The Gettysburg Economic Review

Volume 11 Article 7

2019

Unsustainable Sustainability: Do Policies that Increase Environmental Quality Exacerbate Income Inequality?

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Class of 2019

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Abstract

International pressure to meet climate and sustainability goals are mounting. Countries attempting to industrialize in the age of sustainability are tasked with industrializing using low-carbon practices. The transition to a "green" economy requires elimination of some jobs and skillsets that may upset social equality. This paper empirically examines the hypothesis that policies aimed at increased environmental performance promote increased income inequality in developing countries. Because existing literature firmly supports the hypothesis that lower income inequality leads to higher environmental performance, this paper develops a simultaneous equations model (SEM) to estimate the hypothesized endogenous relationship using two stage least squares (2SLS) estimation with an instrumental variable. While the instrumental variables employed were not per se valid, the 2SLS estimation results for the sample of developing countries reflects a positive and practically large, though statistically insignificant effect of air quality on income inequality.

Keywords

sustainability, climate, industrialization, green economy, social inequality

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3 May 2019

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International pressure to meet climate and sustainability goals are mounting. Countries attempting to industrialize in the age of sustainability are tasked with industrializing using low-carbon practices. The transition to a "green" economy requires elimination of some jobs and skillsets that may upset social equality. This paper empirically examines the hypothesis that policies aimed at increased environmental performance promote increased income inequality in developing countries. Because existing literature firmly supports the hypothesis that lower income inequality leads to higher environmental performance, this paper develops a simultaneous equations model (SEM) to estimate the hypothesized endogenous relationship using two stage least squares (2SLS) estimation with an instrumental variable. While the instrumental variables employed were not per se valid, the 2SLS estimation results for the sample of developing countries reflects a positive and practically large, though statistically insignificant effect of air quality on income inequality.

Acknowledgements: The author would like to thank Professor L. Nyiwul, Professor J. Cadigan, Professor B. Cushing-Daniels, Professor J. O'Brien, Professor R. Cavender, Professor T. Lin, Mr. L. Menicali, Ms. E. Miller and Mr. K. Klassen for their helpful contributions.

Honor Code: I affirm that I have upheld the highest principles of honesty and integrity in my academic work and have not witnessed a violation of the Honor Code.

I. INTRODUCTION

Economies around the globe are facing pressure to become more environmentally friendly in their economic activities. Since the 1970's, global agreements, protocols, and conventions have arisen with the goal of achieving collaborative solutions to mounting environmental strain. This pressure was intensified by the 2015 adoption of the United Nations' Sustainable Development Goals (SDGs), a comprehensive list of goals to continue global economic growth in environmentally, economically, and socially sustainable ways. However, despite the SDGs' concurrent goals of reduced inequality, inclusive economic growth, and environmental sustainability, the transition to sustainability necessarily involves shifting away from many traditional, stable carbon-intensive industries including industrial sectors, non-renewable energy, natural resource extraction, etc.

Both developed and developing countries are tasked with meeting such goals, whether through formal contract or economic and social pressures from other nations. I expect that developing countries might be disadvantaged in achieving the same goals as those who have achieved advanced levels of income and development. The development process historically relies on carbon-intensive industrialization activities as a fundamental driver of economic prosperity and growth. Such carbon-intensive industries also provide many low-skilled and labor-intensive jobs, such as mining and truck driving. Due to the large environmental impact of industrialization and subsequent goals to alter or diminish its environmental footprint, I expect that developing countries experience challenges and ramifications when attempting to meet these goals that developed countries do not.

The transition from manufacturing and resource-intensive (environmentally degrading) industries to an economy powered by more environmentally friendly, low-carbon industries will require education and training that is not yet present and less accessible to particular factions of the population. Poorer people who conventionally hold low-skilled, labor-intensive jobs and have less access to education and training will suffer disproportionately from this change. Thus, this research attempts to ask the question: do policies that increase environmental quality tend to increase income inequality? I hypothesize that decreased environmental degradation (that is, higher environmental quality) leads to increased income inequality in developing countries.

Section II of this paper will explore the conclusions of the existing literature surrounding this relationship. Section III will discuss the theory used to formulate the hypothesis and the methodology employed to test it. Section IV describes the data used for econometric testing. Section V discusses the results and Section VI will discuss overall conclusions, policy implications, and challenges for future research on this topic.

