Economic Growth and Emissions in China and India: A Comparison with the other G5 Emerging Nations

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Abstract:

This paper investigates the possibility of different modes of production affecting the emission levels of developing nations. China and India have experienced substantial economic growth of the past few decades. Past economists have found emission levels positively correlated with GDP growth. Nonetheless, China has significantly higher emission levels than India, given their respective growth in GDP. Whether a country bases their growth on agriculture, industry, manufacturing or services has an effect on their subsequent emission levels. Comparing these results with the other G5 nations indicate the relative importance of GDP level in comparison with economic structure. This paper finds that emission levels will continue to rise with GDP levels, in contrast to the inverted Kuznets curve theory. The results of this study also determine that countries utilizing industry, rather than service for the basis of their growth can be attributable to their subsequent higher emission levels.

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1.0 INTRODUCTION

Over the past few decades, there has been great attention paid to the environment, global warming and pollution. As societies become more developed and use more fossil fuels, pollution has increased and concerns over global warming and degradation of the environment are justified.

In the new global economy, we have seen many foreign nations experience substantial economic growth. Economic growth generally has the benefits of reduced poverty, increased standards of living, and greater access to goods and services. Nonetheless, many economists claim economic growth can negatively impact the environment. These claims are refuted by those who believe the economic growth and emission tax revenues provide the funds and technology needed to reduce emission intensity.

This research paper was guided by a research objective that differs from the other studies because it focuses on the different structures of economic growth. Two of the fastest growing nations today are China and India. However, China has been assailed for their high level of emissions, while India has maintained substantially lower emission levels. China and India are two of the five G5 nations. The other nations comprising the G5 are South Africa, Brazil, and Mexico. These nations also have relatively high emission levels, although the growth rate of the emission levels are not as high.

This paper will determine whether the structure of these countries' economic growth may be the underlying reason for their varying emission levels. The structure of economic growth can be determined by the different sectors of the economy that add value to Gross Domestic Product (GDP). They are agriculture, industry, and service, with industry and service being most dominant.

The issue over growth and emissions becomes important because of the rapid economic growth of many developing countries. If the connection between the value added to GDP by sectors and emission levels can be determined, it may be possible to better project and reduce future emission levels.

The rest of the paper is organized as follows: Section 2 provides information regarding recent trends and gives a brief literature review. Section 3 outlines the empirical model. Data and estimation methodology are discussed in section 4. Finally, section 5 presents and discusses the empirical results. This is followed by a conclusion in section 6.

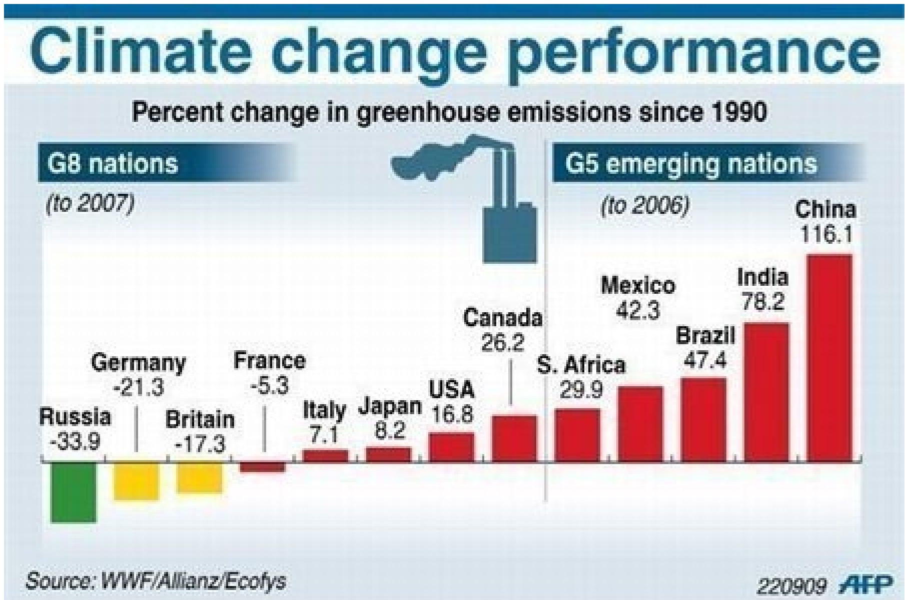
2.0 TRENDS

The size and scope of economic growth has been increasing over the last few decades. At the same time, emission levels have risen substantially. As countries become more developed, they rely on different modes of production to generate income. Generally, this equates to becoming less dependent on agriculture. At the same time, economic growth allows countries to obtain higher standards of living, use more fossil fuels, and buy goods that use more fossil fuels. For this reason, as we see GDP levels rise, we see emissions increasing as well.

