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ORIGINAL PAPER

Is There a Kuznets Curve for CO_2-Emissions?

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Abstract
The history of the environmental Kuznets curve is traced. We estimate how the CO_2-intensity of economies is related to GDP per capita and examine the implications for the Kuznets curve. We find mixed evidence for the existence of this curve. In many poor and medium rich countries the CO_2-intensity has increased since 1990, while in rich countries it has fallen. In some of those it has fallen at an increasing rate, but in others at a declining rate. If the CO_2-intensity converges to a lower limit as countries grow richer the Kuznets curve would not exist.

Keywords Environmental Kuznets curve · CO_2 emissions · Economic growth · CO_2-intensity · GDP

JEL Classification O13 · O44 · Q32 · Q43 · Q54

Introduction

For more than 30 years, reductions in carbon dioxide (CO_2) emissions have been on the world agenda. The Kyoto Protocol set explicit goals for emission reductions, but only for the developed countries. Yet the total emissions of this substance have continued unabated, as Fig. 1 shows. The reason could be that economic growth in developing countries is relatively energy-intensive and that these countries are still growing out of poverty, some rapidly. The fact that the emission reductions stipulated in the Kyoto Protocol did not apply to developing countries can be seen as an acknowledgement of this, making an allowance for further growth in developing countries.

Even if emissions of CO_2 are still increasing, they have nevertheless peaked in about half of all countries in our sample (90 out of 183).[1] Most of these countries are developed ones. This accords with the environmental Kuznets curve, which predicts that emissions of toxic or other undesirable substances will initially rise with the degree of affluence and then fall. The reason why we still have not seen the world emission curve for CO_2 bend downwards could be that too few countries have reached the level of affluence where CO_2 emissions begin to fall.

The evidence for a Kuznets curve for CO_2 emissions is not strong, however. Many attempts have been made at estimating the Kuznets curve for CO_2 emissions with various results; for some countries and periods a Kuznets curve seems to exist, but for others not. A recent contribution is Luzzati et al. (2018) who also summarize much of the literature on this issue. They find little or no evidence for the existence of a Kuznets curve for CO_2 emissions. In their abstract, they go as far as saying that "the fragile evidence [of an environmental Kuznets curve] that was emerging at the end of the last century has vanished with the new wave of globalization."

Related to the debate on the Kuznets curve for CO_2 emissions is another one on dematerialization of GDP as countries grow richer. In this context the dematerialization pertains to less use of energy sources that release CO_2. This is thought to be driven by a disproportionally large growth of services as countries grow richer, given the premise that services are less energy intensive than other components of GDP. This would imply a Kuznets curve for CO_2 emissions, albeit for other reasons than usually thought to lie behind the Kuznets curve. Income-elastic demand for

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[1] The World Bank data on emissions comprise 217 countries and jurisdictions. We have excluded those for which we lack data on GDP or have only very short time series; these are mostly small jurisdictions. We consider CO_2 emissions as having peaked if the maximum emissions are more than 5% higher than the emissions in 2018.

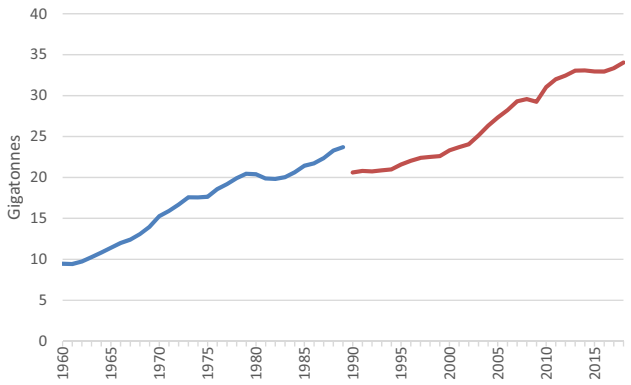

Fig. 1 World total CO_2 emissions 1960–2018. Data from the World Bank. The discontinuity is due to a change in the primary source

a cleaner environment is usually supposed to be the main driver behind the environmental Kuznets curve, although, as we shall see, technological relationships have not been entirely absent as potential causes of the Kuznets curve. The dematerialization hypothesis, in this particular context, has recently been analyzed by Fix (2019) and found wanting.

