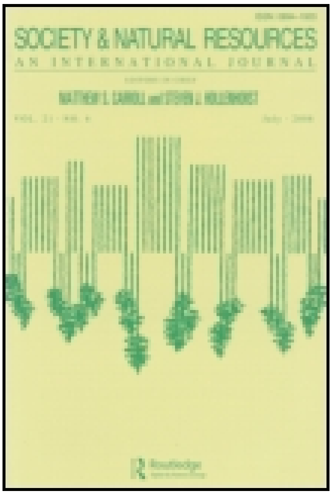

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Ecological Modernization or Aristocratic Conservation? Exploring the Impact of Affluence on Carbon Emissions at the Local Level

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Social scientists have debated how affluence impacts carbon emissions at the national level. We conduct an exploratory study at the subnational level to expose another dimension of the affluence–emissions debate. Based on the notion of aristocratic conservation, we hypothesize that affluence is positively related to carbon emissions from consumption activities but negatively related to emissions from production activities. We test these hypotheses using county-level data in the United States for the year 2002. A spatial regression analysis demonstrates that median household income is positively associated with consumption-based emissions; nevertheless, we find evidence of an environmental inequality Kuznets curve in the relationship between median household income and production-based emissions. This finding suggests that the wealthiest counties are able to displace certain types of emissions, specifically those related to energy and industrial production. We discuss the theoretical and political implications of these results.

Keywords carbon emissions, environmental inequality, environmental Kuznets curve, growth machine, spatial regression

Social science research on the drivers of climate change at the international level has shown that affluence, measured in terms of economic output per capita, is positively related to carbon emissions (e.g., Jorgenson and Clark 2012). Recent subnational studies on carbon emissions confirm results from the international level (Clement 2011; Clement and Elliott 2012), suggesting that the positive association between economic output and carbon emissions is multiscalar. Furthermore, at the

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international level, ecologically unequal exchange theory has been applied to examine how international trade has influenced the uneven spatial distribution of carbon emissions among developed and developing nations (Jorgenson 2012). Yet there has been no discussion in this literature about how there might be a comparable process at the subnational level. Indeed, at the local level in the United States, research in environmental inequality has revealed connections between exposure to industrial pollution and affluence, measured in terms of household income (e.g., Crowder and Downey 2010). Drawing on a range of environmental social science literatures, we ask whether there is a similar process at work with respect to affluence and carbon emissions at the local level within the United States: Do wealthy and poor localities emit different quantities of carbon dioxide because of inequalities in local affluence? The answer to this question has theoretical and political implications. Theoretically, we frame this discussion as a tension between ecological modernization theory and the notion of aristocratic conservation (Molotch 1976; Clement and Elliott 2012). In the conclusion, we also discuss political implications and emphasize the need for greenhouse gas policies to address variation in local measures of affluence.

In the following study, we conduct an exploratory analysis of the different ways that distinct measures of affluence are related to carbon emissions at the county level in the United States. To that end, we draw on a variety of theoretical frameworks to develop hypotheses that we then test with ordinary least squares (OLS) and spatial regression models. We utilize a novel county-level data set on carbon emissions developed by the Vulcan Project (Gurney et al. 2009). These data represent the first comprehensive, nationwide inventory of local carbon emissions in the United States not based on proxy measures, such as population. We merge these county-level data on carbon emissions with Census data that represent various dimensions of affluence. We control for demographic factors examined in other research that has also used the data from the Vulcan Project (Clement and Elliott 2012; Parshall et al. 2010). Following the results of that analysis, we discuss the theoretical implications of our findings. In the conclusion, we expand our discussion to acknowledge the political implications and encourage social and physical scientists as well as policymakers currently working on carbon-footprint methodology and climate policy process models to acknowledge that affluence plays a role in the spatial distribution of carbon emissions at the local level.

Social Science Research on Affluence and Environmental Outcomes

In the environmental social science literature, there has been a debate about the way affluence is related to carbon emissions at the international level (see Jorgenson and Clark 2012). On the one hand, ecological modernization theory (e.g., Spaargaren 2009) posits that increasing affluence will drive the dematerialization of the economy by reducing the amount of fossil fuel consumed per unit of economic output. On the other hand, the treadmill of production theory suggests that growing affluence will increase the total quantity of emissions (Jorgenson and Clark 2012; Schnaiberg 1980), which can happen despite improvements in the carbon efficiency of the economy, a phenomenon known as the Jevons paradox (see York 2006). To briefly summarize, the research cited above has revealed little support for ecological modernization theory (EMT) as an explanation for variation in carbon emissions at the international level.