II. LITERATURE

The existing literature relevant to this hypothesis is broken up into two main bodies. First, that which acknowledges the relationship but hypothesizes causality such that income inequality affects environmental quality. Second, that which posits a relationship such that environmental quality affects income inequality. This paper contributes uniquely to the existing literature by proposing an empirical model to test the latter relationship.

i. INEQUALITY AFFECTS ENVIRONMENTAL PERFORMANCE

The Environmental Kuznets Curve (EKC) theory hypothesizes that as income per capita increases, environmental degradation increases up to a particular point in the development process (as illustrated by a threshold amount of income). After this threshold is reached, environmental degradation begins to fall again when economies shift to less resource-intensive growth strategies. Graphically, this demonstrates what has been described as an "inverted-U-shape" (Dinda, 2004; Grossman and Krueger 1991; Shafik and Bandyopadhyay, 1992; and Panayotou, 1999). Boyce (1994) expands EKC theories to include income inequality as a necessary determinant of environmental quality. He argues that when there is economic activity that is environmentally harmful, there are people who benefit from it ("winners") and people are harmed by it ("losers"). The winners, he posits, are those with some form of power over others. If these winners could theoretically compensate losers for environmentally damaging activities and still win, then it is efficient to continue with the degrading activity. Generally, he notes, winners will not compensate losers and will simply ignore externalities, thus the degrading activity will be pursued even when its net impact to society is negative (Boyce, 1994). Thus, higher levels of inequality in both power and wealth (which he essentially equates because those with greater wealth are generally more powerful) will incite greater environmental damage. He dubs this idea the "equality hypothesis." Torras and Boyce (1998) build off of Boyce (1994) by using empirical analysis to criticize EKC scholars which rely on income per capita as the chief explanatory variable. Echoing Boyce (1994), they find that more equitable income/power distributions will result in lower environmental degradation.

While these hypotheses are not directly comparable to my hypothesis, they are important and relevant. Unlike traditional EKC theorists, my hypothesis focuses on income inequality as opposed to income per capita. Furthermore, this paper treats environmental quality as the independent variable which affects income inequality, as opposed the literature which treats income as the independent which affects environmental quality. Nonetheless, this literature is useful to consider as it explains linkage between environmental performance and income inequality. Moreover, the EKC theory is helpful to my hypothesis because it suggests that after a certain point of economic development, the relationship between environmental degradation and income changes dramatically. Thus, this theory guides my expectation that for developed countries, environmental performance will have a negative if not neutral relationship with income inequality.

ii. ENVIRONMENTAL PERFORMANCE AFFECTS INEQUALITY

While previous theory indicates a link between the two variables, there is little existing research that supports this paper's hypothesis that greater environmental performance increases income inequality. Some authors and international organizations published reports discussing the theoretical causal relationship between environmental performance and income inequality, but nobody has formulated an empirical model to test it. This section will examine the existing theoretical reasoning for my hypothesis.

The OECD (2016) discusses expected economic challenges that accompany the transition to environmentally friendly economic activities, which are summarized in *Figure 1*. This lays a foundation for the discussion of a potential relationship working opposite the relationship already established in the literature. Dercon (2012) contributes to this theoretical foundation for the argument by explaining that the poor are disproportionately affected by such economic shifts. It is important to consider these economic implications from the poor both in situations where the poor act as consumers and where they act as producers, Dercon (2012) argues. In the consumption context, the poor typically spend a larger share of their income on energy and environmental goods like water and fuel. The poor also lack resources to adapt to environmental pressures. Therefore, shocks to the price of these goods due to policy changes and regulation to mitigate environmental degradation will most heinously affect the poor (Dercon, 2012: 11).

On the production side, too, the poor tend to suffer disproportionately. The United Nations Environment Programme (UNEP) produced a report in 2008 which discusses in depth the potential implications of the transition towards sustainable development. One noteworthy conclusion is that such economic change will be accompanied by be several changes to overall employment which will thus affect the poor as producers. With greater global focus on environmental performance, it is expected that some jobs will be created – such as the design, innovation, and manufacturing of new equipment such as abatement devices and monitors. Some jobs will be substituted or transformed – for example, those working in extraction of fossil fuels may instead be hired by renewable energy industries. Other positions will be completely eliminated, such as production of goods such as packaging materials which may be discouraged or banned for environmental reasons (UNEP, 2008). Not all low-skilled jobs will be eliminated, but as with any new venture, there will be a learning curve to many new processes.