Rather than estimating the Kuznets curve directly, we focus on the CO_2-intensity of GDP and how it might be related to the level of GDP per capita. This has implications for the Kuznets curve, as will be explained, and is a novel approach to investigating its existence. We estimate the relationship between CO_2-intensity and GDP per capita for individual countries. We find that CO_2-intensity rises with GDP per capita for certain countries, mainly developing ones, which is consistent with the rising part of the Kuznets curve. As countries get richer, CO_2-intensity falls in most cases, which is a necessary but not a sufficient condition for the falling part of the Kuznets curve. In some countries CO_2-intensity falls at a declining rate, which would reverse the fall of the Kuznets curve and make it N-shaped, in which case we would not really have a Kuznets curve. This is, needless to say, bad news for those who hope that growing richer will help reduce CO_2 emissions.

In the next section we shall trace the idea of the environmental Kuznets curve. We move on, then, to examine the relationship between CO_2-intensity and the Kuznets curve. In the penultimate section we estimate the relationship between CO_2-intensity of GDP and GDP per capita and discuss what it means for the existence of the Kuznets curve.

The Origin of the Environmental Kuznets Curve

The idea behind the Kuznets curve originated in a Presidential address by Simon Kuznets to the American Economic Association in late 1954 (Kuznets 1955). He noted that the income distribution in the UK and the US since the 1890s (UK) and the 1920s (US) had become more equal. Kuznets found this surprising, as one would expect strong forces perpetuating and even accentuating income inequality, in particular that only the rich can afford to save and thus accumulate more and more wealth, providing a further increase in income from wealth.

Kuznets thought it likely that political reasons were behind the increasingly equal distribution of income, manifested in deliberate redistribution through progressive taxation and public consumption. He conjectured that income distribution had been more unequal during the first phase of industrialization, leading to the hypothesis that the distribution of income would initially become more unequal as economies grew, a development that would be reversed as they grew further and political forces for redistribution became stronger. But he also thought that migration of labor from rural to urban areas could potentially explain the growing equalization of income and devoted a sizeable part of his presentation to numerical examples of rural and urban income distribution to show why this might happen.[2]

One could represent the relationship conjectured by Kuznets as an inverted U-shaped curve with national income per capita on the *x*-axis and the degree of income inequality on the *y*-axis. This is the Kuznets curve we know, but he did not present his ideas in this graphical form himself.[3] Many years went by without the "Kuznets curve" making its appearance in the literature. Scholars writing on economic growth and development, or income distribution, would refer to the relationship conjectured by Kuznets, but without mentioning the Kuznets curve. The first mentioning of the Kuznets curve this author has been able to find is in a paper by Montek S. Ahluwalia, who worked at the World Bank, in the Journal of Development Economics in 1976 (Ahluwalia 1976). He used a U-shaped curve and not an inverted U, putting the degree of income equality instead of the opposite on the *y*-axis and the income per capita on the *x*-axis.[4] A year later, the "Kuznets curve" appeared in the title of a paper presented to a workshop on the analysis of distributional issues in development planning, organized by the World Bank (Bacha 1977). From then on, the phrase "Kuznets curve" was increasingly used. By 1985 it was well

[2] Kumar (1974) emphasizes this point in his review of the income distribution literature.

[3] Kuznets was very modest in characterizing his talk as "perhaps 5 per cent empirical information and 95 per cent speculation, some of it possibly tainted by wishful thinking."

[4] The use of the phrase Kuznets curve is unlikely to have been widespread before that time, as a prominent scholar of income distribution and economic development in a paper published in 1975 referred to Kuznets' conjecture without calling it the Kuznets curve (Adelman 1975).

enough established for a paper to be devoted to an empirical investigation of it (Lindert and Williamson 1985).