Nevertheless, as York and Rosa (2003) point out, much of the evidence for ecological modernization is purportedly found within individual nations, especially from the developed world. Therefore, an alternative assessment of the impact of affluence on carbon emissions should be carried out at the subnational level within a developed country, like the United States. Indeed, as mentioned earlier, comparative international analyses have revealed that EMT does not help explain emissions variation between nations in terms of economic production. However, we argue that affluence should be conceptualized both in terms of both production and consumption; these international studies have not explicitly considered how affluence in terms of average household consumption might shape the global landscape of carbon emissions. EMT does make a case for studying domestic consumption (Spaargaren 2009; see also Carolan 2004). This theory claims that changing patterns of consumption can result in positive environmental outcomes, emphasizing "the role of citizen-consumers in shaping and reproducing some of the core institutions of production and consumption" (Spaargaren 2009). In this sense, modernization and the affluence that comes with it are supposed to generate environmentally efficient forms of consumption. This happens either through the purchase of environmentally sustainable products, or by reducing the quantity of material consumed, or through increased recycling activities (Scheinberg 2003; see also Scheinberg and Anschütz 2006). Other environmental social scientists have questioned the ability of consumers per se to bring about such change. For instance, Carolan (2004) notes that the knowledge necessary for rational action on behalf of domestic consumers is limited due in part to far-flung and complex global commodity chains. In terms of energy consumption, previous empirical research by Luna (2008) has found that the greater the distance between households and electrical power plants, the more energy is consumed. Both Luna (2008) and Lutzenhiser and Hackett (1993) have shown that income is positively correlated with household energy use, suggesting that wealthier households consume more energy than poorer ones. Consequently, the research examining the environmental impact of consumption does not support an EMT-based hypothesis of affluence, which points to an alternative perspective we discuss in the following.

However, we need to address a number of issues in order to adjudicate more thoroughly the claims made by EMT. First, we need to disentangle the different components of affluence, which means distinguishing affluence in terms of consumption and production. Second, we must conduct an empirical analysis of their independent effects on both consumption- and production-based carbon emissions. Third, this analysis must be done at the local level within a developed nation. And, finally, we argue that a more complete assessment of EMT is not possible without addressing the role that affluence plays in the spatial distribution of carbon emissions.

As previously mentioned, environmental social scientists have already examined how the unequal structure of global trade has transferred emissions from the developed to the developing world (Jorgenson 2012), arguing that carbon-intensive industrial activities are being relocated to poorer nations. Yet, with the exception of the agriculture sector (Jorgenson 2007), the data used in these analyses do not distinguish between different sectors generating CO_2; thus, the analyses do not have separate emissions estimates for production- and consumption-based activities. More refined data sets with carbon emissions estimated for different sectors of activity, like the one published by the Vulcan Project (Gurney et al. 2009), can make it possible to empirically distinguish between emissions that come from production activities and emissions that come from consumption activities. We use these subnational data in the subsequent analysis and discuss them in the following in greater detail.

In the meantime, we can clarify how alternative measures of affluence are differentially related to consumption- and production-based emissions at the subnational level. As already mentioned, previous studies at the international level have discussed the production side of affluence, measured in terms of gross domestic product, and have found that for the most part economic production is positively related to emissions. We also consider the production side of affluence by testing the relationship between economic output and carbon emissions at the local level.

Our focus, however, is on the consumption side of affluence, measured in terms of median household income. Drawing on research in environmental inequality, we expect household affluence to play a role in the spatial distribution of emissions at the subnational level. As already mentioned, Luna (2008) and Lutzenhiser and Hackett (1993) have found a positive correlation between household income and residential energy use.[1] This points to a hypothesis that affluence measured in terms of household income is positively related to consumption-based emissions. Other environmental inequality research has examined how exposure to industrial pollution varies by household income (e.g., Crowder and Downey 2010). This points to a hypothesis that household income may be negatively related to production-based emissions. When we combine these insights we start to see a more complete picture about the different ways that household affluence might distribute emissions in space. The greater the household affluence, the greater the consumption of natural resources. However, increasing household income also results in the displacement of unwanted industrial activities from wealthier localities.