Because curbing environmental damage implies diversion of resources and investment from "conventional growth-oriented opportunities," demand will drop for many exports (which tend to be resource-intensive) from low-income countries (Decron, 2012: 3, 8). The economic costs of transforming an economy into a green economy will be most felt by the developing world which hopes to achieve economic growth and mobility. Decron (2012) discusses the tight link between growth and poverty and points out that inhibited growth tends to inhibit poverty reduction. Therefore, he argues, "there will be distributional effects that do not necessarily imply Pareto improvements for everyone unless there are also (lump sum) transfers to compensate the losers… [which] rarely happens" (2012; 9). For example, it is common for the poor's income to rely on "environmental capital" (natural resources, animal products, etc.), thus making them most susceptible to income shocks due to environmental policy changes (Dercon, 2012: 12). Policy change or regulation that raises the cost of using environmental capital will incentivize a shift to production that relies less on environmental goods and more on other forms of capital (physical, human). The poor tend to face greater barriers to these alternative forms of capital (for example, transition to new technology may require skills or training that is costly to the poor but more accessible to the wealthy). "The key for the poor would be the low-skilled-labor intensity [of greener industries]," Dercon explains. "The expectation that industries need to find more energy efficient ways of production may lead to higher intensity in human and physical capital with sophisticated technologies, which are not necessarily labor intensive" (Dercon, 2012: 12). Dercon acknowledges that, due to lack of existing relevant research focused on developing countries, these conclusions are greatly conjecture. Nonetheless, the conclusions imply that, absent policy provisions to favor or compensate the poor, prioritization of environmental quality through emphasis on green economic activity will promote inequality.

Musyoki (2012) argues accordingly that green economic policies must involve measures aimed at poverty reduction and empowerment of minorities to avoid unequal economic growth. Some of the policies and stipulations he suggests include equal access to skill development, opportunities for livelihood diversification, and ensure affordable green energy to the poor (Musyoki, 2012: 4). Without such accommodating policies and provisions, the transition to a greener economy may have concentrated benefits which exacerbate societal inequalities (Cook et al., 2012; ADBI, 2013). There is a plausible concern for simultaneity such that environmental degradation may exacerbate inequality *in addition to* the well-documented belief that inequality affects environmental quality (UNRISD, 2012). For this reason, I anticipate that low-skilled labor may be more adversely affected than higher skilled labor, which may potentially create inequality. This paper builds upon existing literature by empirically testing this hypothesis.

IV. DATA

This research uses panel data covering a sample of 110 countries of varying income level/development status spanning the years 2007 to 2017. Where a few data were missing, I filled gaps with the variable mean. However, for datasets with no data for an individual country across all years, I left absent data as blank observations.

My dependent variable is income inequality (*ineq*), which I measure using the United Nations Development Programme (UNDP) Human Development Reports' measure of inequality in income (UNDP, Income Inequality, Inequality in income, 2018). This metric uses the Atkinson index to capture inequality in an income distribution based on household surveys. I chose this indicator over other conventional measures of inequality (such as the GINI coefficient, Palma coefficient, or quintile ratio) primarily due to data availability. While I considered attempting to create my own income distribution ratio, international datasets are not complete enough to sufficiently improve my model by offering data for a greater number of countries. This data unavailability ultimately creates an issue of small sample size which I will discuss in my conclusions and opportunities for further research.

This paper uses air quality (*aq*) as a proxy for environmental policy (and subsequently environmental quality) as measured as an indicator included in Yale University's Environmental Performance Index (EPI). The EPI scores and ranks individual country's performance on priority environmental issues. The index is constructed using data on several measures that fall under one of two main issue areas: environmental health and ecosystem vitality (Hsu et al., 2016

Environmental Performance Index, 2016). In this index, air quality is an indicator of environmental health that is comprised of several subcomponents. The first subcomponent is household air quality, defined as the percentage of the population using solid fuels as primary cooking fuel and Health Risk from PM2.5 (particulate matter that have a diameter of less than 2.5 micrometers) exposure. The second is air pollution defined as average exposure to PM2.5. The third subcomponent is air pollution exceedance, measured as the proportion of the population with exposure levels above World Health Organization thresholds. The fourth and final subcomponent is air pollution based on exposure to nitrogen dioxide.