What, then, about the environmental Kuznets curve? Do the two Kuznets curves have anything other in common than the inverted U-shape? The environmental Kuznets curve postulates that the emissions of some undesirable substances (wastes such as sulfur dioxide and carbon dioxide emitted into the air, wastes of various kinds emitted into water bodies or dumped on or into the ground) first increase with economic growth and then fall. The mechanisms behind the original Kuznets curve and the environmental one may be somewhat similar. Public intolerance towards income inequality could lead to increasingly strong policies to counteract unequal income distribution, although it is unclear why this should set in after a certain period of increased inequality has been accompanied by a rising income per capita and be maintained thereafter. In fact, over the last two or three decades, this postulated relationship has been contradicted by a rising income inequality as income per capita has continued to grow (Piketty 2014). As to emission of waste products, it has been argued that people accept this in the initial phase of economic development as its inevitable by-product, but become less and less willing to tolerate it as income and the standard of living rise; as basic needs such as for food and shelter are satisfied, people turn their attention to other, one could say less basic, components of their well being.

The first publication containing the germ of the idea of an environmental Kuznets curve this author has found is one by Susanna B. Hecht from 1985. She put it this way (Hecht 1985, p. 664):

> Ecological problems in this view follow a sort of Kuznets curve: as development begins, things deteriorate, but as growth accelerates, technical solutions eventually diminish the deleterious environmental effects.

Clearly, she thought that the reason for the turning of the Kuznets curve was technological development resulting from economic growth rather than changing preferences of individuals affecting government policy.

Yet it took a few years for the "environmental Kuznets curve" to make its appearance in the literature. Stern (2004), in his review of the literature of the environmental Kuznets curve, traces the concept to two publications. One is Grossman and Krueger (1995) who found an inverse U-shaped relationship between income per capita and various indicators of environmental pollution. The other is the World Bank Development Report 1992. Neither of these publications used the term "environmental Kuznets curve." In Grossman and Kruger (1995) there is, however, a reference to a paper from 1994 entitled "Is There a Kuznets Curve for Air Pollution?" (Selden and Song 1994). This is the earliest reference to the environmental Kuznets curve this author has been able to find. In that paper they point out that (Footnote 2, p. 147)

> [T]he postulated relationship between pollution and development bears a striking resemblance to that between income inequality and development found by Kuznets.

From that point on, references to the environmental Kuznets curve spread like wildfire; one could say that estimating environmental Kuznets curves for various emissions in various corners of the world has become a major sub-field of environmental economics. The literature on the environmental Kuznets curve is vast and summarizing it is beyond the scope of this paper. Several surveys have, in fact, been published over the years; an early one is Stern (2004), which focuses on econometric issues in estimation. Another, more recent, is Kaika and Zervas (2013). Carson (2010) surveys a large part of the literature, both from policy and econometric perspectives, even if that paper is not meant to be a survey.

CO_2-Intensity and the Environmental Kuznets Curve

An environmental Kuznets curve for CO_2 implies a relationship between emissions (E) and GDP (Y) such that emissions initially rise with the level of affluence and then fall as countries grow richer beyond a certain level. Affluence is most easily measured by GDP per capita (x). Let emissions as a fraction of GDP depend on GDP per capita:

$$\frac{E}{Y} = f(x).$$

Total emissions then can be written as

$$E = f(x)Y.$$

The derivative of E with respect to Y is

$$\frac{\partial E}{\partial Y} = f(x) + f'(x)x.$$

If there is an environmental Kuznets curve for CO_2 emissions, $\frac{\partial E}{\partial Y} > 0$ initially and then turns negative as Y grows beyond a certain level. This requires that the CO_2-intensity falls as GDP per capita increases [$f'(x) < 0$]. In the following we examine the development of CO_2-intensity and $\partial E/\partial Y$. If $f(x)$ falls at a declining rate, the derivative $\frac{\partial E}{\partial Y}$ may eventually change sign again, this time from negative to positive, and emissions would increase with GDP. If, for example, $f(x)$ approaches a constant level, emissions would simply increase linearly with GDP. Suppose, for example, that the CO_2-intensity (E/Y) of GDP is

$$\frac{E}{Y} = \begin{cases} a - bx + cx^2 & \text{for } x \le \bar{x}, \\ a - b\bar{x} + c\bar{x}^2 & \text{for } x > \bar{x}. \end{cases}$$