The ability of wealthy localities to distance themselves from negative environmental outcomes is what Molotch (1976) characterized as aristocratic conservation in his growth machine theory. That is, affluence can create a veneer of environmental sustainability as wealthy communities use their localities "as a setting for life and work, rather than as an exploitable resource" (Molotch 1976, 328). The uneven ability to conserve the local natural environment concerns not just the exploitation of mineral resources within but also the relocation of industrial activities outside of a locality. In terms of carbon emissions, we expect that wealthier localities are able to displace those emissions created from electrical generation and industrial activities. These are what we call production emissions (see Table 1). The growth machine theory is similar to the treadmill of production theory; both acknowledge the environmental impacts of increasing consumption. Therefore, the notion of aristocratic conservation also argues that increasing local affluence in terms of household income translates into greater consumption of natural resources that have been extracted elsewhere, such as fossil fuel. We expect that this measure of affluence will be positively related to emissions from the residential, commercial, and transportation sectors. These are what we call consumption emissions.

To summarize, we consider affluence at the local level in terms of both economic output per capita and median household income. We argue that the carbon

Table 1. Sectors contributing to production and consumption emissions

Production emissions	Consumption emissions
Electrical	Transportation
Industrial	Residential
	Commercial

consequences of these measures of affluence are not straightforward when we delineate between emissions resulting from production versus those from consumption activities. The hypothesized effects of affluence on carbon emissions at the local level depend on the specific theoretical framework. Based on ecological modernization theory, we test an environmental Kuznets curve (EKC) in the relationship between economic output per capita and production and consumption emissions (see Dietz et al. 2012; Dinda 2004). Taking the shape of "∩," emissions should rise then fall with increasing economic output. According to aristocratic conservation, household income may exhibit a similar curvilinear relationship with local production emissions, rising at lower levels of income, peaking, and then dropping at the highest levels as opportunities for aristocratic conservation increase. In other words, the relationship between household income and production emissions takes the general form of an EKC, but the forces underlying this curve differ from those associated with the traditional EKC. The traditional EKC is based on the EMT idea that development will eventually reduce pollution through improvements in the environmental efficiency of the economy. We propose an alternative mechanism based on forces similar to those observed in the environmental inequality literature (e.g., Crowder and Downey 2010). Controlling for economic output, wealthier communities may be associated with fewer emissions from the electrical and industrial sectors because their high affluence confers an ability to displace pollution. We call this relationship an *environmental inequality Kuznets curve*, in which production emissions rise and then fall with higher levels of household affluence within a locality.[2]

Integrating the preceding insights on ecological modernization and aristocratic conservation, Table 2 displays two sets of hypothesized effects of the different measures of affluence on consumption- and production-based emissions.

Data and Methods

We test the preceding hypotheses about county-level emissions with two spatial regression models. In this section of the article, we first review the variables in our regression models and discuss how our analysis makes a contribution to previous research on local carbon emissions (e.g., Parshall et al. 2010). Second, because our study includes all counties in the continental United States, the potential arises for violating the assumption of independent observations in classic OLS, specifically through spatial autocorrelation of the regression residuals. We address these concerns by controlling for spatial dependence.

Table 2. Hypothesized relationships between measures of affluence and production and consumption emissions

	Ecological modernization		Aristocratic conservation	
Measure of affluence	Production emissions	Consumption emissions	Production emissions	Consumption emissions
Economic output per capita	∩	∩	+	+
Median household income	∩	∩ or −	∩	+

Measuring and Modeling the Distinction between Consumption and Production Emissions

The first model looks at per-capita emissions from both the electrical and industrial sectors; we call this the *production emissions model*. The second model looks at per-capita emissions from the residential, commercial, and transportation sectors; this is called the *consumption emissions model*. We note that alternative conceptualizations of "consumption emissions" might include the household purchase and use of electricity and products that are the outcome of electrical generation and industrial processes, but in our analysis these emissions would be included in "production emissions." These are typically referred to as Scope 2 emissions. However, we do not use this alternative conceptualization. Our models focus on Scope 1 emissions, or rather, CO_2 directly emitted from the use of fossil fuel by the electrical and industrial sectors (i.e., production-based emissions) and the residential, transportation, and commercial sectors (i.e., consumption-based emissions). Our conceptualization of production- and consumption-based emissions allows us to employ the Vulcan data in order to investigate the potential for spatial displacement of emissions as proposed by aristocratic conservation.