The second instrumental variable explored in this paper, tree cover loss (*forest)*, is also sourced from EPI 2016 data. EPI measures this as tree cover loss in greater than 50% tree cover divided by 2000 levels. It is thus expressed as a rate of loss. *See Figure 3* for a more complete breakdown of other subindexes which compose the EPI and their relative size and relevance to the air quality index. EPI is a biennial project. Data is available using the 2018 index, but the index has evolved over time. Therefore, in order to create panel data using this index, I used the 2016 backcasted data, in which the developers of the data reevaluated the years 2007 to 2015 using the 2016 index. Using this backcasted data allows me to make valid comparisons across different years (Hsu et al., 2016 Environmental Performance Index, 2016).

Because I expect, as existing literature indicates, that political and economic institutions also have a strong influence on economic inequality, I control for political oppression using the variable *opp* to capture a rating of political freedom as calculated by Freedom House in their 2018 *Freedom in the World* report. Freedom House has produced this report annually since 1973, and therefore its data covers 195 countries and 14 territories for over 40 years. This variable represents a score between 0 and 4 for each of 10 indicators of political rights such that countries with a score of 0 have the smallest degree of freedom and those with a 4 have the greatest. The questions measure three categories of interest: electoral processes, political pluralism and participation, and the functioning of government. This score is then translated into a rating between 1 and 7 such that countries with a rating of 1 are quite free and "enjoy a wide range of political rights…candidates who are elected actually rule, political parties are competitive…and the interests of minority groups are well represented in politics and government" (Puddington & Dunham, 2019). Alternatively, countries rated 7 are quite unfree "because of sever government oppression...some are police states…[while others] suffer from extreme violence or rule by regional warlords" (Puddington & Dunham, 2019). Because, when included, an index of economic freedom (Fraser Institute's Economic Freedom index) is collinear with political oppression, I omit this economic freedom variable. Theoretically, it is fair to assume that generally, the two go hand in hand such that countries that are politically free are often more economically free and globally integrated. Thus I capture the effect of both political and economic institutions using the *opp* variable.

I control for levels of education among a population as a potential determinant of income inequality. Education (*educ*) data is captured using mean years of education achieved by people age 25 and older in a population as recorded by the UNDP as part of the Human Development Reports. While I considered using literacy rates to gauge education (which would benefit this research by capturing both formal and informal education), lack of data availability dictated my use of mean years of schooling. I collected data on GDP per capita (*gdppc*) based on purchasing power parity measured in current international dollars from the World Bank (2018).

This paper also controls for the impact on inequality of reliance on agriculture relative to other industries like manufacturing which tend to drive down income inequality. Countries with higher employment in manufacturing are generally more equal because manufacturing generally offers a narrow range of relatively high earnings for modestly educated people (Long, Rasmussen, & Haworth, 1977). Contrarily, countries with a larger share of employment in agriculture will tend to be less equal. Thus, I control for this influence using *ag*, that is, the relative size of the agricultural sector. This variable takes the form of employment in agriculture as a percentage of total employment in an economy, as per the World Bank.

The control variable *ldc* is a binary variable such that *ldc* = 1 for less developed countries and *ldc* = 0 for developed. I used data from the World Bank on analytical classification history by country and the World Bank's 2018 standards for characterization of low- and middle-income countries as developing and high-income countries as developed. For years when a country was considered low- or lower-middle-income, I classified the country as "developing." If at some point it became high-income, as determined by the Bank, it would be reclassified as "developed."

The instrumental variable *cprecip* (change in precipitation between years) was calculated using data from the World Bank Group's Climate Change Knowledge Portal. The dataset was produced by the Climatic Research Unit (CRU) of University of East Anglia (UEA) and reformatted by the International Water Management Institute (IWMI). I collected the data initially as monthly averages of rainfall in millimeters, which I later converted to annual averages. This paper also experiments using tree cover loss (*forest*) as an instrumental variable. Because forests are an important subindicator of the EPI, I extracted the data from that dataset.

III. THEORY & METHODOLOGY

There is no universal understanding of what environmental policies and economic activities necessarily encourage higher environmental performance. Literature often refers to such activity as being "low-carbon," "sustainable," or "green." More than a dozen published definitions of "green growth," exist to date. The OECD synthesize some of these definitions in *Figure 2* which may be helpful for our practical understanding of what sustainable environmental policies might look like in practice. By adopting policies such as those discussed by the OECD (see *Figure 1*) and implied by the definition of low-carbon infrastructure discussed above, environmental quality will increase, though I expect at the cost of economic equality (as explained in the literature review). Alternatively, I expect that developed countries will not have a positive relationship between environmental quality and income inequality. The EKC theory indicates that after a certain point in the growth process (i.e. once a country is developed), environmental degradation sharply decreases. After a country is "developed," the marginal impact of a policy to increase environmental quality will be smaller. By improving quality of life for the population (including the poor), perhaps they will have better health and even be able to achieve greater mobility. Therefore, it would make sense that developing countries would see a different relationship between environmental quality and income inequality than their developed counterparts.