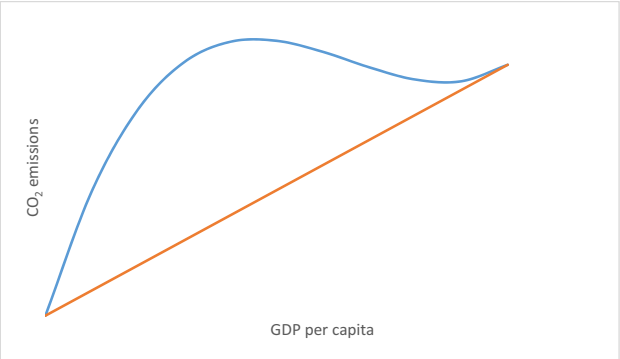

Fig. 2 A "Kuznets curve" with CO_2-intensity falling at a decreasing rate

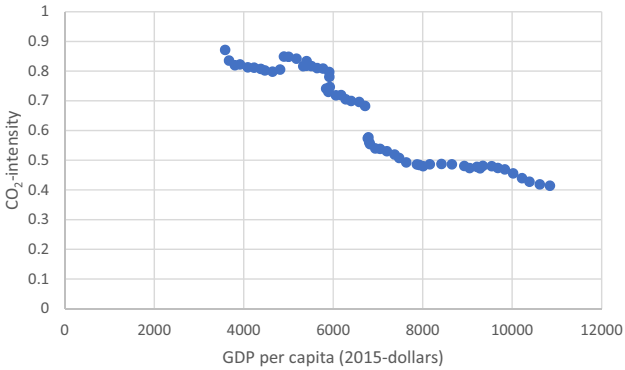

Fig. 3 CO_2-intensity for the world 1960–2018

The environmental Kuznets curve would look like the one in Fig. 2.[5] In this example, the curve rises with GDP to begin with, then falls, and rises again and does so linearly with GDP beyond the critical level $\bar{x}$. In the following we will pay particular attention to whether $f(x)$ might be falling at a declining rate.

Estimations

The World Bank has calculated CO_2-intensity for individual countries for the period 1960–2018, expressed in emissions of kg CO_2 per 2015 US dollars. Figure 3 shows the CO_2-intensity for the world economy. There is a discontinuity in the data in 1990, as is also evident in Fig. 1. This is due to a change in the primary data source; data from before 1990 are from the Carbon Dioxide Information Analysis Center while data from 1990 onwards are from the World Resources Institute. Linking these two sources is not straightforward; for some countries emissions fell from 1989 to 1990 by as much as 20%, while for others they rose by a similar magnitude. We shall henceforth use the data from 1990 onwards. A further argument for beginning the analysis in 1990 is that no less than 23 countries entered the sample for the first time that year, mostly countries in the former Soviet Union and its satellites in Eastern Europe. Finally, the awareness of the global warming issue began about 1990; the Rio Environmental Summit was held in 1992, with obvious implications for the environmental Kuznets curve as it applies to CO_2 emissions.

Figure 3 suggests that the CO_2-intensity for the world economy has been falling at a declining rate since 1990 and is perhaps converging to a bottom limit. This would be bad news for the Kuznets curve, as already explained. What happens to the global CO_2-intensity is the result of decisions taken in individual countries at different stages of development and with different attitudes to the global warming issue. It is therefore necessary to look at what is happening with CO_2-intensity at the individual country level and the implications for the Kuznets curve in each case.

We begin by investigating whether the CO_2 emissions have been rising or falling in individual countries since 1990. The results are summarized in a table in the "Appendix". There are 183 countries represented in the sample we use; some other countries and jurisdictions have too short time series to be meaningful. In the majority of countries (100 out of 183) emissions have tended to decline, but in 34 countries they have tended to increase, with 49 countries showing no trend (defined as a statistically insignificant linear trend at the 5% level).

It is mostly poor and medium rich countries that show an increasing or no trend in emissions. In the hierarchy of GDP per capita, the first country with no trend is Italy, which ranks as number 27, with a per capita GDP of about 30,000 dollars in 2015 (see "Appendix"). The first one with an increasing trend is Saudi Arabia, with a GDP per capita of about 20,000 dollars in 2015, and then the Maldives, with a GDP per capita of 9000 dollars in 2015. There are, however, many poor countries with a declining trend in emissions. The poorest four (Malawi, Madagascar, Central African Republic and Burundi) are among those. In three (Malawi is the exception) of these the GDP per capita has declined, so the decline in emissions is probably due to increased poverty.