Since G5 nations have some of the world's largest, fastest growing economies, it is not surprising that they also have fast growing emission levels. The following graph shows how the G5 nations emission levels are rising at a faster rate than all the G8 countries.

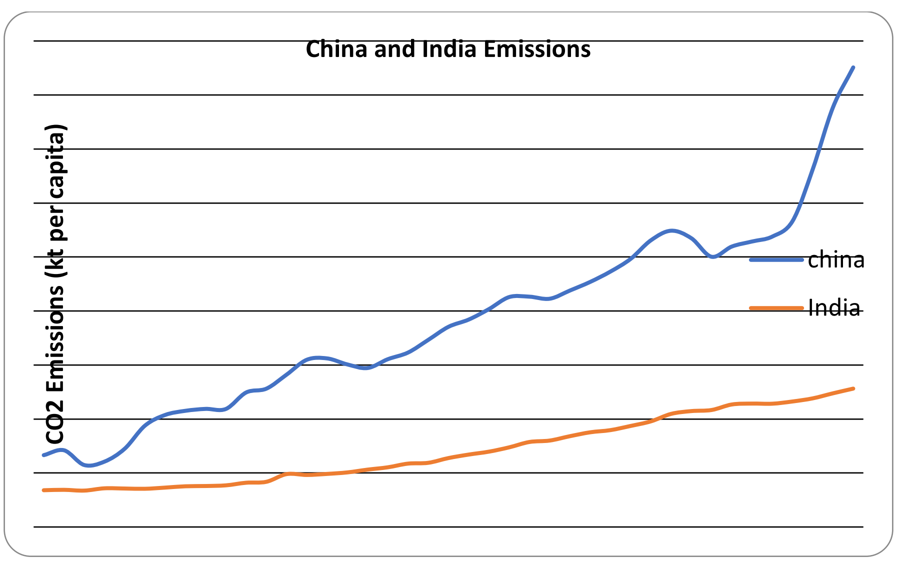
We would expect to find China to have more emissions than India because of the relative sizes of their economies and populations. However, even when we look at carbon emissions in per capita terms, we see that India has almost 4 times fewer emissions and the emission levels are growing at a slower rate.

Figure 1) **Percent Change in Greenhouse Emissions**



SOURCE: WWF/Allianz/Ecofys

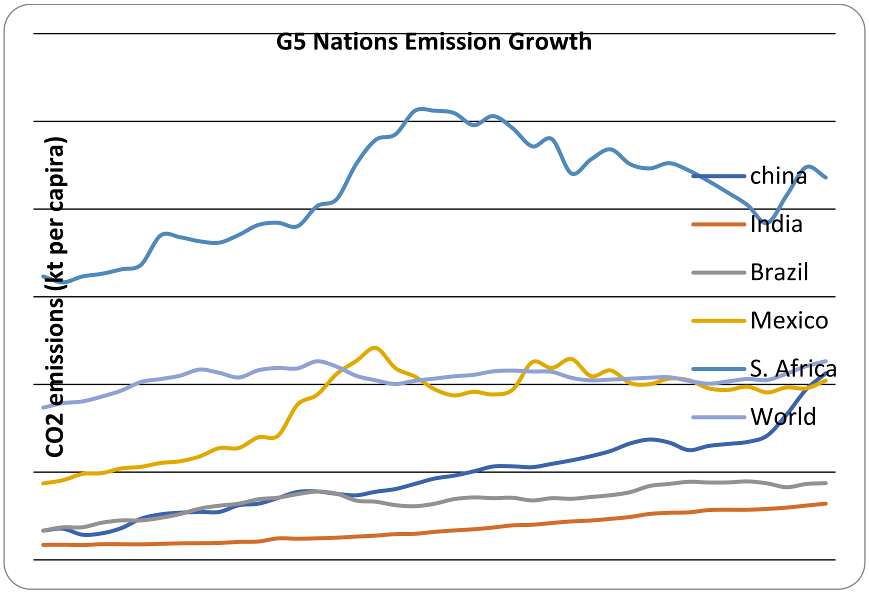
Figure 2) **China and India Emission Growth**



SOURCE: Author's compilation

As of 2005, China had an emission level of 4.26kt per capita, while India had emission levels of 1.28kt per capita and the Brazil, Mexico and South Africa had emission levels of 1.75, 4.09, and 8.72 kt per capita, respectively.

