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Can Reducing Income Inequality Decouple Economic Growth from CO_2 Emissions?

Julius Alexander McGee[1] and Patrick Trent Greiner[2]

Abstract

In the past two decades, income inequality has steadily increased in most developed nations. During this same period, the growth rate of CO_2 emissions has declined in many developed nations, cumulating to a recent period of decoupling between economic growth and CO_2 emissions. The aim of the present study is to advance research on socioeconomic drivers of CO_2 emissions by assessing how the distribution of income affects the relationship between economic growth and CO_2 emissions. The authors find that from 1985 to 2011, rising income inequality leads to a tighter coupling between economic growth and CO_2 emissions in developed nations. Additionally, the authors find that increases in the top 20 percent of income earners' share of national income have resulted in a larger association between economic growth and CO_2 emissions, while increases in the bottom 20 percent of income earners' share of national income reduced the association between economic growth and CO_2 emissions.

Keywords

decoupling, STIRPAT, environmental sociology, CO2 emissions

Understanding how nations effectively reduce the amount of CO_2 emitted from economic growth is an important part of planning for climate change mitigation. Although it has been established that the majority of economic growth that has occurred in developed nations since World War II has greatly increased the amount of CO_2 in earth's atmosphere (Intergovernmental Panel on Climate Change 2014), researchers are still assessing how changes in social dynamics through this period have helped reduce the amount of CO_2 emitted from economic development (Jorgenson and Clark 2012; Knight and Schor 2014; York 2008, 2012; York and McGee 2017). One social dynamic that has changed rather drastically through this period is the distribution of income, which is heavily tied to economic growth (Piketty 2014). Recent research has argued that economic growth over time produces an unequal distribution of domestic income in developed nations (Piketty and Saez 2014). Changes in the distribution of income in developed nations have coincided with changes in CO_2 emissions. For example, in Spain and Italy, the average income of the bottom 10 percent of income earners declined drastically from 2010 to 2014 (Organisation for Economic Co-operation and Development 2013). During this same period, CO_2 emissions in both Spain and Italy increased drastically relative to other developed nations, because of increases in fossil fuel energy consumption (Netherlands Environmental Agency 2016). Although some recent studies have attempted to understand the direct association of income inequality and emissions (Jorgenson, Clark, and Giedraitis 2012; Jorgenson et al. 2015, 2016; Jorgenson, Schor, and Huang 2017; Knight, Schor, and Jorgenson 2017; Ravallion, Heil, and Jalan 2000), in the present study we seek to further understand the relationship among economic growth, domestic income inequality, and CO_2 emissions by analyzing how income inequality affects the amount of CO_2 emitted from economic activity. We construct a series of fixed-effects panel regression models with robust standard errors that account for clustering in 35 developed nations from 1985 to 2011 to assess how domestic income inequality interacts with gross domestic product (GDP) per capita to influence CO_2 emissions per capita. Our findings indicate that in nations where domestic income is more equally distributed, the association between GDP per capita and CO_2 emissions per capita is much lower than in nations where income is distributed more unequally.

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Background

Our modeling approach is based on the structural human ecology tradition (Dietz and Jorgenson 2013). We use the common control variables used in the structural human ecology (GDP per capita, percentage urban population, and age dependency) and introduce a number of new variables to measure domestic income inequality. In including these variables and exploring how they modify the relationship between economic activity and environmental impact, our goal is to address critiques of structural human ecology and other macro-structural approaches to environmental sociology that note an inadequate empirical incorporation of inequality into understandings of socioenvironmental relationships (Downey 2015).

Studies using traditional variables in the structural human ecology tradition have found that the relationship between GDP per capita and CO_2 emissions follows a nonlinear, inverted U-shaped curve or what is commonly called an "environmental Kuznets curve" (EKC) (Chow and Li 2014; Dinda 2004; Ibrahim and Law 2014). The EKC suggests that the nature of the relationship between CO_2 emissions and economic growth changes at higher levels of economic development. Specifically, in the early stages of economic development, the relationship between economic growth and CO_2 emissions (as well as many other forms of environmental degradation) is positive, but at higher levels of economic development, the relationship between economic growth and CO_2 emissions starts to attenuate.

A common explanation for the existence of an EKC is the "ecological rationalization" of social and economic processes (Mol and Spaargaren 2000), whereby at certain levels of economic development, societies become conscious of their impacts on the environment and begin to reduce hazardous output. The concept of ecological rationality is a core feature of ecological modernization theory[1] (EMT). Proponents of EMT often analyze instances of environmental reform to assess the degree to which nations, organizations, and various markets are able to institute environmentally conscious production practices (Mol, Spaargaren, and Sonnenfeld 2009; Spaargaren and Cohen 2009). Critics of EMT argue that the existence of ecologically rational policies and production practices does not necessarily curtail environmental degradation at the national or global level (York and Rosa 2003). For instance, York (2004) contended that increases in environmentally conscious goods in an economic market are simply a treadmill of diversified production. This is to say that environmentally conscious goods are reactions, not counterforces, to environmental degradation and thus additions to markets already dominated by environmentally hazardous goods.

