series properties of

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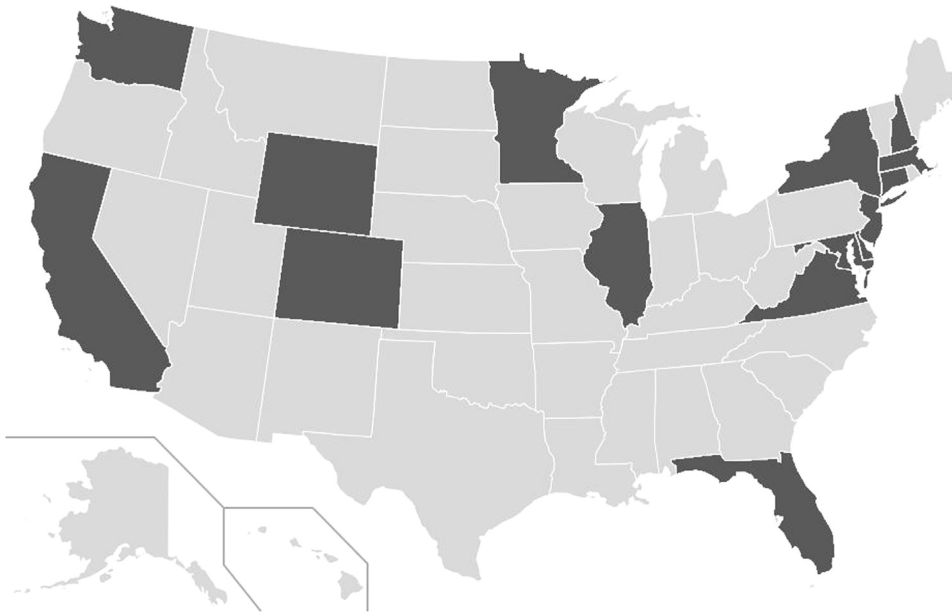

Fig. 1. Map of subsample states.

emissions. Section 2 then concludes with a discussion of works that look at emissions from a state-level perspective. Section 3 develops the dynamic panel model. Section 4 concludes with a discussion of policy implications that stem naturally from the model estimates Fig. 1.

2. Background

The environmental impact of trade liberalization and economic growth in general has been at the vanguard of attention in the environmental economic literature for quite some time and has led to many theoretical and empirical mainstays that are useful for analyzing regional effects of economic growth on the environment. Despite the robust literature on the income–environment relationship at international and country levels, and the variance in state and federal policies regarding CO_2 emissions, very little has been written on state-level CO_2 emissions. For the sake of brevity, then, only a few papers that use national or international data will be discussed in this section. In order to motivate and add structure to the empirical application that follows elements from the free trade and the environment will be discussed here in modest detail.[1]

The net effect that economic growth has with regard to the environment can be decomposed into three separate effects: the composition, technique, and scale effects (Copeland and Taylor, 2003; Antweiler, et al., 2001; Managi et al., 2009). The composition effect demonstrates how emissions are affected by changes in the composition of output in an economy. The composition of output would likely change due to the degree of trade liberalization in a country and its relative comparative advantages compared to other countries. Naturally, the composition effect is country or state specific and can lead to a net increase or decrease in emissions. In their seminal work on the environmental Kuznets curve (discussed below), Grossman and Krueger (1991) estimate that the composition effect is what drives lower pollution levels in Mexico. They argue that instead of Mexico being turned into a pollution haven, higher demand for environmental quality from the United States will mitigate this worry.

The technique effect measures how growing incomes change the intensity of emissions. Typically, rising income will result in a decrease in emissions because more environmentally sound production methods are demanded. Thus, as trade and income growth gives consumers a greater variety of goods to consume, this will afford countries the opportunity to attain higher levels of welfare, for a given level of domestic output, which will in turn increase the demand for better environmental quality (Frankel, 2003). The technique effect itself has fostered a robust body of research on what is commonly known as the environmental Kuznets curve (EKC).[2] The hypothesis behind the EKC is that pollution transitions from being a normal good to being an inferior good as income increases. That is to say, carbon dioxide emissions follow an "inverted-U" shape: increasing as income increases for a time, and eventually falling with increases in income after a threshold level is reached. It is interesting to note that the EKC does not seem to hold in the case of global pollutants like CO_2 (Dinda, 2004; Müller-Fürstenberger and Wagner, 2007). Many authors find that CO_2 emissions do not follow the inverted parabolic trend that can be found in pollutants like ozone and sulfur dioxide (Cole et al., 1997; Frankel, 2003; Kim, 2013). Vollebergh et al. (2009) suggest, though, that the lack of robustness for EKC findings may be due to under-identification. Luzzati and Orsini (2009) suggest that differences in EKC findings can be attributed to including outliers, using measures of per capita CO_2 instead of CO_2 in levels, and including time trends. The present study uses CO_2 emissions in (log) levels because it is better justified theoretically (Luzzati and Orsini, 2009). Carson (2010) suggests that instead of income being the causal agent for increasing environmental quality it is instead good government regulations which are correlated with higher incomes that motivate emissions reductions.

The scale effect measures the basic effect that an increase in production, or GDP, has on emissions. According to theory, if the scale effect is positive then we can conclude that economic growth is a driver of pollution. There is also the so called "scale-technique effect" which measures the combined scale and technique effects

[1] For a more comprehensive review of the literature on free trade and the environment Frankel (2009) and Copeland and Taylor (2003) are both excellent sources.

[2] A thorough background on the EKC can be found in Dinda (2004).