Figure 3) **G5 Emission Growth**



SOURCE: Author's Compilation

So, although their China and India may have fast growing emissions, their levels in per capita terms are still lower than the other G5 nations. This may be because of their relative lower per capita GDP's. Although China and India have fast growing economies, their GDP is per capita terms is still substantially lower to the other G5 nations. The following tabel shows each country's average GDP per capita and CO2 emssions per capita from 1965-2005.

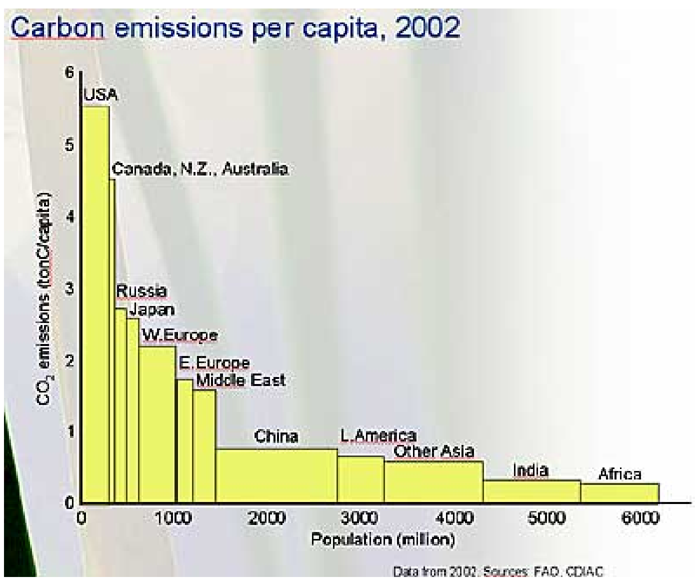
More evidence of this is show in the following graph. This chart shows a comparison of per apita emissions with nations with larger economies, such as the United States, Japan, Russia and European nations, all of which have higher emission levels per capita.

Table 1: **GDP and CO2 Comparison**

Country	GDP per capita	CO2 per capita
China	440.200	1.895
India	305.400	0.708
Brazil	3113.000	1.3636
Mexico	4757.000	3.501
South Africa	3146.300	8.410
World	1189.000	4.144

SOUCE: Author's Compilation

Figure 4: **International Emission Comparison**



SOURCE: FAO/CDAC

The question becomes why China has such greater emissions than India, given there similar GDP per capita and, secondly, how a country like Mexico is able to maintain such a low level of emissions given their higher GDP. Mexico has a GDP per capita 34% higher than South Africa, yet their emissions are 140% lower than South Africa. . The reason for this may the structure of these countries in regards to what sector of the economy their GDP is comprised most of (Industry or Service). Although this may also be due in part to policy differences, South Africa ranks highest in emissions of all African nations. The table below indicates that India gets a greater contribution to their GDP from service compared to China between 1965 and 2005. Mexico, having low levels of emissions for their GDP, has the highest contribution to GDP from service.

Table 2: **Sector Comparison**

Country	CO_2 (kt) per capita	% Industry	% Services
China	1.895	43.698	29.47
India	0.708	24.674	42.937
Brazil	1.3636	36.84	53.04
Mexico	3.501	30.857	60.546
South Africa	8.41	38.399	55.871

SOURCE: Author's Compilation

Thus, two determining factors of emission levels appears to be GDP level (per capita) and structure of the economy (service-based vs. industry-based).

LITERATURE REVIEW

Bruyn, Bergh and Opschoor (1996) investigated previous claims that economic growth would have a positive impact on the environment. They debunked the idea that emission growth takes on an inverted U pattern, known as a Kuznets curve. This pattern would indicate that at a certain level of GDP growth, emission intensity begins to decline because of pollution-reducing technological improvements. It was believed that CO_2 emissions "tend to rise monotonously with income" since economic growth will "depend heavily on energy use". The technological improvements do not offset this because it "is very costly, if feasible at all".