Another criticism of EMT, which has been explored far less, is its lack of engagement with issues of inequality, and injustice. Bonds and Downey (2012) argued that "green technologies" conceptualized by EMT often disproportionately favor the interest of those with power at the expense of other groups. As a result, green technologies with the capacity to greatly reduce environmental inequality are overlooked in favor of those that minutely reduce environmental degradation and yield the highest return on investments for the wealthy. By overlooking the effects of socioeconomic inequality on the use and production of environmentally conscious goods, EMT overestimates the ability of green technology to reduce environmental degradation. This criticism is particularly relevant when one considers recent trends in domestic income inequality within an increasing number of developed nations.

Income Inequality, Economic Growth, and the Environment

The relationship between economic development and income inequality is dialectical. Changes in the pattern of inequality often influence, and are influenced by, the nature of economic growth. Sociologists have examined the effects of economic development on income inequality, finding that processes such as financialization (Lin and Tomaskovic-Devey 2013), the rise of information technology (Acemoglu 2003; Blanchard 1997), globalization (Harrison 2002; Kristal 2010), and deunionization (Kristal 2010) all contribute to income inequality. These processes have clear environmental implications. For instance, environmental sociologists have argued that the rise of information technology in locations such as Silicon Valley has reified historical legacies of environmental injustice (Park and Pellow 2004). Furthermore, financialization is argued to be a redistribution of privileges from laborers to financial elites (Lin and Tomaskovic-Devey 2013). One outcome of this process is the reduction of laborers' ability to lobby for environmental reform (Obach 2004).

Research on the effect of economic growth on income inequality has produced mixed results. In 1955, Simon Kuznets found that the relationship between inequality and growth followed a nonlinear trajectory whereby at low levels of economic growth, inequality increased, but at higher levels, it decreased. The explanation given for Kuznets's findings is that higher inequality is associated with higher aggregate savings, which result in a more consistent convergence pathway for growth (Foellmi and Zweimüller 2006; Rosenzweig and Binswanger 1993). However, over the past few decades, scholars have argued that income inequality reduces economic growth by creating expensive fiscal policies (Alesina and Rodrik 1994; Perotti 1993; Persson and Tabellini 1994), undermining human capital (Galor and Moav 2004), and/or undermining the structure of the legal system (Glaeser, Scheinkman, and Shleifer 2003).

[1]To be clear, EMT is a theoretical and empirical tradition in sociology that is independent of the EKC hypothesis.

In a recent study, Halter, Oechslin, and Zweimüller (2014) argued that the diversity of findings regarding the relationship between economic growth and income inequality is due to the methodological and theoretical differences in research. The authors pointed out that research that finds a positive association between inequality and economic growth often emphasizes the direct association of income inequality and growth as well as the economic implications of increases in the wealthy's share of income (e.g., higher savings). Meanwhile, research that finds that income inequality reduces economic growth often emphasized the "lagged" effect of inequality on economic growth and the political and social implications of unequally distributed income (e.g., lower levels of human capital). Halter et al. concluded that "higher inequality helps growth in the short term but may be harmful over longer periods of time."

The explanations given for both the short-term and the long-term effects of inequality on growth have clear environmental implications that coincide with specific theories in environmental sociology. In the short term, inequality is argued to support economic growth through convex savings and a higher capacity for risky capital investments. These mechanisms can also contribute to the "treadmill of production" (Schnaiberg 1980; Schnaiberg, Pellow, and Weinberg 2002) by, for instance, allowing a greater level of investment in fixed capital and, ultimately, placing greater pressures on the environment through productive processes and market expansion. Concerning long-run impacts of inequality, recent work has theorized that insofar as inequality can be understood as representing the "expendability of human and nonhuman populations facing socioecological threats" (Pellow 2016:223), reductions of inequality will likely lead to an increase in overall environmental quality. Put differently, Pellow (2016, 2017) argued that by reducing inequality such that all populations, and the environmental spaces they occupy, are valued equally leads to societies that are able to more effectively act in ways that encourage the development of socioenvironmental resiliency. Relatedly, Downey's recently developed inequality, democracy, and environment approach notes that the environmental crisis can largely be understood as a function of undemocratic decision-making processes at both the national and international levels that allow the exploitation of public goods and environmental resources for the financial benefit of relatively few social actors (Downey 2015; Downey and Strife 2010). For instance, Pattison, Habans, and Clement (2014) noted that in the United States, reductions in emissions at the county level often occurred at higher levels of income as a result of wealthy counties' shifting productive activities to poorer areas, though such counties typically also maintain higher levels of consumption-related emissions.

Here we draw from such theories by arguing that although inequality is a complex and multidimensional concept, income inequality is a fundamental facet of inequality, broadly understood. Thus, considering work on the links between environmental sociology, social inequality, and economic growth, we should expect to see that reductions in income inequality might generally reflect a pattern of economic development associated with lower levels of CO_2 emissions, a subject to which we now turn.