To determine the proper estimation technique for my panel data model, I run the Hausman Specification Test which recommends a fixed effects estimation rather than random effects. This makes sense as the presence of unobserved country-fixed effects is more than likely. I run separate fixed effects estimations for a sample of developed countries and a sample of developing (or less developed) countries. Comparing normal standard errors to those which are robust reflects a difference, thus indicating the presence of heteroskedasticity. I also suspect autocorrelation may be present; thus I use the Wooldridge test for autocorrelation in panel data on both of these regressions. The tests indicate that both the regression of developing countries and that of developed countries contain autocorrelation. I therefore attempt to correct for autocorrelation and heteroskedasticity. Because my panel is of the "large N, small T" variety (that is, my data is comprised of a relatively large number of panels and a small number of time periods), I attempt to simultaneously correct for both using cluster-robust standard errors.

Existing literature argues that greater inequality negatively influences environmental quality, which I believe is a well-supported argument. I also contend that my hypothesis that environmental quality impacts income inequality holds merit. Thus, I suspect that these variables are endogenous and jointly determined. I begin with an OLS estimation (see Appendix *Table 3*) which does not yield efficient estimators, nor does it display a statistically significant relationship. This is to be expected, as it does not properly account for endogeneity. Thus, o estimate this relationship while properly accounting for endogeneity, I employ a simultaneous equations model (SEM) using an instrumental variable and two-staged least squares (2SLS) estimation.

(1) $aq_t = \beta_0 + \beta_1 ineq_t + \beta_2 educ_t + \beta_3 gdppc_t + \beta_4 ag_t + \beta_5 opp_t + \beta_6\, cprecip_t + \beta_7\, ldc + u_t$

(2) $ineq_t =$

$$\propto_0 + \propto_1 aq_t + \propto_2 opp_t + \propto_3 educ_t + \propto_4 gdppp_{t-1} + \propto_5 gdppp^2{}_{t-1} + \propto_6 ag_t + \propto_7 ldc + \varepsilon_t$$

The first equation (1) represents the relationship between inequality and environmental performance with the causality that most of the existing literature supports, whereas the second (2) represents the relationship I hypothesize.

The selection of an appropriate instrument is challenging, as most factors that influence environmental issues also somehow affect income distributions. A valid instrument in this case is a variable which must be both correlated with my measure of environmental quality (air quality *aq*) and uncorrelated with inequality (*ineq*). I hypothesize that the change in precipitation (*cprecip*) affects air quality without directly influencing income inequality because precipitation washes out water-soluble pollutants and other particulate matter from air, thus improving air quality. By examining correlation coefficients, it is not clear that this instrument is strong. This instrument is a statistically significant determinant of income inequality for developing countries, as demonstrated by a p-value of 0.038 in the first-stage regression on the less developed sample. However, for the sample of developed countries, the instrument did not prove to be significant in first-stage regression results, thus calling its strength into question.

Due to the questionable nature of the strength of precipitation rates as an instrument, I also estimate the endogenous relationship using changes in tree cover (*forest*).

(3) $$aq_t = \beta_0 + \beta_1 ineq_t + \beta_2 educ_t + \beta_3 gdppc_t + \beta_4 ag_t + \beta_5 opp_t + \beta_6\, cforest_t + \beta_7\, ldc + u_t$$

(4) $$ineq_t = \propto_0 + \propto_1 aq_t + \propto_2 opp_t + \propto_3 educ_t + \propto_4 gdppp_{t-1} + \propto_5 gdppp^2{}_{t-1} + \propto_6 ag_t + \propto_7 ldc + \varepsilon_t$$

Tree cover loss does not boast a very direct influence on income inequality. However, there is an argument to be made that deforestation has an effect on economic growth which may translate into an effect on income inequality. Referring back to previous discussion of the EKC, one could argue that deforestation (as a form of environmental degradation) increases with national income (as a country develops), until that country reaches an amount of income associated with being “developed,” at which point environmental protection is less of a luxury and more of a normal good. After this threshold of national income, the deforestation would decline. Given the Kuznets Curve (the inverted U-shaped relationship between income inequality and income per capita), we know that income inequality also has this type of relationship with income per capita. Thus, there is likely some relationship (though perhaps indirect such that A leads to B leads to C) between deforestation and income inequality.

