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# Developing spatial inequalities in carbon appropriation: A sociological analysis of changing local emissions across the United States

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## ABSTRACT

This study examines an overlooked dynamic in sociological research on greenhouse gas emissions: how local areas appropriate the global carbon cycle for use and exchange purposes as they develop. Drawing on theories of place and space, we hypothesize that development differentially drives and spatially decouples use- and exchange-oriented emissions at the local level. To test our hypotheses, we integrate longitudinal, county-level data on residential and industrial emissions from the Vulcan Project with demographic, economic and environmental data from the U.S. Census Bureau and National Land Change Database. Results from spatial regression models with two-way fixed-effects indicate that alongside innovations and efficiencies capable of reducing environmentally harmful effects of development comes a spatial disarticulation between carbon-intensive production and consumption *within* as well as across societies. Implications for existing theory, methods and policy are discussed.

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## 1. Introduction

For most of human history, social activities that degraded the environment did so locally. With the rise of modern cities, industrial combustion, and capitalist economies, this arrangement changed, and the environmental impacts of local life became increasingly global in scale. Nowhere is this historic shift more evident than in releases of carbon dioxide (CO<sub>2</sub>) to the atmosphere (Clark and York, 2005, 2008; Gonzalez, 2009; Grimm et al., 2008; Jorgenson and Clark, 2012). To understand better this type of socio-environmental interaction, the present study takes a closer look at the relationship between local development and carbon emissions within the United States – the second largest producer of greenhouse gases on Earth (U.S. Energy Information Administration, 2013). The aim is to illuminate the spatial contours of this socio-environmental interaction and what they reveal about the social bases of global environmental change now taking place at and from the local level within advanced market societies.

Although most sociological research on carbon emissions has focused on anthropogenic drivers at the national level (e.g., Grimes and Kentor, 2003; Jorgenson, 2007; Rosa and Dietz, 2012; Satterthwaite, 2009; York et al., 2003), there is growing interest in local-level dynamics (e.g., Clement and Elliott, 2012; Grant et al., 2013; Lankao et al., 2009; Pattison et al.,

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2014; Videras, 2014). Building from this interest and related sub-national studies, we believe it is useful to consider local links between development and emissions for a number of reasons.

One reason is the simple fact that nearly all carbon is emitted locally – i.e., from a particular location in time and space – as well as unequally. So it makes empirical sense to examine contributing factors *within* as well as across societies, especially those characterized by significant social inequality. While Grant and colleagues (2013) have advanced this argument in international research on energy-related carbon emissions, it is particularly pertinent in the United States, where nearly half of all counties emit more carbon waste than many less developed nations (Satterthwaite, 2009). Another reason to focus on local drivers of emissions involves policy. To date, the United States has delegated primary responsibility for carbon mitigation to local, state and regional initiatives – e.g., the Regional Greenhouse Gas Initiative and the Mayors Climate Protection Agreement (Lutsey and Sperling, 2008). This approach means that effective government intervention must cultivate better understanding of local variation in sources as well as amounts of carbon released into the atmosphere. Otherwise, successful strategies deployed in one type of area may be inappropriately applied to other types of areas, leading to frustration, failure, or indifference.

A final reason to investigate local drivers of emissions is theoretical, which is where we find a gap in the nascent sub-national literature on carbon emissions. Like related cross-national research, much of the local level literature is organized around the STIRPAT model (York et al., 2003) to evaluate general theories from human ecology, ecological modernization, and political economy (Lankao et al., 2009; Pattison et al., 2014; Roberts, 2011; Videras, 2014). Yet, moving down in scale – from national to local – also allows us to incorporate and assess relevant sociological theories of place and space for understanding how societies organize their ongoing appropriation of the global carbon cycle. These theories begin with political economy's intractable tension between the social production of local use and exchange values in advanced market societies. They then point to how more affluent areas strive to resolve this tension through reductions in the latter, lending insight into how and how much carbon is released locally over time. From this modified framework, we advance and test several hypotheses using county-level data from the 2001 and 2006 waves of the Vulcan Project (Gurney et al., 2009). This dataset includes direct monitoring data from a wide array of governmental sources, allowing us to conduct one of the most thorough, locally comparative studies of CO<sub>2</sub> output to date.

Results indicate that the United States is now shifting carbon-intensive industrial production from more to less developing areas, with areas of rising affluence showing no sign of reducing carbon-intensive residential energy emissions. The implication is that as advanced market societies develop, they re-organize where carbon is appropriated for different purposes, further complicating local solutions to global warming.

## 2. Social appropriation of the carbon cycle

Sociological research emphasizes that carbon emissions are best understood as part of a global carbon cycle, which refers to the circulation of carbon through living organisms and non-living matter in support of Earth's biosphere (Clark and York, 2005). The connection of human societies to this cycle is as old as our species. Before written records, humans appropriated carbon in the form of fire for cooking, foraging and agricultural practices, tapping energy stored in renewable carbon resources, such as wood (Bowman et al., 2009). Thereafter, humans extended appropriation of the carbon cycle into non-renewable resources, such as coal, petroleum and natural gas for an expanding array of activities – from making salt to heating homes to smelting metals. These activities increased human production and trade capacities but remained for centuries small in scale and oriented mostly towards local use (Ponting, 2007).

Over the past century and a half, however, these social connections to the carbon cycle have shifted dramatically in scale and purpose, rendering environmental consequences of local human activities increasingly global in scale (Foster, 1994). To explain this development, scholars now point not only to well-documented drivers of population size and growth (see Rosa and Dietz, 2012) but also to two specific dimensions of global economic change. One is the rise of industrial combustion, which has greatly increased the use of fossil fuels to power a growing number of human activities (Rockström et al., 2009). The other is the expansion of capitalism, which has harnessed the power of industrial combustion to the production of commodities for expanding market exchange and capital accumulation (Foster et al., 2010).

In environmental sociology, the latter development is commonly associated with Schnaiberg's (1980) theory of the treadmill of production. This theory contends that capitalism and the environment are in inherent conflict because of the former's intrinsic drive to increase profits through heightened use of natural resources. Theories of ecological modernization contest this claim, arguing instead that advanced market societies will improve resource efficiency through social and technological innovations that are now in process (e.g., Mol, 1997). Efforts to resolve this debate empirically have focused on national-level data and uncovered support for each side, pointing to different outcomes in different socio-spatial contexts (Jorgenson and Clark, 2012). This complexity is now pushing scholars to develop middle-range theories that better account for variation in carbon-related activities within, as well as across, societies.

One example of this new line of research is Shwom's (2011) study of subnational variation in the implementation of new policies for energy-efficient appliances. Another is Zahran and colleagues' (2008) study of inter-metropolitan variation in local support for climate protection campaigns (see also Dietz et al., 2007; Krause, 2010). In the present study, we advance a related but distinct line of research. Instead of focusing on variation in local support for specific policies and programs, we return to classic political economy to highlight tensions between the social production of use and exchange values for which

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