Previous research on income inequality and emissions has found that domestic income inequality drives CO_2 emissions in high-income nations (Jorgenson et al. 2016; Knight et al. 2017; Ravallion et al. 2000) and the United States in particular (Jorgenson et al. 2015, 2017). These analyses are based on the tradition of stochastic impacts by regression on population, affluence, and technology (STIRPAT), and as such, they estimate the effect of income inequality as an additional multiplicative contributor to environmental degradation. These studies have focused on the temporal effect of income inequality by interacting income inequality with time dummies to assess how the effect of income inequality changes over time. They have found that inequality has the strongest association with emissions in high-income nations and that the effect of inequality on emissions increases over time. These studies are concerned with the extent to which the nature of inequality changes over time and the environmental implications of that change. They broadly conclude that the concentration of power coincides with the concentration of wealth such that they both contribute to the intensification of environmental degradation. Furthermore, Knight et al. (2017) contended that these studies are "limited" in that "they does not identify the specific mechanism(s) that may link wealth inequality to emissions, but only empirically demonstrates an association between the two." We hope to expand on these studies by further identifying the mechanisms that link inequality and emissions.

The approach applied in these studies is useful particularly when one considers the dynamic nature of income inequality discussed above. However, because it has been shown that income inequality is directly correlated with economic growth, we suspect that the relationship between emissions and inequality is, to a notable degree, based on the dynamic relationship of inequality and economic growth. Thus, we contend that income inequality and economic growth function to moderate each other's effect on emissions. Building on criticisms of EMT, we argue that increasing income inequality limits the ability of nations to incorporate ecologically conscious technologies and policies in a way that effectively decouples economic growth from emissions. Furthermore, we argue that the attenuating relationship between economic growth and emissions (see Chow and Li 2014; Ibrahim and Law 2014) is moderated by level of inequality and that change in the relationship between inequality and emissions over time (see Jorgenson et al. 2016) is moderated by the effect of economic growth.

Modeling Approach

To explore these relationships empirically, we incorporate a commonly used measure of income inequality (taken from Solt's [2009] Standardized World Income Inequality Database [SWIID]) and interact it with GDP per capita (held constant in 2010 U.S. dollars) to assess whether income inequality significantly influences the relationship between GDP per capita and CO_2 emissions per capita. Considering the theories discussed above, our hypothesis in this analysis is that at least one aspect of the change in the relationship between CO_2 emissions and economic growth that is found in EKC analyses is due to changes in income inequality. That is to say, rather than the observed attenuation in the relationship between growth and emissions in the EKC being a function of processes of ecological rationalization (e.g., changes in technological efficiency and environmental policy), leading to a decoupling of emissions and growth, it is more likely a function of nations with lower income inequality having more equity in decisions regarding the use and distribution of technology that lower emissions. Following Pellow (2016) and Downey (2015), we argue that lower levels of income inequality can broadly be taken as a proxy for greater valuation of the environmental goods that populations rely upon, as well as more distributed control over democratic decision-making processes and, subsequently, the form and extent of economic growth that takes place. Thus, we hypothesize that the relationship between economic growth and CO_2 emissions will change at different levels of income inequality. Specifically, we argue that because income inequality in high-income nations accelerates economic growth and CO_2 emissions, the association of economic growth and CO_2 emissions at higher levels of income inequality will be larger than it is at lower levels of income inequality.

Our technique for assessing this hypothesis is based on previous research that has used interactions to understand the extent to which processes decouple economic growth from CO_2 emissions (York and McGee 2017). Similar to this study, our goal is to determine if GDP per capita significantly interacts with income inequality. We use the term *decoupling* to refer to the ability of income inequality to change the nature of the relationship between GDP per capita and CO_2 emissions per capita, such that additional economic growth results in substantially lower emissions than when income inequality is not considered. Moreover, our approach allows us to further explore how GDP per capita changes the relationship between income inequality and emissions.

Our primary measure for assessing income inequality is the Gini coefficient (see “Data and Methods” for more detail), which ranges from 0 (equal distribution of wealth across a population) to 100 (one person having all the wealth across a population) to quantify inequality at the national level. In previous research on the relationship between income inequality and CO_2 emissions, the relationship between economic growth and income inequality has been explored by grouping nations together on the basis of GDP per capita (Jorgenson et al. 2016; Ravallion et al. 2000). Here we are interested in assessing the moderating effect of income inequality on the relationship between economic activity and environmental impact to determine the degree to which income inequality can be understood to serve as a proxy for the form of economic development that takes place within a nation insofar as it is understood to drives CO_2 emissions. Considering our aim, here we focus on understanding this relationship in United Nations–classified “most developed nations,” as it is in such nations that ecological rationalization is understood to occur most commonly. Additionally, it is in such nations that a large share of the growth in economic activity and income inequality described by Piketty (2014) has occurred in the period we observe.