Nonetheless, this paper experiments with the *forest* instrument and compares it to the seemingly stronger instrument, *cprecip*. It is easy to understand how tree cover influences air quality, given that trees supply oxygen and absorb gaseous pollutants, thus facilitating a natural cleansing process of air (Nowak et al., 2014). The first-stage coefficient estimate on *forest* for the instrumental variable regression of less developed countries reflects statistical insignificance, while this estimate for the sample of developed countries was statistically significant. Unfortunately, like *cprecip*, it is not apparent based on correlations or first-stage regression results that *forest* is a strong instrument. Nonetheless, the inconclusive results and theory offer some support to its potential legitimacy.

V. RESULTS

Because I hypothesize endogeneity in income inequality and air quality, a linear fixed-effects estimation is unlikely to be the most efficient means of estimation. Thus, I defer to two-stage least squares estimation. First, I instrument using changes in precipitation rates (*cprecip*) as demonstrated below in columns (1) and (2) of *Table 1*.

Table 1: 2SLS Results (Dependent Variable = Income Inequality)

Variables	(1) **LDC** (*cprecip*)	(2) **Developed** (*cprecip*)	(4) **LDC** (*forest*)	(5) **Developed** (*forest*)
Air quality (*aq*)	2.242	3.752	-6.751	0.364
	(1.826)	(2.574)	(9.820)	(0.414)
Political oppression (*opp*)	2.448**	2.052	-1.058	-0.174
	(1.201)	(2.722)	(4.664)	(0.538)
Education (*educ*)	-1.360	1.581	-3.229	-0.525
	(3.155)	(2.978)	(4.093)	(0.919)
Size of agricultural sector (*ag*)	-0.0512	0.620	-0.0367	0.500*
	(0.161)	(0.481)	(0.409)	(0.302)
Lag GDP (*gdppp_1*)	-0.00791*	-0.00102	0.000238	-0.000578
	(0.00447)	(0.00126)	(0.0141)	(0.000444)
Lag GDP squared (*sqgdppp_1*)	3.73e-07*	1.07e-08	1.55e-07	6.62e-09*
	(2.12e-07)	(1.17e-08)	(5.53e-07)	(3.94e-09)
Year	1.009*	1.258	-0.745	0.302
	(0.572)	(0.893)	(2.215)	(0.199)
Constant	-2,139*	-2,813	2,016	-603.4
	(1,215)	(1,960)	(5,088)	(405.5)
N	378	433	378	435
Number of Countries	51	62	51	62

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the two-stage estimation of the less developed sample (column 1), the coefficient on air quality suggests that a 1% increase in air quality increases income inequality by 2.242%. While this estimate's statistical insignificance does not indicate that air quality is especially important in determining income inequality in developing economies, the sign and magnitude otherwise support my hypothesis. Moreover, the estimate is practically large, and thus deserves consideration. The same two-staged regression on the sample of developed countries (column 2) reflects a positive relationship such that a 1% increase in air quality would increase income inequality by 3.75%. Similar to the developing regression, this coefficient is insignificant. The sign and magnitude of this relationship do not support my hypothesis and seem counterintuitive to EKC theory.

Given the apparent weakness of my instrument choice based on first stage statistical insignificance on *cprecip,* I conduct the same estimation using a different instrument: tree cover loss (*forest*), the results of which are reflected above in columns (3) and (4) of *Table 1.* This estimation contradicts the results of the previous estimation using *cprecip* as an instrument. Where before the coefficient on air quality for less developed countries was 2.242, it has now drastically changed in size and magnitude to -6.751. This would suggest that a 1% increase in air quality leads to a 6.751% decrease in income inequality in developing countries, which staunchly opposes my hypothesis. The coefficient on air quality in the sample of developed countries (column 4) suggests a small positive increase of 0.364%, which is nearly negligible. The magnitude counters my expectations, but the miniscule magnitude makes sense.