According to the Millennium Goals Development Indicators (2009), China has the largest amount of CO_2 emissions in the world. China's emissions have continued to rise faster than expected (Inman, 2008). Inman reports China's CO_2 emissions were expected to rise by 2.5 to 5% from 2004 to 2010, but the actual figures appear to be 11%.

Banister (2007) went as far as to say China "is now the global manufacturing workshop". This was due to their low cost of labor in the manufacturing sector. In 2004, China had 104.6 million manufacturing employees. Foreign countries are quick to engage into business agreements with Chinese-made products because of the productivity of the low-cost workers. Almost all of the labor force has a basic level or literacy and quantitative skills, as well as primary education and some middle education. This makes China's manufacturing workers "embody moderately high human capital by global standards".

In a study of India and the effect of potential emission controls on economic growth, Ohja (2005) found India to already have low levels of per capita carbon emissions. In 1990, India's per capita emissions was 0.21 tonnes, compared to a global average of 1 tonne. These low levels were achieved despite not having any emission abatement measures such as command-and-control, carbon taxes, and international emissions trading. Ohja (2005) looked at how different sectors of the economy used energy to determine how pollution controls would affect each of them. It was observed that the service sector does not use a substantial amount of energy compared to the industry sector.

Gupta's (2008) study comparing the growth of the two nations found India's growth rate was increasing, while China's remained relatively stable. This occurred despite India only increasing its capital stock 6.6times from 1978 through 2005, compared to China, which multiplied its capital stock 22.6times. Gupta observed a pattern of service sector growth in India and manufacturing sector growth in China. China had higher manufacturing and service sector growth rates than India. However, China's service sector growth (10.7%) was smaller than its manufacturing sector growth (11.4%). India's service sector growth (6.8%) was larger than its manufacturing sector growth (5.8%).

These findings are confirmed by Verma (2008), who stated "empirical data reveal two significant trends in the service sector…growth in service sector productivity and growth in services' trade." Many lower income industrializing nations must rely on service as their source of growth. Verma's analysis of "11 Rapid Growers" revealed that India was a service sector "dominated" country. They also led all countries in the most rapid growth in GDP and in GDP per capita from 1980 through 2004. In 1980, India's service sector accounted for 38 percent of its output, but by 2004, the figure had risen to 52%.

Furthermore, Gupta (2008) concluded India was able to achieve this by having a higher level of human capital than China. He measured human capital in terms of percentage of the population with post-secondary education. From 1980 through 2000, India increased the average year of schooling in the population over 15 years old by 54.7%, while China's increase was only 33.4%.

Gupta found the output-per worker was related positively with productivity and service sector output in India. In China, output-per-worker was positively correlated with productivity and energy consumption.

One more factor this study considers is the effect of real fuel prices on emission levels. It would be expected to see a reduction in emissions when fuel prices rise because energy consumption will decrease in response to prices. Shi and Polenske found China's emission intensity had dropped from the expected level since 1978 because of increased fuel prices. Hypothetically emissions should grow at the same rate as GDP. Shi and Polenske found negative price energy intensity elasticity as a reason for emissions growing at a rate less rapidly than GDP. They stated, "China's production-technology improvement had negative effects on energy consumption, helping China save energy in the 1980s and early 1990s".

It was also noted that regulation did not effect energy consumption in the industry sector, so this can be ruled out as a possibility for emissions staying high. They found the short run inelasticity of energy intensity "existed not only in the overall economy but also in the industry sector, while the one in the overall economy was less in absolute value than the one in the industry sector".