Data and Methods

We constructed fixed-effects panel regression models with robust standard errors that account for clustering in 38 most developed nations from 1985 to 2011 using the nation as the unit of analysis and including dummy variables for each year to control for general period effects. This approach controls for any effects that are constant over the span of time examined for each nation, such as geographical and geological characteristics, and any effects that are constant across nations for a given point in time. All reports of statistical significance or nonsignificance are based on an α level of .05 with a two-tailed test. We chose to focus on developed nations because of acknowledged inconsistencies in the data on the top and bottom 20 percent income earners for nondeveloped nations. Specifically, the World Bank (2017) noted that for nondeveloped nations, there is a low frequency of observations and a lack of available comparable data, which creates uncertainty over the magnitude of the effect over time. To make accurate comparisons of the effect of the Gini coefficient and the top and bottom 20 percent of income earners’ share of income on the association of GDP per capita and CO_2 emissions per capita, we limit the data in this analysis to available data on the top and bottom 20 percent of income earners. As a result, our data are limited to 35 nations from 1985 to 2011, but we note that the data for our other variables capture a larger number of nations and years. We estimated additional models, which can be found in the Appendix Table A1, to check the robustness of our finding on the effect of the Gini coefficient on the association between GDP per capita and CO_2 emissions per capita for all nations with available data and found that our finding is consistent.

All data used in the models from this analysis, with the exception of the Gini coefficient for income inequality, are from the World Bank’s (2017) World Development Indicators. The dependent variable in all of our models is national CO_2 emissions (metric tons) per capita from the burning of fossil fuels and the manufacture of cement. Although some previous analyses estimating the effect on income inequality on CO_2 emissions have used consumption-based emissions, we focus on production-based CO_2 emissions because this variable captures a larger sample of nations and years. Furthermore, it has been noted that the largest contributor to consumption-based emissions in most countries is territorial emissions from domestic production (Peters, Davis, and Andrew 2012).

Our main indicator variables in this analysis are income share held by the lowest and highest 20 percent of income

Table 1. Descriptive Statistics.

Variable	Mean	Median	*SD*	Minimum	Maximum
CO_2 emissions per capita (*t*)	8.14	7.88	4.14	1.38	21.63
GDP per capita	29,234	23,073	20,432	5,127	103,589
Gini coefficient	31.20	30.40	5.83	19.00	51.10
Urbanization (%)	73.39	73.63	12.85	8.90	97.69
Age dependency	67.02	67.07	2.30	58.77	72.37
Bottom 20 percent's share of income (%)	7.47	7.67	1.54	3.34	11.85
Top 20 percent's share of income (%)	41.17	40.39	5.21	31.36	62.46

Note: GDP = gross domestic product.

earners and the Gini coefficient. The data for income share held by the lowest and highest 20 percent of income earners reflect the share of income or consumption accruing to a portion of the population ranked by income or consumption levels. The data derive from nationally representative household surveys. The national survey data are used to directly calculate the income or consumption shares by quintile. The data are also adjusted for household size.

The data for national-level Gini coefficient of inequality measures and household disposable income (after tax, after transfer) are taken from Solt's (2009) SWIID. The SWIID uses a custom missing-data multiple-imputation algorithm to standardize observations collected from the United Nations University's World Income Inequality Database (version 2.0c), the Organisation for Economic Co-operation and Development Income Distribution Database, the Socio-economic Database for Latin America and the Caribbean generated by the Center for Distributive, Labor and Social Studies and the World Bank, Eurostat, the World Bank's PovcalNet, the United Nations Economic Commission for Latin America and the Caribbean, the World Top Incomes Database, national statistical offices around the world, and many other sources. The Gini coefficient ranges from 0 (equal distribution of wealth across a population) to 100 (one person having all the wealth across a population) to measure inequality. All models were originally estimated with both a linear and a quadratic term of urbanization and GDP per capita, but because the quadratic versions had a nonsignificant coefficient, the model was reestimated with only the linear term.

In addition to CO_2 emissions per capita, GDP per capita, and the Gini coefficient, a number of control variables were included in all models because of their theoretical relevance to these questions as demonstrated in previous work. We include urbanization, which represents the percentage of the total population residing within urban areas. Previous research has demonstrated that patterns of consumption, land use, and transportation can vary between urban and nonurban areas to such a degree that fossil fuel–based CO_2 emissions are significantly affected (Clement 2010; Liddle 2014). Additionally, we include the percentage of the population aged 15 to 64 years to account for the average productive activity of a nation.

All variables are in natural log form (except period dummy variables). Thus, the regression models estimate elasticity coefficients, where the coefficient for an independent variable is the estimated net percentage change in the dependent variable associated with a 1 percent increase in the independent variable.

Results

Table 1 shows the descriptive statistics of all the variables used in our analysis in their raw form. Table 2 shows the statistical models used to assess the moderating effect of income inequality on the relationship between economic growth and emissions, using the Gini coefficient to measure inequality. Model 1 in Table 2 shows the association of our control variables for population trends, affluence, and CO_2 emissions. Model 2 in Table 2 expands on model 1 by testing for the nonlinear association between GDP per capita and emissions (the EKC hypothesis) by including a quadratic term for GDP per capita. Our quadratic term in model 2 is negative but not significant in a .05 test, indicating that there is no EKC within nations observed in our model from 1985 to 2010. Because the quadratic term for GDP per capita is not significantly different from zero, we do not include it in later models. We note that in models not shown here, but available upon request, we include the quadratic term for GDP per capita in the subsequent models shown in Table 2, and the relationships of all the variables do not significantly change.