The drastic change in the coefficient estimate on my variable of interest, air quality, begs suspicion. Upon examining the coefficients on my controls, I find questionable estimates in the *forest* instrument regression. The coefficient estimate for political oppression (*opp*) for developing countries when instrumenting with precipitation rates shows a statistically significant and positive coefficient such that a 1 unit increase in the political rights rating (that is, a whole number increase on the 1-7 scale which demonstrates a *loss* of political freedom) increases income inequality by 2.448%. This result corresponds with intuition and theory which contend that less free societies tend to be more unequal. This estimate is statistically significant for developing countries. For developed countries, we see very similar magnitude and sign (which again makes sense), though the coefficient is now insignificant. When the *forest* instrument is employed (columns 3 and 4), we see a negative coefficient on *opp* for both developing and developed countries. This relationship follows neither intuition nor theory. Therefore, I am inclined to prefer the results from the regression which employs the precipitation rate *cprecip* as an instrument, though experimentation with other instrumental variables would surely benefit this research, as neither instrument employed in this paper is especially compelling.

VI. CONCLUSION

This paper sought to determine the nature of the relationship between environmental policies and income inequality in developing countries. This empirical study of the hypothesis that policies that increase environmental quality (as captured by air quality) increases income inequality in developing economies contributes uniquely to existing literature by formulating a simultaneous equations model to test this theory, where there had previously been no proposed empirical strategy.

Results from this SEM estimation offer some support for my hypothesis. Using the instrumental variable *cprecip,* I find a positive coefficient estimate on air quality indicative of a roughly 2.2% increase in income inequality as a result of a 1% increase in air quality in less developed countries. For the less developed sample, *cprecip* is a more valid and legitimate instrument than *forest*, and thus I consider this estimation to be most plausible. Therefore, if a policy were enacted strengthening air pollution standards thus resulting in an increase in air quality, we would expect income inequality to increase. This corroborates my hypothesis that, in developing countries, environmental policies increase income inequality. I recognize that the insignificance of the coefficient indicates that perhaps air quality is not a strong determinant of income inequality as I have estimated it. However, literature and theory support the probability that this causal relationship exists. Therefore, future work can improve upon my model and estimation techniques to hopefully find similar results with more reliable test statistics and significance levels.

The estimates for air quality's impact on income inequality in developed samples defies expectations that it would be unlikely to have a positive impact. In fact, in the estimation using the *cprecip* instrument (the instrument I ultimately prefer), this coefficient is notably larger than that in developing countries, indicating that air quality improvements lead to an even greater increase in income inequality in developed countries. Based on the EKC and the fact that developed countries are generally post-industrial and more likely to respond well to technology or skill changes than developing countries, this is a surprising result. Again, however, it is statistically insignificant, so it must be taken with a grain of salt.

A potential policy implication that may be drawn from this conclusion is that international organizations and sovereign governments alike must be weary of the consequences of "sustainable development" through pursuit of "low-carbon" or "green" infrastructure and industries. Meeting SDGs requires environmentally friendly activity that also promotes equality – which these results indicate is a challenge. All policies aimed at sustainable development ought to be accompanied by job training, skill-development programs, lump-sum transfers to compensate the poor, or other poverty reduction measures as discussed in the literature. However, due to the lack of statistical significance on these coefficients, these policy implications require further, more robust research and corroboration before these results could be truly useful and reliable for policy formulation.

Future research can improve this model in a number of ways. Firstly, as data in developing countries becomes more accessible, better variables (and proxies) will become available to more accurately measure the relationship at hand. As data collection continues to improve globally and more years of data become available, a longer time frame can be evaluated, which would improve upon this study which focuses on an effect over a relatively short time period. For example, my dependent variable, income inequality, was captured using data with many holes in it. Due to lack of availability, I was forced to use a measure of inequality that is uncommon and less ideal than a GINI coefficient or ratio of top income earners to bottom income earners in a distribution. A more typical measure of income inequality with more complete data may yield results that are easier to interpret and estimate. Moreover, lack of data on inequality dramatically reduced the sample size on which this analysis rests. Existing literature tends to work with much smaller sample sizes, such as individual countries or countries in a particular geographic region. Thus, I would recommend narrowing the sample size and ultimately the scope of the paper in accordance with these papers for more robust estimates with less gaps in data.