We regress our two models on the same six independent variables: (1) economic output per capita, (2) household income, (3) household income squared, (4) percent of the population living in urban areas, (5) population density, and (6) a dummy variable for location in a metropolitan area. See Table 3 for a complete list and description of all variables. Table 4 reports means, standard deviations, bivariate

Table 3. Variable descriptions

Variable	Description	Source
1. Production emissions per capita	Electrical and industrial emissions divided by total population, 2002	Vulcan Project[a]
2. Consumption emissions per capita	Residential, commercial, and transportation emissions divided by total population, 2002	Vulcan Project[a]
3. Economic output per capita	Total earnings from all industries divided by total population, 2002	USA Counties[b]
4. Median household income	Median household income, 2000	USA Counties[b]
5. Median household income squared	$(\text{Median household income})^2$	USA Counties[b]
6. Percent urban	Urban population divided by total population × 100, 2000	USA Counties[b]
7. Population density	Total population divided by total land area, 2000	USA Counties[b]
8. Metropolitan county	Dummy variable indicating if county is in a metropolitan area (0 = no; 1 = yes), 2000	USDA Economic Research Service[c]

[a]Gurney et al. (2009).
[b]U.S. Census Bureau (2010).
[c]USDA Economic Research Service (2013).

Table 4. Descriptive statistics and bivariate correlations (all continuous variables have been logged)

Variable	Mean	*SD*	Minimum	Maximum	Moran's *I*	1	2	3	4	5	6	7	8
1. Production emissions per capita	0.867	1.076	0.000	6.677	0.159*	1.000							
2. Consumption emissions per capita	1.127	0.456	−0.073	4.831	0.329*	0.003	1.000						
3. Economic output per capita	2.923	0.353	0.000	5.224	0.142*	0.143	−0.020	1.000					
4. Median household income	10.456	0.241	9.617	11.450	0.654*	0.055	−0.115	0.465	1.000				
5. Median household income squared	109.386	5.076	92.496	131.109	0.653*	0.053	−0.116	0.463	1.000	1.000			
6. Percent urban	2.945	1.700	0.000	4.615	0.213*	0.137	−0.346	0.415	0.355	0.354	1.000		
7. Population density	3.765	1.674	−2.307	11.112	0.688*	0.023	−0.587	0.358	0.477	0.478	0.589	1.000	
8. Metropolitan county	0.349	0.477	0.000	1.000	0.398*	0.038	−0.313	0.226	0.520	0.521	0.325	0.579	1.000

*Pseudo $p \leq .001$ based on 999 permutations.

correlations, and Moran's *I* statistics for each variable, all of which are significant at the $p < .001$ level. As expected, these descriptive statistics reject the null hypothesis of spatial randomness, providing evidence for the existence of spatial patterns.

As formulated already, we hypothesize that the independent variables representing affluence will have different effects on production and consumption emissions. Our analysis builds on previous work by Parshall et al. (2010), who also examined how different measures of urbanization influence consumption-related emissions at the county level. They argue, based on a reference to Isserman (2005), that conventional dichotomous measures of urbanization (from the Census Bureau and the Office of Management and Budget) may misrepresent county-level conditions. To address these problems of misrepresentation, Isserman created a county-character typology using three dimensions of urbanization: (1) urban residence, (2) county-level population density, and (3) metropolitan designation. This and other typologies (e.g., the rural–urban continuum and urban influence codes) have improved the way researchers can characterize counties in terms of urbanization. In our analysis, instead of creating a single urban indicator, we treat the three dimensions that Isserman used as three separate variables: (1) percent urban, (2) population density, and (3) a dummy-code designation for metropolitan county.

In our analysis, production-based emissions are those from the electrical and industrial sectors. Because there is a spatial mismatch between the production and consumption of electricity, Parshall et al. (2010) do not include the electrical sector in their assessment of consumption-based emissions despite the fact that these emissions are a significant contributor to total emissions at the local and national scales. While this spatial mismatch makes it difficult to include the electrical sector in a study of consumption-based emissions, our proposed framework justifies the inclusion of the both electrical and industrial sectors in production-based emissions. To test the effect of median household income on production emissions, we control for the effect of economic output at the county level. Thus, we include in our models a variable that measures per-capita earnings from all industries.[3] This measure of economic output per capita reflects the value produced by all economic activity in the county. This is different from median household income, which reflects the typical income earned by the county's residents. What a county's economy produces and what a county's residents earn are conceptually distinct. The value from production can flow out of a county, while household income indicates how affluent the county's residents are. This again indicates that our model can examine emissions resulting from both trans-local consumption as well as point-of-use consumption.