Model 3 in Table 2 assesses the association between inequality, measured as the Gini coefficient, and emissions. In this model, the relationship between income inequality and CO_2 emissions is negative and significantly different from zero, suggesting that on average, increases in income inequality reduce CO_2 emissions. However, we caution against putting too much weight on this result, as our next few models demonstrate that the effect of inequality on emissions is interconnected to economic development. Model 4 in Table 2 assesses the moderating effect that income inequality and GDP per capita have on each other's relationship to emissions. Specifically, this model interacts GDP per capita and income inequality. The interaction of income inequality and GDP per capita is positive and significant. This indicates

Table 2. Association of Income Inequality and GDP per Capita on Emissions per Capita in Developed Nations.

	Model 1	Model 2	Model 3	Model 4
Gini coefficient	—	—	−1.25*** (0.28)	−8.75*** (2.38)
GDP per capita	0.39** (0.14)	0.48 (1.27)	0.33*** (0.09)	−2.52* (0.94)
(GDP per capita)^2	—	−0.00 (0.07)	—	—
Gini Coefficient × GDP per Capita	—	—	—	0.81** (0.26)
Urbanization	1.47 (1.54)	1.45 (1.46)	0.30 (1.16)	−0.39 (0.97)
Age dependency	0.57 (1.47)	0.56 (1.46)	0.54 (1.03)	1.00 (0.83)
R^2 within	.39	.39	.49	.55
Nations	35	35	35	35
Nation-years	311	311	311	311

Note: Model 1 displays results from fixed-effects panel regression with fixed-effects estimators for country and year and robust standard errors. All variables have been natural log transformed, with the exception of year dummies. Coefficients represent the percentage change in CO_2 emissions per capita associated with a 1 percent change in the independent variable under consideration. Standard errors are in parentheses. GDP = gross domestic product.
*p < .05, **p < .01, and ***p < .001 (two-tailed tests with zero as the null hypothesis).

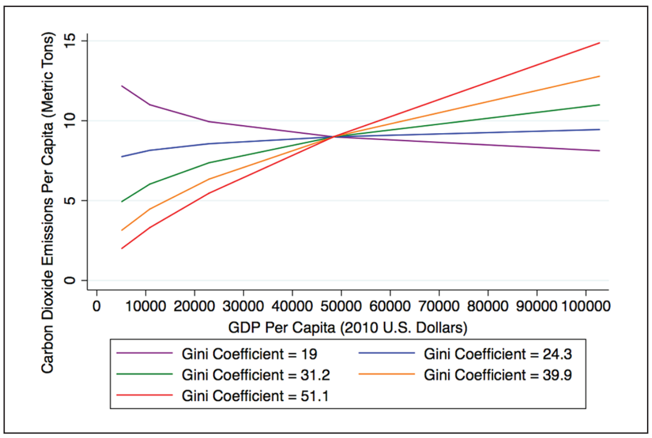

Figure 1. The relationship between gross domestic product (GDP) per capita and CO_2 emissions per capita at different levels of income inequality. In nations with the highest income inequality in our model (Gini coefficient = 51.1), growth in GDP per capita is shown to consistently have a larger association with CO_2 emissions per capita. This suggests that nations with the most unequal distributions of income have the tightest coupling between GDP per capita and CO_2 emissions. For nations with the lowest income inequality in model 1 (Gini coefficient = 19), growth in GDP per capita is shown to consistently have a negative association with CO_2 emissions. This suggests that economic growth is decoupled from CO_2 emissions in nations with the most equal distribution of income in our model.

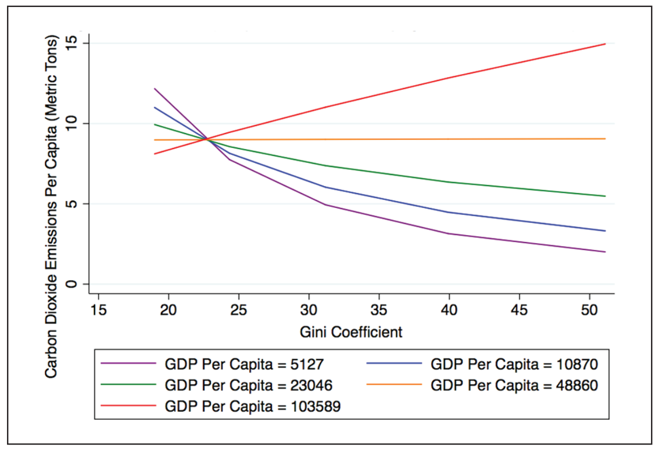

Figure 2. The relationship between income inequality and CO_2 emissions per capita at different levels of gross domestic product (GDP) per capita. In nations with GDP per capita lower than roughly $20,952, increasing income inequality is estimated to reduce CO_2 emissions per capita. However, in relatively wealthy developed nations (those with GDP per capita of roughly $48,500 or higher), on average, increasing income inequality is also associated with increases in CO_2 emissions per capita.

that the association of GDP per capita and CO_2 emissions per capita varies at different levels of income inequality, and the association of income inequality varies at different levels of GDP per capita. To better interpret this finding, we turn to Figures 1 and 2.