It is, of course, not surprising that we find rising emissions primarily in poor and medium rich countries. Many of these, but unfortunately by no means all, have experienced rapid economic growth in the period after 1990. These countries are in a development phase which brings

[5] In this example we have used the numbers $a=1$, $b=-1.68$, $c=0.85$, and $\bar{x}=1$. We make no distinction between GDP and GDP per capita, but this does not affect the qualitative relationship between emissions and GDP.

industrialization and that, in turn, requires growth in the use of energy. Fossil fuels are still the main source of primary energy in the world, comprising more than 80% in 2020 (BP Annual Statistical Review of World Energy).

These results are in agreement with the environmental Kuznets curve; a falling CO_2-intensity as GDP per capita increases occurs primarily in rich countries. CO_2 emissions could nevertheless still rise as the world grows richer because economic growth occurs primarily in poor and populous countries. This was pointed out by Holtz-Eakin and Selden (1995), who estimated that "global carbon dioxide emissions growth will continue at 1.8 percent per annum for the foreseeable future." In retrospect that was not a bad prediction; from 1990 to 2019 the emissions of carbon dioxide from fossil fuels increased at an annual rate of 1.6 percent per annum.[6]

We turn now to investigating the development of CO_2-intensity in countries where it has fallen since 1990. Our focus is on whether this has been falling at a diminishing rate and may thus be approaching some lower limit, in which case the Kuznets curve would not exist. We use two strategies to examine this: (i) regressing CO_2-intensity on GDP per capita and the latter squared; (ii) calculating the change in CO_2-intensity from one year to another. If the coefficient of GDP per capita squared is positive it indicates that the CO_2-intensity is indeed falling at a declining rate. If the change in CO_2-intensity is getting smaller and smaller over time it would indicate that it is falling at a declining rate as GDP per capita increases, as the latter tends to increase over time. With a negative change, this would show up as a positive trend. In the "Appendix" we report the results of these investigations. If CO_2-intensity falls at a diminishing rate in rich countries this would be a clear indication that a Kuznets curve for CO_2-emissions does not exist.

There are 100 countries with declining emissions since 1990. In one of these (Myanmar) emissions declined to begin with and then rose, but not enough to reverse the declining trend. The falling trend in Albania is entirely due to two high outliers at the beginning. We disregard both of these, neither of which is a rich country. This leaves us with 98 countries. Of these, the coefficient of squared GDP per capita is positive in 34 cases, negative in 21, and not significant in 43 cases (significance level set at 5%).

Even if CO_2-intensity is falling at a declining rate in more cases than it is falling at a rising rate it would be rash to take this as a strong evidence against the existence of the Kuznets curve. If it were, this evidence would be strongest for the richest countries of the world. This is not so; poor and medium rich countries are overrepresented among these countries. Of the countries with more than 30,000 2015-dollars per capita, 12 (Switzerland, Norway, the US, Australia, Netherlands, Austria, Belgium, the United Arab Emirates, New Zealand, France and Israel) have a negative coefficient for the quadratic term while 4 (Luxembourg, Ireland, Singapore and Germany) have a positive coefficient.

As to the year to year changes in CO_2-intensity, we find a significantly (5% level) rising trend (declining trend in the absolute value) in only 9 cases among the 98 countries where emissions have declined since 1990 (see "Appendix"). A rising trend indicates that the CO_2-intensity is declining at a diminishing rate and may be converging to some lower limit, in which case the Kuznets curve would not exist. The countries involved are, however, all poor or medium rich. This is not an overwhelming evidence that the emissions are converging to some lower limit as countries get richer; for many rich countries they are even declining at an accelerating rate. Overall, the evidence against a Kuznets curve for CO_2 emissions emerging from this paper seems weak rather than strong. This is at odds with the above-mentioned conclusion by Luzzati et al. (2018), who find little or no evidence for the existence of a Kuznets curve for CO_2 emissions.