Controlling for Spatial Dependence

Another methodological issue to address in our article is spatial dependence. We do this by employing the maximum-likelihood approach developed by Anselin and colleagues (Anselin 1988; Anselin and Bera 1998; Baller et al. 2001; Anselin 2002). As defined here, spatial dependence can manifest in the presence of either spatial "effects," such as a diffusion or spillover into neighboring counties, or as spatial "disturbance" caused by omitted, spatially correlated covariates. The former is addressed through a spatial "lag" model and the latter through a spatial "error" model as detailed in the following. In either case, the observation of OLS residual spatial autocorrelation would affect inference based on "pure" structural variable estimates derived from traditional OLS regression.[4]

Results and Discussion

We first discuss results from our spatial analyses, which highlight the limits of raditional OLS for modeling consumption- and production-based carbon emissions. Second, we turn to an interpretation of slope estimates to discuss the strengths and weaknesses of the two frameworks under investigation: EMT and aristocratic conservation. We recognize, however, that a more robust test for these frameworks would include time-series data. Our study indicates factors and processes that should be considered in later analyses when time-series data become available. On that note, we believe our exploratory analysis yields significant findings to guide subsequent investigations.

Model Estimation

OLS regression diagnostics revealed the presence of heteroskedasticity[5] and spatial dependence for both models, leading to a consideration of spatial models. Table 5 presents results for the production emissions specification (Model 1) derived from a spatial lag specification.[6,7] The choice of spatial lag as the appropriate spatial regression procedure was based on an interpretation of spatial diagnostics derived from the classic OLS model. The Global Moran's I statistic, which tests the degree of spatial autocorrelation among regression residuals, was 0.146, significant at the $p \leq .001$ level. Both Lagrange multiplier (LM) statistics for error and lag models are also significant. Consequently, we turn to robust LM statistics to distinguish between alternate models. Here, the robust LM-lag statistic remains significant at the $p \leq .01$ level, indicating the appropriateness of spatial lag model to control for spatial dependence.[8] The spatial lag (ρ) is positive and statistically significant, suggesting the presence of a spatial effect whereby the factors that result in production emissions diffuse across county borders—although an exploration as to the precise mechanism of this relationship will be saved for subsequent analysis. A Moran's I

Table 5. Spatial lag model of production emissions (Model 1) (all continuous variables have been logged)

Independent variables	Estimates
Economic output per capita	0.348** (0.062)
Median household income	19.225** (4.192)
Median household income squared	−0.917** (0.199)
Percent urban	0.079** (0.014)
Population density	−0.058** (0.016)
Metropolitan designation	0.063 (0.050)
Intercept	−101.161** (22.025)
Spatial lag (ρ)	0.326** (0.025)
R-squared	0.111[a]

Note. Standard errors in parentheses. All variables except the metropolitan dummy variable are natural log transformations.

[a]Pseudo-R-squared is reported for the spatial regressions; this is not directly comparable with the R-squared reported for OLS.

$^{**}p \leq .01$.

test on the regression residuals failed to reject the null hypothesis, suggesting the absence of bias in parameter estimates due to the existence of spatial regimes. In other words, residuals are not spatially autocorrelated after controlling for spatial dependence.

While the production emissions regression revealed a spatial effect, the consumption emissions regression revealed a spatial disturbance effect, leading us to select a spatial error model for the latter. Table 6 reports results of the spatial error model on consumption emissions (Model 2). The Global Moran's *I* on the residuals was 0.137, significant at the $p \leq .001$ level, revealing a high degree of spatial dependence in the model. Both LM-lag and LM-error tests were significant, but unlike with Model 1, the robust LM-error remains significant at the $p \leq .001$ level. These diagnostic tests reveal the spatial error model as the most appropriate approach to controlling for spatial dependence in the production emissions regression.

The spatial error term (λ) is significant and positive, which suggests that spatial clustering in consumption emission is accounted for simply by spatial clustering of observed and unobserved variables. In other words, spatial dependence is limited to spatial "disturbance" and not necessarily to spatial "effects" (Baller et al. 2001).[9] In most cases, the addition of the spatial error term did not substantially alter the estimated effect of the structural variables, with the notable exception of the quadratic relationship between median household income and consumption emissions. In the spatial error model, both the median household income variable and its squared term are significant at nearly the $p < .01$ level. As in the previous model, a Moran's *I* test on the regression residuals was not statistically significant and provided no evidence of bias due to the existence of spatial regimes.