The logic of Figures 1 to 4 is to estimate the effect of economic growth on emissions while income inequality is held constant (in the case of Figure 2, the logic is reversed). Note, that these figures represent estimates based on the range of values in our models and do not necessarily characterize any observed value in our data. For example, in the case of Figure 1, there is no nation at any time with a Gini coefficient of 19 and GDP per capita of $90,000; rather, Figure 1 demonstrates what emissions would be (hypothetically) in a nation with those values.

Figure 1 demonstrates the association of GDP per capita and CO_2 emissions per capita at different levels of income inequality. We chose five separate values of Gini coefficient ranging from the lowest to highest values observed in our model to capture the range of the effect of Gini coefficient. On the basis of Figure 1, it is clear that as income inequality shrinks, GDP per capita becomes increasingly decoupled from CO_2 emissions per capita. Specifically, Figure 1 demonstrates that in nations where income inequality is low, the association of GDP per capita and

Table 3. Associations of Interactions between GDP per Capita and Percentage of Income Earned by the Top and Bottom 20 Percent of Earners on Emissions per Capita in Developed Nations.

	Model 1	Model 2	Model 3
Top 20 percent's share of income	−0.170 (0.36)	−8.07* (3.55)	−0.15 (0.37)
Bottom 20 percent's share of income	0.380* (0.16)	0.29* (0.13)	4.81** (1.61)
GDP per Capita	0.389** (0.12)	−2.63 (1.46)	1.31*** (0.33)
GDP per Capita × Top 20 Percent	—	0.80* (0.39)	—
GDP per Capita × Bottom 20 Percent	—	—	−0.46** (0.16)
Urbanization	1.03 (1.22)	0.69 (0.96)	0.64 (0.85)
Age dependency	0.126 (1.19)	0.34 (0.91)	0.07 (0.90)
R^2 within	.44	.51	.52
Nations	35	35	35
Nation-years	311	311	311

Note: Models 2 and 3 displays results from fixed-effects panel regression with robust standard errors for 38 developed nations from 1961 to 2006. All variables have been natural log transformed, with the exception of year dummies. Coefficients represent the percentage change in CO_2 emissions per capita associated with a 1 percent change in the independent variable under consideration. Standard errors are in parentheses. GDP = gross domestic product.
*$p < .05$, **$p < .01$, and ***$p < .001$ (two-tailed tests with zero as the null hypothesis).

emissions is its highest when GDP per capita is low, and the association of GDP per capita and emissions becomes smaller as GDP per capita increases (it should be noted that very few nations reach those levels of equality[2]). Inversely, in nations where income inequality is high, the association of GDP per capita and emissions is highest when GDP per capita is large, and in these nations, the association of GDP per capita and emissions becomes larger as GDP per capita increases.

Figure 2 demonstrates the association of income inequality and CO_2 emissions per capita at different levels of GDP per capita. Similar to Figure 1, we chose five separate values of GDP per capita ranging from the lowest to highest observed values in our model. A basic interpretation of this figure suggests that larger economies have a tighter coupling between rising income inequality and CO_2 emissions. As can be seen in the figure, in developed nations with relatively low GDP per capita, the association of income inequality and CO_2 emissions per capita is highest when income inequality is low, and the association of income inequality and emissions in these nations' decreases as income inequality increases. Inversely, Figure 2 demonstrates that in nations with high GDP per capita, the association of income inequality and emissions is lowest when income inequality is low and increases as income inequality rises.

In an effort to further understand this phenomenon, we estimated additional models (see Table 3) assessing the association of GDP per capita and CO_2 emissions on the basis of changes in the share of income between the top and bottom 20 percent of income earners. In these models, instead of measuring inequality using the Gini coefficient, we explore how changes in the share of income moderates the relationship between economic growth and emissions. Model 1 in Table 3 shows the individual association between of the top 20 percent and the bottom 20 percent of income earners and emissions. Here we find that changes in the top 20 percent of income earners share of income has no association to CO_2 emissions per capita. Conversely, model 1 in Table 3 shows that increases in the bottom 20 percent of income earners share of income significantly increases CO_2 emissions per capita. Model 2 in Table 3 assesses the moderating effect that the top 20 percent has on the relationship between GDP per capita and emissions by interacting the variable for the top 20 percent's share of income with GDP per capita. The interaction of GDP per capita and the top 20 percent's share of income is significant in a .05 test. We further explore this relationship in Figure 3. Figure 3 demonstrates the association of GDP per capita and CO_2 emissions per capita at different levels of the top 20 percent's share of income. Similar to Figures 1 and 2, we chose five separate values of the top 20 percent's share of income ranging from the lowest to highest observed values in our model. The findings in Figure 3 further elaborate on our findings in Table 2 and Figure 1, showing that increasing the top 20 percent's share of income leads to tighter coupling between GDP per capita and CO_2 emissions per capita.