3.0 Empirical Model

$E=\beta 0+ \beta 1Y +\beta 2I+ \beta 3SI + \beta 4P + €$

<u>Dependent Variable</u>:

E=level of emission (CO_2 kt per capita)

<u>Independent Variables:</u>

Y=level of GDP (GDP per capita constant $2000 US)

I= Industry value added (as % of GDP)

S=Service value added (as % of GDP)

P=Price of Fuel (inflation adjusted)

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 Methodology

Bruyn, Bergh and Opschoor constructed the following model from which my model took its basis:

$$Ln\ (E_t/E_{t-1})=\beta 0ln(Yt/Yt\text{-}1) + \beta 1 + \beta 2lnYt\text{-}1 + \beta 3ln(Pt/Pt\text{-}1) + €$$

The model being used captures the sectors of production used to grow GDP and specifically measures CO_2 levels as the metric for emissions. The CO2 emission levels will be this studies dependent variable. It will be measured in per capita terms because of differing sizes of economies. The explanatory or independent variables include GDP level, Price of fuel, agriculture value added, industry value added, and service value added. It would be expected for countries to have higher emission levels regardless of any other factors if the GDP of that country is higher. For this reason, GDP level will be measured in per capita terms because of China's substantially higher level of GDP. Similarly, the value added sector variables as measured as a % of GDP in order to account for differences in levels. It is expected that emissions could be reduced when fuel prices rise. It is also expected that prices would rise over time due to inflation. To take naturally rising prices into account, fuel prices have been adjusted for inflation.

The countries under primary observation are China and India. Both have had rapid rises in economic growth. We will compare their emission levels and the makeup of their sectors of production using this model. The countries will also be compared to the other G5 nations and the world as a whole. This will be used to determine if a similar correlation between sectors of production and emission levels exist, as well as the effect of GDP levels.

4.2 Data

Data used for the regression model was annual data for the years 1965-2005 and was taken form the World Bank's World Development Indicators (WDI).

5.0 EMPIRICAL RESULTS

The empirical findings of this study confirm a relationship between GDP level and emissions, as well as differences in emissions based on economic structure. First, emissions levels are positively correlated with GDP levels. Secondly, and contributions to GDP from industry are increase emission levels more than contributions to GDP from service. Thus, nations with economies more dependent on industry can be expected to have higher levels of emissions than those dependent on service.

The Descriptive statistics show that of the three sectors of production, service provides the largest contribution to GDP (43.0%) with a much lower contribution from industry (24.7%). Meanwhile, China gets the largest contribution from industry (44.8%), followed by services (29.5%).

The regression results show that contributions from industry to GDP have a positive correlation with emission levels for China, India, and South Africa at the highest level of significance (alpha=.01 level). Mexico has a negative coefficient (indicating a negative correlation) but this value was not significant. Brazil also had a negative coefficient that was significant at a lower level of significance (alpha=.10).

For service, Brazil and Mexico again had negative coefficient but they were either insignificant or only significant at the lowest level of significance. China, India, and South Africa all had positive coefficients at the highest level of significance. However, the regression confirms that industry contributes positively to CO_2 emissions than services for the three nations. This is indicated by the positive coefficients for each variable, with the coefficients for industry being higher than those for services.

It should also be mentioned that the results for the World show that industry and agriculture contribute so significantly to emissions, that more contributions from service to GDP has a negative effect on emissions. This is indicated by the negative coefficient for services and positive coefficient for industry.

As for the influence of GDP per capita, the positive coefficients for all countries show that as GDP levels rise, so do emissions levels. The one country that proved not to be significant at any significance level was South Africa. However, a second regression was run to take into account for the possibility of the inverted Kuznets curve, which would indicate that after a certain point of increasing GDP level, emissions levels decrease. In order to test this possibility a fifth variable was added to the regression equation, which squared the GDP level (per capita). Thus, the variable of Y^2 was added and the model became:

$E=\beta0+ \beta1Y +\beta2I+ \beta3SI + \beta4P + \beta5Y^2 + €$

The regression results are listed in table 5. The results, now significant at the highest level (alpha=.01) for all variables. The negative GDP coefficient and positive GDP-squared coefficient disprove the inverted Kuznets curve theory. In other words, it supports the earlier results for the other G5 nations, which all showed evidence for increasing emission levels as GDP level increases.

This is likely due to the increases in output, which requires energy to be used during the production processes. In addition, as GDP rises, household income will rise. This causes an increase in consumption and increase in use of goods that require more energy.