Our spatial models yield lessons for similarly minded studies of climate change at the scale of local political jurisdictions. Our attempt to incorporate spatial relationships into the regression analysis should be considered as tentative and preliminary, but our findings provide fairly strong evidence for the presence of spatial dependence. This possibility has far-reaching implications, from spatial variation

Table 6. Spatial error model of consumption emissions estimates (Model 2) (all continuous variables have been logged)

Independent variables	Estimates
Economic output per capita	0.232** (0.021)
Median household income	4.001* (1.572)
Median household income squared	−0.180* (0.075)
Percent urban	−0.021** (0.005)
Population density	−0.182** (0.007)
Metropolitan designation	−0.016 (0.018)
Intercept	−20.929* (8.270)
Spatial error (λ)	0.330** (0.025)
R-squared	0.443[a]

Note. Standard errors in parentheses.
[a]Pseudo-*R*-squared is reported for the spatial regressions; this is not directly comparable with the *R*-squared reported for OLS.
*$p \leq .05$, **$p \leq .01$.

in the validity of emissions inventories on the local level to the potential existence of a causal spatial "effect" that ties emissions produced in one jurisdiction to the characteristics of its neighbors. We believe future research concerned with the subnational scale might do well to broaden its focus beyond merely considering the local political unit as a unique site of inquiry and policy activism to also look toward interlocal and cross-political jurisdictional relationships.

Regression Results

The results from the spatial regression analyses indicate strong support for the aristocratic conservation framework and limited support for ecological modernization.[10] Economic output per capita is positively related to production- and consumption-based carbon emissions, meaning bigger economies emit more emissions regardless of the type of activities involved. We tested and did not find an EKC in economic output per capita. The log-linear and quadratic forms of household income are significant in the spatial models for both production and consumption emissions. However, to evaluate our hypothesis about an environmental inequality Kuznets curve, we graphically display the relationship between household income and per capita production- and consumption-based emissions in Figure 1. The predicted values for per-capita emissions used in this figure come from the spatial model estimates for both production and consumption emissions, in which we hold the other independent variables at their means. This figure shows that the effect of affluence on production emissions follows the form of a Kuznets curve, with emissions going up, reaching a plateau, and then declining for wealthier localities. The same is not true for consumption emissions; here we see that affluence has a generally positive effect on consumption emissions. While there is a turning point in the consumption emissions graph, this point is very high, and only about 30 counties, or 1% of the total, fall to the right of it. As a consequence, the evidence of ecological modernization in terms of consumption is limited to the wealthiest localities in the United States. Moreover, to reiterate, there was no EKC in economic output per

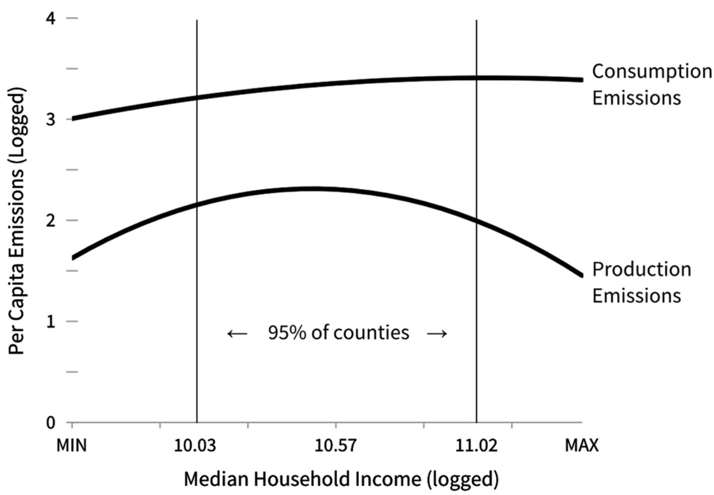

Figure 1. Environmental inequality Kuznets curve.

capita for either consumption- or production-based emissions. Looking at affluence in terms of household income, we found that the wealthiest counties generally consume the most fossil fuel for commercial, residential, and transportation purposes. Consequently, if we look back at Table 2, we argue that our analysis supports neither EMT nor the traditional EKC. Instead, our results show that (1) economic output is positively related to consumption- and production-based emissions, (2) household income is positively related to consumption-based emissions, and (3) there is negative quadratic relationship between household income and production-based emissions. Therefore, our results support aristocratic conservation and indicate the presence of an environmental inequality Kuznets curve. Shown in Figure 1, the environmental inequality Kuznets curve becomes apparent with the growing gap between the two lines above the mean median household income. To the right of this point, as household income increases, production-based emissions decrease while consumption-based emissions continue to generally increase.

Second, we briefly discuss the results of our control variables. These results challenge and corroborate previous research on the efficiency of urban density (Parshall et al. 2010; Satterthwaite 2008). While percent urban increases production emissions, it, along with population density, decreases consumption emissions. Meanwhile, metropolitan designation did not have an effect on either production or consumption emissions. This finding suggests that the different dimensions of Isserman's (2005) county-character typology may not equally impact carbon emissions.