Model 3 in Table 3 assesses the moderating effect that the bottom 20 percent has on the relationship between GDP per capita and emissions by interacting the variable for the bottom 20 percent's share of income with GDP per capita. In model 3 in Table 3, the interaction of bottom 20 percent of income earners and GDP per capita is significant. We explore this relationship further in Figure 4. Figure 4 demonstrates the association of GDP per capita and CO_2 emissions when the bottom 20 percent's share changes. Similar to Figures 1, 2, and 3, we chose five separate values of the bottom 20 percent's share of income ranging from the lowest to highest observed values in our model. As shown in Figure 4, for nations where the share of the bottom 20 percent of income earners is high, growth in GDP per capita is less coupled with CO_2 emissions per capita, but for nations where the share of the bottom 20 percent of

[2]Of the nations included in our model, only the Slovak Republic had Gini coefficients this low.

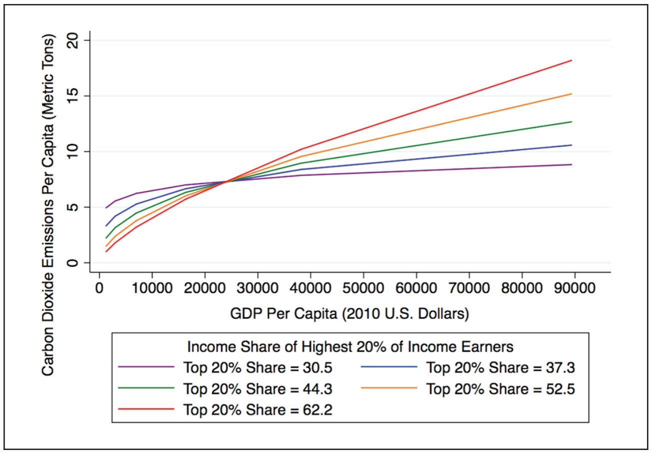

Figure 3. The relationship between gross domestic product (GDP) per capita and CO_2 emissions per capita at different levels of the share of national income held by the top 20 percent of all income earners. As the share of income held by the top 20 percent of earners grows, the relationship between GDP per capita and CO_2 per capita becomes increasingly positive, suggesting that in nations where larger shares of income are held by the top 20 percent, economic growth is tightly coupled to CO_2 emissions.

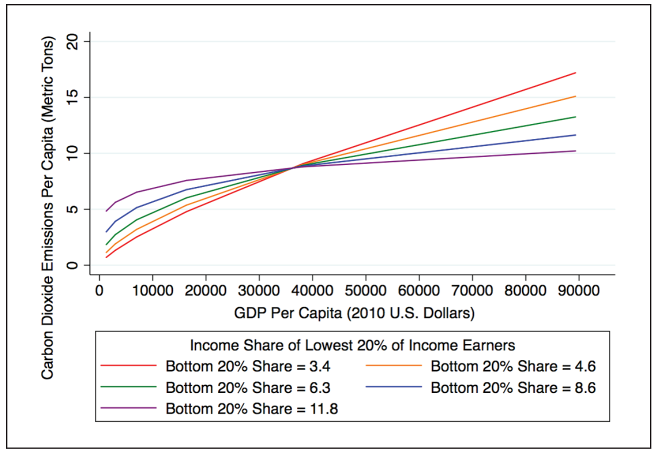

Figure 4. The relationship between gross domestic product (GDP) per capita and CO_2 emissions per capita at different levels of the share of national income held by the bottom 20 percent of all income earners. As the share of income held by the bottom 20 percent of earners declines, the relationship between GDP per capita and CO_2 per capita becomes increasingly positive. This relationship suggests that in nations where the bottom 20 percent of earners hold a larger share of national income, economic growth is less coupled with CO_2 emissions.

income earners is low, there is a tighter coupling between growth in GDP per capita and CO_2 emissions.

As discussed above, previous research on the relationship between income inequality and economic growth (Halter et al. 2014) has posited that in the long run, the effect of income inequality on economic growth differs from the immediate effect of such inequality on growth. Specifically, Halter et al. (2014) noted that when the effect of income inequality is lagged, it is associated with reductions in economic growth, while it is associated with increases in growth when the relationship is examined immediately or in the same year. Our analyses were not designed to explore these distinctions empirically. However, from a theoretical standpoint, we note that the figures presented here serve to offer some insight into this question as it relates to environmental outcomes by effectively visualizing the trajectory of the relationship between GDP per capita and CO_2 emissions per capita when income inequality is held constant at various values of the Gini coefficient. Thus, although our analyses cannot speak to how income inequality affects the relationship between growth and emissions in different intervals of time, they do allow us to speculate as to how a particular level of national income inequality influences this association throughout the range of observed values.