Regression Tables:

Table 3: **Regression Summary**

Industry (% value added of GDP)				
Country	**Coefficient**	**t-score**	**p-val**	**Significance**
China	**0.05825**	**4.790**	**0.000**	***
India	**0.030912**	**5.330**	**0.000**	***
Brazil	**-0.0153**	**-1.810**	**0.078**	*
Mexico	**-0.0876**	**-0.700**	**0.487**	
South Africa	**0.86549**	**10.220**	**0.000**	***
World	**0.08422**	**3.700**	**0.001**	***
Services (% value added of GDP)				
Country	**Coefficient**	**t-score**	**p-val**	**Significance**
China	**0.05698**	**2.960**	**0.005**	***
India	**0.014992**	**2.260**	**0.030**	**
Brazil	**-0.001435**	**-0.200**	**0.843**	
Mexico	**-0.0581**	**-0.560**	**0.576**	
South Africa	**0.6563**	**10.920**	**0.000**	***
World	**-0.02394**	**-1.850**	**0.072**	*

GDP Per capita				
Country	**Coefficient**	**t-score**	**p-val**	**Significance**
China	**0.0010157**	**3.140**	**0.003**	***
India	**0.0015192**	**5.630**	**0.000**	***
Brazil	**0.0004**	**12.140**	**0.000**	***
Mexico	**0.0010776**	**2.890**	**0.007**	***
South Africa	**0.0008963**	**1.160**	**0.254**	
World	**-0.0007266**	**-3.040**	**0.004**	***

SOURCE: Author's Compilation

Table 4**: Descriptive Statistics Summary (Means for 1965-2005)**

Country	**CO2 per capita**	**% Industry**	**% Services**	**GDP per capita**
China	**1.895**	**43.698**	**29.47**	**440.2**
India	**0.708**	**24.674**	**42.937**	**305.4**
Brazil	**1.3636**	**36.84**	**53.04**	**3113**
Mexico	**3.501**	**30.857**	**60.546**	**4757**
South Africa	**8.41**	**38.399**	**55.871**	**3146.3**

SOURCE: Author's Compilation

Table 5**: South Africa and Kuznets Curve Evaluation**

	% Industry	**% Services**	**GDP per capita**	**GDP (per capita) ^{2}**
Coefficient	**0.93509**	**0.71081**	**-0.02841**	**0.0000048**
P value	**0.000**	**0.000**	**0.0089**	**0.0079**

SOURCE: Author's Compilation

The overall models for all countries were significant at the highest level (alpha=.01). The overall models for China, India, Brazil, South Africa and Mexico had the following correlation coefficients:

Table 6: **Correlation Coefficients**

Country	r^2
China	0.943
India	0.98
Brazil	0.965
Mexico	0.795
South Africa	0.792
South Africa (2)	0.786

SOURCE: Author's Compilation

6.0 CONCLUSION

It has been theorized that as a nation increases its production and wealth, they also increase their emissions. With many developing nations experiencing rapid economic growth, emission levels become more of a concern. As fast developing countries, China, India and the other G5 nations provide a reference for which we can base emission level patterns of developing economies.

The results of this study confirm that both economic structure of the economy as well as GDP level have a strong correlation with emission levels. Countries with fast growing economies will have faster growing emission levels, but emission levels are determined by GDP level. These results disprove the inverted Kuznets curve theory that states emission levels will begin decreasing with GDP increases after a certain point.

Even when GDP level and growth rate are accounted for, countries can have varying emission levels and rates of emissions due to the structure of their economies. The second factor of emission levels identified in this study is economic structure. We witnessed a positive correlation between the percent of value added to GDP from industry, which was of greater magnitude than that of service for all G5 nations. Thus, the more an economy relies on industry than it relies on service, the higher we can expect their emission level and rate to be. This is can be explained by the energy requirement of many industrial processes being larger than the energy requirement of providing services.

These results can be useful in predicting emission levels of growing economies. The results could also be used as a tool for reducing emission levels. Although a growing economy would not want to slow growth in order to maintain lower emission levels, if they focused on a service-based economic growth rather than industrial-based growth, their rate of emissions and emission levels would be reduced. This could create economic savings due to the cost to comply with environmental standards and fines, as well as provide future benefits by doing less environmental harm and doing less destruction to natural resources.

One limitation of the results disproving the inverted Kuznets curve theory may be due to too small a sample size and the sample size used. The countries being analyzed were, in fact, “emerging” nations. It may be that these nations have net yet reached the point of inflection, in which their increasing emission levels (per capita) would reverse. The second limitation of this study is the possibility of other variables that are were not identified and accounted for. Such variables could also factor into the disparity we observe in emissions between developing nations. Nonetheless, the variables under observation remain significant in determining emission levels.

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