Finally, our results support a spatial lag model for production emissions and a spatial error model for consumption emissions, a finding that bears further exploration. Although spatial error models account for the technical issues associated with the spatial patterning of measured and unmeasured independent variables (i.e., a spatial disturbance), spatial lag models also imply an actual relationship of influence among neighbors (i.e., a spatial effect). At this point, we can only speculate regarding the nature of a spatial "effect" that would apply to production emissions but not to consumption emissions. Recall that consumption emissions per capita are relatively strongly negatively correlated with our measures of urbanization (Table 4). Ultimately, consumption per capita is determined on the basis of household-level decisions. One household's level of consumption in a given county has no direct influence in a household's consumption in a neighboring county—other than the induced effect of consumption dollars rippling throughout a regional economy. Mapping these values reveals much higher rates in the sparsely populated West, with relatively lower rates varying gradually over more heavily urbanized areas, probably due to differences in urban form, disposable income, and cultural preferences. The spatial error is likely attributable to unmeasured differences, for example, between the East Coast and the Sunbelt with respect to urban form.

On the other hand, the geography of production emissions reveals a much patchier tapestry, as production activity can be determined by economic relations that cross county lines. For example, a manufacturing plant in a given county may provide inputs, share factor markets like labor or natural resources, or create spillover efficiencies in conjunction with a plant in neighboring county. As a result, certain production complexes will form in certain regions as similar and related industries cluster together; these qualitatively differentiated production complexes generate different carbon signatures. Two examples are the industrial belt of the Midwest and the oil and gas infrastructure on the Louisiana and Texas Gulf Coast, both of which are discernible concentrations of production emissions. These regions span dozens of counties and multiple states but are distinguished less by urban form than by industry-specific forms of agglomeration. Again, we would highlight that the difference in model specifications tentatively supports our initial argument for unpacking the sources of anthropogenic emissions.

To summarize our results, we highlight four main points. First, economic output and household income are distinct forms of affluence at the county level. Second, these distinct measures of affluence are differentially related to production- and consumption-based emissions. Third, our results suggest that household income plays a significant role in the spatial distribution of production-based emissions. Fourth, there is a significant degree of spatial dependence between neighboring counties in terms of carbon emissions; the causal mechanism for this final point and its significance for local climate policy need to be further explored.

Conclusion and Contextualization

In terms of affluence, our results indicate that economic output per capita and household income are differentially associated with production and consumption emissions. While household affluence is generally positively related to consumption emissions, it expresses a curvilinear relationship with production-based emissions. In other words, the most affluent counties, measured in terms of household income, generally have more consumption-based emissions but less production-based emissions. Thus, we propose an environmental inequality Kuznets curve in the relationship between household income and production emissions. The most affluent counties are able to displace production-related emissions; this finding holds even as we control for the effect of economic output. Given that the vast majority of the production-related emissions are products of energy generating processes, this concentration of production-related emissions is likely not the result of more efficient production of consumer goods in more affluent counties.

These results have both theoretical and political implications. Theoretically, our study provides another perspective on the debate in environmental social science about the effects of affluence on emissions. Similar to previous research, we find little support for ecological modernization theory. However, because this was a cross-sectional study, we frame our analysis as exploratory and use our results to advance arguments that can be more appropriately evaluated when time-series data become available. Our results suggest that future studies should consider distinctions between affluence and emissions in terms of production and consumption. Other than emissions from agriculture (Jorgenson 2007), international research on CO_2 has not adequately examined the different sectors of emissions. Nor have previous studies considered the ways in which affluence can be conceptualized in terms of production and consumption; this is true despite the fact that ecological modernization theorists (e.g., Spaargaren 2009) have argued that positive environmental change can result from the actions of ecologically conscious consumers (see Carolan 2004). Yet our study reveals limited evidence of EMT in terms of consumption. Furthermore, with respect to production-based emissions, affluence at the subnational level, measured in terms of household income, is playing a role comparable to international trade at the global level. The most affluent localities have the power to displace carbon-intensive industrial activities onto less affluent communities.

Politically, this finding has implications for local government carbon footprint methodology and policy process models that seek to educate policy actors but do not include explicit examinations of different measures of local affluence. We have shown that affluence and per-capita carbon emissions are related at the county level, and that patterns of production- and consumption-related emissions are not the same. Given the unequal and nonlinear relationship between the different measures of affluence and different types of emissions, policymakers must strongly consider the potential disproportional impacts that may be imposed on different communities when climate policies are implemented.