Conclusion

An environmental Kuznets curve for CO_2 emissions would offer an easy way out of the climate change dilemma: just wait for countries to get rich enough, and CO_2 emissions will fall. The speed of this process could, however, be a problem: economic development takes time, and until all countries of the world have reached the required level of affluence, much will have been emitted, presumably with long-term effects on climate. The problem could be more serious still: rather than fall uniformly with rising affluence the emissions may only do so for a time and then rise again, because emissions per unit GDP may fall at a declining rate and asymptotically reach a constant level. This, needless to say, makes stronger demands on new technologies if further economic growth is to be reconciled with reductions in CO_2 emissions.

The falling CO_2-intensity in rich countries may exaggerate what happens as the world as a whole gets richer. Rich countries have to a large extent outsourced the production of CO_2-intensive goods to developing countries. Allocating CO_2 emissions among countries on the basis of consumption rather than production shows that CO_2 emissions in rich countries have fallen less, or even increased (Helm 2012). This harks back to a result obtained by Aldy (2005), who found a difference between Kuznets curves for CO_2 emissions in individual US states based on consumption versus production. Curves based on consumption peaked at a higher

[6] Calculated from data in *BP Statistical Review of World Energy* June 2019.

income level than those based on production, indicating outsourcing of CO_2 intensive processes.

Appendix

Results of Statistical Analysis

(i) Trend in CO_2-intensity of GDP 1990–2018 (5% significance level, 0 = no significant trend).

(ii) Sign of coefficient c in the equation $CO_2\text{-intensity} = a + b * \text{GDPcap} + c * (\text{GDPcap})^2$.

(ii) Trend in $\Delta x = x_t - x_{t-1}$, $x = CO_2$-intensity of GDP.

	GDP per capita, 2015 dollars	Trend in CO_2-intensity	Sign of c	Positive trend in Δx
Luxembourg	105,420	−	+	
Switzerland	84,776	−	−	
Norway	74,356	−	−	
Qatar	63,039	−	0	
Ireland	61,988	−	+	
United States	56,863	−	−	
Australia	56,707	−	−	
Singapore	55,647	−	+	
Denmark	53,255	−	0	
Iceland	52,952	−	0	
Sweden	51,545	−	0	
United Kingdom	45,405	−	0	
Netherlands	45,175	−	−	
Austria	44,178	−	−	
Canada	43,596	−	0	
Finland	42,785	−	0	
Germany	41,087	−	+	
Belgium	40,992	−	−	
United Arab Emirates	38,663	−	+	
New Zealand	38,631	−	−	
France	36,638	−	−	
Israel	35,808	−	−	
Andorra	35,771	−	0	
Japan	34,961	−	−	
The Bahamas	31,776	−	0	
Brunei	31,164	−	0	
Italy	30,230	0		
Kuwait	29,870	−	0	
Korea (South)	28,732	−	0	
Spain	25,732	−	0	
Malta	24,922	−	0	
Cyprus	23,408	−	0	
Bahrain	22,634	0		
Slovenia	20,882	−	0	
Saudi Arabia	20,628	+		
Portugal	19,242	−	−	
Oman	18,445	0		
Trinidad and Tobago	18,214	−	+	
Greece	18,077	−	+	
St. Kitts and Nevis	18,029	0		
Czech Republic	17,830	−	+	
Estonia	17,395	−	+	
Barbados	16,525	0		
Slovakia	16,336	−	+	Yes
Palau	15,876	0		
Uruguay	15,614	−	−	
Seychelles	14,745	0		
Antigua and Barbuda	14,285	0		
Lithuania	14,258	−	+	Yes
Argentina	13,789	−	0	
Latvia	13,781	−	+	Yes
Panama	13,630	−	−	
Chile	13,574	−	0	
Hungary	12,721	−	+	
Poland	12,578	−	+	
Croatia	11,933	−	−	
Costa Rica	11,643	−	−	
Equatorial Guinea	11,283	−	+	Yes
Turkey	11,006	−	0	
Kazakhstan	10,511	−	0	
St. Lucia	10,094	0		
Malaysia	9955	0		
Mexico	9617	−	−	
Russia	9313	−	0	
Mauritius	9260	0		
Suriname	9168	−	+	
Grenada	9097	0		
Maldives	9033	+		
Romania	8969	−	+	Yes
Brazil	8814	0		
Nauru	8341	−	0	
China	8016	−	+	
Cuba	7694	−	0	
Lebanon	7664	0		
Dominica	7597	+		
Gabon	7385	+		
Bulgaria	7075	−	0	
St. Vincent and the Grenadines	6922	0		
Dominican Republic	6922	−	−	