Discussion

Taken together, these findings demonstrate that the relationship between CO_2 emissions and economic growth varies on the basis of the distribution of income in developed nations, indicating that (1) increased income inequality leads to a tighter coupling between economic growth and CO_2 emissions per capita, (2) increasing the top 20 percent of income earners' share of income leads to a tighter coupling of economic growth and emissions, and (3) increasing the bottom 20 percent of income earners' share of income decouples economic growth from emissions. Similarly to how Piketty's (2014) elaboration on processes behind income inequality offered new insights into the Kuznets curve hypothesis, our findings offer new insights into the Kuznets curve's environmental cousin, the EKC hypothesis (Dinda 2004). The EKC hypothesis contends that, similar to the relationship between economic growth and inequality, the relationship between economic growth and environmental degradation follows an inverted U-shaped curve (particularly in developed nations), where early on, economic growth increases environmental impacts but eventually reduces them. Our findings suggest that a potential process driving the EKC is changes in the distribution of income, which affect the relationship between economic growth and emissions. Furthermore, we note that the findings reported here indirectly lend support to the recently developed theories within environmental sociology—socioecological indispensability (Pellow 2016) and inequality, democracy, and environment (Downey 2015)—which note that reductions in social inequality will likely lead to reductions in environmental impacts by increasing the value that we place on environmental goods that populations must rely upon, as well as by allowing a broader participation in social decision-making processes concerning issues of industry and economic activity.

Our findings also suggest that income inequality in developed countries with small economies may help reduce CO_2 emissions. However, we caution against assuming that this means income inequality is good for reducing CO_2 emissions in smaller economies. It should be noted that the majority of data points used in our models have economies larger than the threshold under which income inequality reduces emissions. Specifically, roughly 28 percent of observations have economies this small or smaller.

To address the question posed in the title of this article—can reducing income inequality decouple economic growth from emissions?—the answer is yes, with a few caveats worth discussing further. First, as is the case with all statistical analyses in the social sciences, it is important to acknowledge that this finding is based on a historical trend that may not continue into the future. Furthermore, part of the reason income inequality has declined in most developed nations is because of the aftermath of global wars, decolonization, and higher taxes on investments (Piketty 2014). The first two of these phenomena have unique environmental implications that may increase global emissions while decreasing emissions in developed nations. Scholars have long discussed the environmental impacts of wars (Clark and Jorgenson 2012; Hooks and Smith 2005), and decolonization has resulted in some developing nations, such as those participating in the Organization of the Petroleum Exporting Countries, relying mostly on fossil fuels to stimulate economic growth.

Despite these caveats, the research presented here supports popular theories that suggest that reducing income inequality by increasing taxes on income derived from investments, which mostly goes to top income earners, may directly or indirectly result in reduced emissions. For example, the "power-weighted social decision rule" contends that the beneficiaries of environmental degradation are often higher income earners who gain at the expense of lower income earners, who are often the cost bearers of environmental degradation (Boyce 1994, 2007). Moreover, income inequality likely helps produce undemocratic institutions and organizations that allow wealthy elites, who benefit from environmental destruction, to continue to degrade the environment (Downey 2015). Finally, it may be that income inequality reduces the ability of marginalized populations and communities to protect the environmental spaces and resources that promote their well-being (Pellow 2016). In light of such theories, our findings suggest that one route to decoupling GDP per capita from CO_2 emissions per capita in developed nations may be to implement policies that result in lower levels of economic income inequality.

Although the data used in the present study do not cover the recent period of decoupling between economic growth and CO_2 emissions[3] (International Energy Agency 2016), in the broadest sense, the findings here suggest that if the drivers of CO_2 emissions and income inequality have not changed drastically since 2011, the decoupling of CO_2 emissions and economic growth can be increased by reducing income inequality in developed nations. It is also worth mentioning here that the type of decoupling assessed in this analysis is slightly different from the type of decoupling reported by the International Energy Agency (2016). Our finding demonstrates that decoupling between economic growth and emissions can occur at different levels of inequality; meanwhile, the recent period of decoupling reported by the International Energy Agency is understood mostly as a product of changes in economic development over time. Future research into this area could benefit from exploring how certain types of income produce environmental harm of varied types and to differing degrees. A large reason behind the recent spike in income inequality is growth in income obtained from investments. Thus, we note that a potential strategy for policy makers attempting to act on the findings presented here is to reduce income inequality through policies that more equally distribute income derived from investments.

[3]We note that one reviewer pointed out that this finding of decoupling has been disputed.

Appendix

Table A1. Association of Income Inequality and GDP per Capita on Emissions per Capita in All Nations.

	Model 1	Model 2	Model 3	Model 4
Gini coefficient	—	—	−0.28 (0.33)	−3.16* (1.52)
GDP per capita	0.65*** (0.07)	0.98** (0.32)	0.71*** (0.09)	−0.51 (0.57)
(GDP per capita)^2	—	−0.21 (.019)	—	—
Gini Coefficient × GDP per Capita	—	—	—	0.35* (0.40)
Urbanization	0.88*** (0.14)	0.82*** (0.16)	0.56* (0.26)	0.58* (0.23)
Age dependency	1.42*** (0.32)	1.33*** (0.33)	1.66*** (0.44)	1.63*** (0.42)
R^2 within	.60	.61	.54	.55
Nations	208	208	154	154
Nation-years	8,157	8,157	3,957	3,957

Note: Model 1 displays results from fixed-effects panel regression with fixed-effects estimators for country and year and robust standard errors. All variables have been natural log transformed, with the exception of year dummies. Coefficients represent the percentage change in CO_2 emissions per capita associated with a 1 percent change in the independent variable under consideration. GDP = gross domestic product.
$^*p < .05$, $^{**}p < .01$, and $^{***}p < .001$ (two-tailed tests with zero as the null hypothesis).

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