It is possible the relationship between household income and per-capita production emission exists at scales smaller than the county level. Thus, as standardized carbon footprint methodologies for cities, towns, and counties develop, national carbon emissions inventories with greater granularity are created (Hillman and Ramaswami 2010; Ramaswami et al. 2008), and models are used by scholars and policymakers to develop and implement subnational and national climate mitigation policy, the effects of local measures of affluence on different types of carbon emissions cannot be ignored. Just as critics of public choice theory have pointed out that environmental inequalities across local governments are not the result of differing tastes but rather differing advantages related to being able to "vote with your feet," we claim that theories that examine the relationship between carbon emissions and local communities must explicitly examine the role of economic advantage and power.

It is also worth mentioning again that while the Vulcan data represent the first comprehensive, nationwide inventory of local carbon emissions in the United States not based on proxy measures, the data set is limited in that it is currently only cross-section data, and cross-county patterns of consumption are not accounted for. We attempted to address this with our theory and analysis, and though our methods do not fully bridge the gap between large nationwide emission inventories, which are capable of a litany of comparative analysis, and locally based carbon inventories of individual cities, which are better able to examine a finer grain of consumption patterns, we believe it is a step forward. Theory is needed to describe and examine the behavior of different categories of social actors across localities and thus better understand greenhouse gas mitigation policies. For instance, based on the typology proposed by Ramaswami et al. (2012) and Davis and Weible (2011), the production emissions in our model may be more determined by the activities of "policy actors" and "infrastructure designers and operators," while the consumption emissions in our models are more determined by "individual infrastructure users" (Davis and Weible 2011, 485). On that note, our findings could aid in the development of interdisciplinary metatheories needed to help explain and understand the complex socioecological systems of local populations and carbon emissions (Ramaswami et al. 2012). We look forward to future work on these important topics.

Notes

1. Using stepwise regression, Luna (2008) did not find a significant slope estimate for household income. We caution against the use of stepwise regression. See York and Rosa (2005) for a discussion about how this procedure can produce misleading results in the case of modeling environmental outcomes.
2. We note that much of the EKC literature (for a review see Dinda 2004) does not address the legacy of Kuznets's (1955) original research on inequality and development.
3. In analyses not reported, we also include a control for the percent of economic output that is from the industrial sector. Including this control does not change the slope estimates of our models.

4. We also explored the potential presence of "spatial heterogeneity" by mapping local indicators of spatial autocorrelation. While the Mountain West contained a large cluster of high values for consumption emissions per capita, these counties are primarily rural areas. The source of variation, thus, is likely captured by the measures of urbanization, population density, and metropolitan designation. In other words, exploratory spatial data analysis based on local indicators of spatial autocorrelation did not reveal clear "spatial regimes" within the continental United States that would clearly suggest taking steps to allow for structural differences in regression relationships across different regions. This issue is further discussed later in conjunction with regression diagnostics.
5. Both Breusch–Pagan and Koenker–Basset tests for heteroskedasticity were significant.
6. That all variables have been transformed into their natural logarithms facilitates interpretation of slope estimates, where the coefficient represents the percent change in the dependent variable for a 1% change in the independent variable, holding the rest of the model constant.
7. The coefficient estimates for classic OLS and the spatial lag model were generally similar, and overall model fit improved slightly with the inclusion of the spatial lag term. Since the traditional *R*-squared is not appropriate for a spatial regression model, fit is measured through log-likelihood, the Akaike information criterion, and the Schwarz criterion. All three indicated better fit in the spatial regression.
8. When using a weights matrix based on second-order contiguity, the spatial error model was actually revealed to be the appropriate alternative, based on a significant robust LM-error statistic. While this did not substantively alter the interpretation of the structural variables, it is notable that the spatial "effect" disappeared when expanding the relationship beyond immediate neighbors. This may suggest that the cross-border spatial "diffusion" process apparent for immediate neighbors evaporates when expanding the scale spatial relationship rule, leaving only spatial "disturbance" in the residuals.
9. Overall model fit also improved with the inclusion of the spatial error term. Log-likelihood, the Akaike information criterion, and the Schwarz criterion indicated that the spatial regression provides better model fit than classic OLS. As with Model 1, the signs and levels of significance generally remained similar across the classic OLS and spatial error models for consumption emissions.
10. We note that without the squared term of household income the maximum variance inflation factor (VIF) is 2.13 in our models. This indicates that multicollinearity is likely not a concern in establishing significance.

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