Future research might also involve experimenting with different instruments. On a theoretical level, finding a valid and strong instrument for this research is a challenge. That challenge is exacerbated by poor data availability for developing countries. Perhaps as data becomes more accessible, future researchers could experiment using participation in environmental agreements or environmental regulatory stringency could be experimented with as instrumental variables. Perhaps with more time, this research could have determined an identifying instrument for the simultaneous equations system that yields a statistically significant coefficient on the dependent variable of interest. Expansion of this research might also include a wider range of control variables. However, I caution that several control variables such as economic freedom, democracy, and manufacturing rates were dropped from this analysis due to collinearity. Collinearity is likely to be a problem in future research due to the inherent nature of inequality and its determinants being so closely intertwined with each other.

Researchers hoping to improve this study could also experiment with different models and estimation techniques. Perhaps to avoid the challenge of finding a stronger, valid instrument, a more experienced researcher could apply the generalized method of moments (GMM) or three-stage least squares (3SLS) to address endogeneity.

APPENDIX

Figure 1: Examples of Policy Challenges by Development Status (OECD, 2016)

Countries	Challenges	Policy options
Developed countries	• High greenhouse gas emission per capita • Lock-in into carbon intensive infrastructure	• R&D into technological innovation • Investment into low-carbon infrastructures • Pricing externality through market-based instruments
Developing Countries	• Industrialisation and increased energy and material consumption • Low energy efficiency • Weak legal enforcement	• Shifting away from carbon-intensive infrastructure and promoting energy and material-efficient technologies • Strengthening government capacity • Technology development, diffusion and transfer
Least developed countries	• High dependence on natural resources (both renewable and non-renewable) • Climate vulnerability • Lack of basic infrastructure (e.g. transport, energy and water) • Insufficient financial and technical capacity in government	• Avoiding open-access regime of natural resources • Increasing productivity of net resource use • Climate risk assessment of national policy, plans and programmes • Investment in infrastructure to support access to markets

Source: OECD, 2011b.

Figure 2: Defining Green Growth (OECD, 2016)

Box 5.1. **Defining Green Growth**

The concept of green growth has its origins in the Asia and Pacific Region. At the Fifth Ministerial Conference on Environment and Development (MCED) held in March 2005 in Seoul, 52 governments and other stakeholders from Asia and the Pacific agreed to move beyond the sustainable development rhetoric and pursue a path of "green growth". Today, at least 13 separate definitions for green growth have been identified in recent publications, including:

- **UNESCAP:** growth that emphasizes environmentally sustainable economic progress to foster low-carbon, socially inclusive development.
- **OECD:** fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.
- **World Bank:** growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters.
- **GGGI:** green growth is the new revolutionary development paradigm that sustains economic growth while at the same time ensuring climatic and environmental sustainability. It focuses on addressing the root causes of these challenges while ensuring the creation of the necessary channels for resource distribution and access to basic commodities for the impoverished.

Source: Green Growth Knowledge Platform; *https://sustainabledevelopment.un.org/index.php?menu=1447.*

Figure 3: EPI Breakdown (Hsu, A. et al., 2016)

Table 2: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
countryid	1,210	5.5	31.76	1	110
year	1,210	2012	3.16	2007	2017
ineq	813	23.67	10.80	4.4	68.3
aq	1,210	73.40	16.66	23.9	97.98
educ	1,210	8.32	3.23	1.3	14.1
opp	1,210	3.29	2.03	1	*polfree*
gdppc	1,210	17177.73	16645.82	613.73	75648.23
ag	1,210	29.10	25.13	0.17	91.56
ldc	1,210	.47	.50	0	1
cprecip	1,123	7.97e+11	2.29e+11	5.15e+07	1.92e+12
forest	1,210	29.75	20.60	0.69	89.26

Table 3: OLS Results (Dependent Variable = Income Inequality)

Variables	(1) **LDC**	(2) **Developed**
Air quality (*aq*)	0.111	0.00326
	(0.174)	(0.0733)
Political oppression (*opp*)	1.617	-0.413
	(1.055)	(0.512)
Education (*educ*)	-1.803	-0.759
	(2.985)	(0.925)
Size of agricultural sector (*ag*)	-0.0478	0.488
	(0.177)	(0.303)
Lag GDP (*gdppp_1*)	-0.00598	-0.000536
	(0.00502)	(0.000423)
Lag GDP squared (*sqgdppp_1*)	3.21e-07	6.22e-09*
	(2.42e-07)	(3.64e-09)
Year	0.593	0.205
	(0.532)	(0.194)
Constant	-1,155	-378.4
	(1,062)	(383.1)
N	378	435
R-squared	0.054	0.091
Number of Countries	51	62

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