	GDP per capita, 2015 dollars	Trend in CO_2-intensity	Sign of c	Positive trend in Δx
Montenegro	6514	−	0	
Turkmenistan	6433	−	0	
Botswana	6403	−	+	
South Africa	6260	−	−	
Peru	6229	−	+	
Colombia	6176	−	+	
Ecuador	6124	0		
Belarus	5967	−	0	Yes
Thailand	5840	+		
Serbia	5589	−	0	
Guyana	5577	−	0	
Azerbaijan	5500	−	+	
Paraguay	5414	+		
Fiji	5391	+		
Jamaica	4908	0		
Iran	4904	+		
Namibia	4897	0		
North Macedonia	4862	−	0	
Belize	4770	−	0	
Bosnia and Herzegovina	4730	+		
Iraq	4688	−	+	
Libya	4338	−	0	
Tonga	4336	0		
Algeria	4178	0		
Angola	4167	0		
Jordan	4164	−	0	
Tunisia	4095	−	0	
Samoa	4072	0		
Georgia	4014	−	+	Yes
Guatemala	3995	+		
Albania	3953	−		
Mongolia	3875	−	+	
Sri Lanka	3844	0		
El Salvador	3706	0		
Eswatini	3680	−	0	
Armenia	3607	−	+	
Egypt	3563	0		
Indonesia	3332	0		
Marshall Islands	3200	0		
Tuvalu	3198	−	0	
Cabo Verde	3043	+		
Bolivia	3036	+		
Philippines	3001	−	+	
Micronesia	2907	0		
Morocco	2875	0		
Uzbekistan	2754	−	+	
Bhutan	2753	0		
Moldova	2732	−	+	Yes
Vanuatu	2696	+		
Nigeria	2687	−	+	
Papua New Guinea	2679	0		
Republic of Congo	2448	0		
Honduras	2286	+		
Solomon Islands	2167	−	0	
Laos	2140	+		
Ukraine	2125	−	+	
Vietnam	2085	+		
Nicaragua	2050	0		
Cote d'Ivoire	1973	0		
Ghana	1774	+		
India	1606	−	0	
Yemen	1602	+		
Sao Tome and Principe	1585	0		
Kiribati	1543	0		
Mauritania	1524	+		
Kenya	1465	+		
Zimbabwe	1445	0		
Haiti	1387	0		
Cameroon	1383	−	+	
Pakistan	1357	0		
Zambia	1338	0		
Timor-Leste	1333	0		
Sudan	1330	+		
Bangladesh	1248	+		
Comoros	1243	+		
Senegal	1219	+		
Myanmar	1197	−		
Cambodia	1163	+		
Lesotho	1146	−	+	Yes
Kyrgyz Republic	1121	0		
Benin	1077	+		
Tajikistan	978	+		
Tanzania	948	+		
Nepal	902	+		
Uganda	847	+		
Chad	776	−	0	
Guinea	769	0		
Mali	751	+		
Rwanda	751	−	+	
Liberia	722	0		
Gambia	661	−	+	
Burkina Faso	653	+		
Ethiopia	641	0		
Guinea-Bissau	603	−	0	
Mozambique	590	0		

	GDP per capita, 2015 dollars	Trend in CO_2-intensity	Sign of c	Positive trend in Δx
Sierra Leone	588	0		
Togo	571	0		
Afghanistan	556	+		
Democratic Republic of Congo	497	0		
Niger	484	+		
Madagascar	467	−	0	
Malawi	381	−	0	
Central African Republic	377	−	+	
Burundi	306	−	0	

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Declarations

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