CO_2 intensity and GDP per capita

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Abstract

The relationship between CO_2 intensity and GDP per capita is studied. Most rich countries show falling CO_2 intensity over time and a negative correlation with GDP per capita. Many poor and medium rich countries show the opposite, a positive time trend and a positive correlation with GDP per capita. For about a half of the countries with a negative correlation between CO_2 intensity and GDP per capita, and in particular the largest economies of the world, there is strong evidence that CO_2 intensity falls at a diminishing rate as countries get richer. Hence, economic growth will not by itself go very far in reconciling economic growth and reductions in CO_2 emissions. There are indications that poor and medium rich countries experience a boost in CO_2 intensity as they embark on industrialization. This will also make it harder to reconcile economic growth and cuts in CO_2 emissions. Falling CO_2 intensity of GDP in rich countries may not give a correct indication of what happens to world GDP because rich countries have outsourced much of their energy-intensive production to poorer countries. Looking at the production of eleven minerals 1960-2017, we find little or no evidence of dematerialization. Production of five minerals has grown more rapidly than world GDP and that of four other minerals more rapidly than world population.

Keywords: carbon dioxide; economic growth; CO_2 intensity; mineral production; GDP; economic growth; dematerialization

JEL classification: N50, O13, Q32, O44, Q43, Q54

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1. Introduction

Is economic growth compatible with reduction in carbon dioxide emissions? If so, carbon dioxide emissions per unit of GDP (hereafter CO_2 intensity) will have to fall. New technologies for energy production on a grand scale are likely to be necessary for this, but it would also help if there are structural trends accompanying economic growth that would bring the CO_2 intensity down. This is not unlikely, as economic growth is accompanied by disproportionate growth of services, which are less energy intensive than material production (Medlock and Soligo, 2001).

What is the historical record? As a part of its battery of world economic indicators, the World Bank publishes carbon dioxide content per unit of GDP at fixed prices for most countries in the world. In this paper we use this data to investigate the historical record across countries and, in particular, how CO_2 intensity is related to GDP per capita. We get mixed results, and yet a tendency that the CO_2 intensity falls as countries get richer, but at a diminishing rate.

According to the BP Statistical Review of World Energy, more than 80 percent of primary commercial energy still comes from fossil fuels. Since most CO_2 emissions are caused by burning fossil fuels, what has happened to CO_2 intensity is in large measure a reflection of what has happened to energy intensity. Many papers on that subject have been published, and most indicate that energy intensity falls as GDP per capita increases, or that the relationship has an inverted U-shape. Csereklyei, Rubio-Varas and Stern (2016) find, for a sample of 99 countries, that energy intensity falls as countries grow richer, but point out that energy intensity may increase in countries experiencing no growth. They also point out that the increasing energy intensity often observed for poor countries could be due to a transition from non-commercial biomass energy to commercial energy. They include non-commercial energy in their data, but recognize the unreliability of such data. Most other studies use only commercial energy. Medlock and Soligo (2001) find the inverted U-shape for intensity of commercial energy, for a panel of 28 countries.

In a recent paper, Semieniuk (2018) investigates the "green growth hypothesis", that is, whether a faster development in productivity will reduce the energy intensity of the economy. Using a large but unbalanced panel of 180 countries 1950-2014 he finds that faster growth is not greener; a higher rate of labor productivity growth is typically associated with a higher rate of growth of energy input per unit of labor, canceling the effect on energy intensity. Hence, faster productivity growth will not contribute to reconciling economic growth and reduction in CO_2 emissions.

Two papers study the relationship between CO_2 emissions and GDP. Bella, Massidda and Mattana (2014) study the relationship between total CO_2 emissions and total GDP for a panel of 22 OECD-countries. They find an inverted U-shape for most countries, which most likely implies a similar shape as well for CO_2 intensity and GDP per capita, as for most countries GDP and GDP per capita have moved in the same direction. Jakob et al. (2012) study the growth of CO_2 emissions and GDP for a sample of 51 countries. They break their sample into developing and industrialized countries and find that both grew at a rate higher than average in developing countries while there is no significant relationship between the growth rates of GDP and the use of energy for developed countries. These results are not directly comparable to ours, but neither do they contradict them.

Looking at the relationship between CO_2 intensity, or energy intensity, and GDP per capita implies that a structural change in GDP as countries grow richer is seen as a driver of changes in CO_2 emissions or energy use. A rationale has already been advanced; as countries get richer, more and more of presumably less energy intensive services is produced and CO_2 intensity falls, while in countries just beginning their industrialization the opposite might happen. But things are more complicated than that. Energy or CO_2 intensity might fall with no change in GDP per capita because of technological progress leading to increased energy efficiency across economic sectors or a transition from fossil fuels to other energy sources, or even between different fossil fuels (such as less reliance on coal and greater use of natural gas). Two studies of the US economy try to tease out how much of energy savings is due to increased energy efficiency (better technology) and how much is due to structural changes following changes in GDP per capita. Metcalf (2008) found that most of the reduction in energy intensity is due to improvements in energy efficiency while Huntington (2010) came to the opposite result. As pointed out by Huntington, the difference could be due to the degree of disaggregation in the data. So, to analyze this question, one needs not only country-specific disaggregated data, but the level of aggregation could have a critical bearing on the answer.

There are more devils in the details. In a recent paper, Croner and Francovic (2018) study structural versus efficiency factors behind changes in energy intensity, using detailed input-output coefficients for a number of countries. They point out that production-based data give more importance to structural factors than consumption-based data would do, because rich countries have to a large extent outsourced the production of CO_2-intensive goods to developing countries, a point also made by Dieter Helm (2012) with the British economy as an example. In the last part of the paper we investigate the development in the extraction of eleven minerals important for industrial production. This is important because digging up minerals and converting them into useful products is energy-intensive. Since the world economy is still critically dependent on fossil fuels, this has implications for reducing carbon dioxide emissions. Unless extraction and processing of minerals can quickly be based on using energy from renewable resources, it will continue to contribute to emissions of greenhouse gases, especially carbon dioxide.

2. How CO_2 emissions have evolved

Figure 1 shows the development of the CO_2 intensity world wide, for real GDP measured in 2010 US dollars. The CO_2 intensity fell steadily from 1960 to 2000 and stagnated after that. This is curious, as efforts to develop green energy and otherwise reduce carbon dioxide emissions have been particularly strong after 2000. When China is removed from the sample the stagnation disappears. Nevertheless, the CO_2 intensity has fallen more slowly for the world excluding China in this century than it did before, so we still face the paradox why efforts at decarbonization have achieved so little since they appeared on the world agenda.

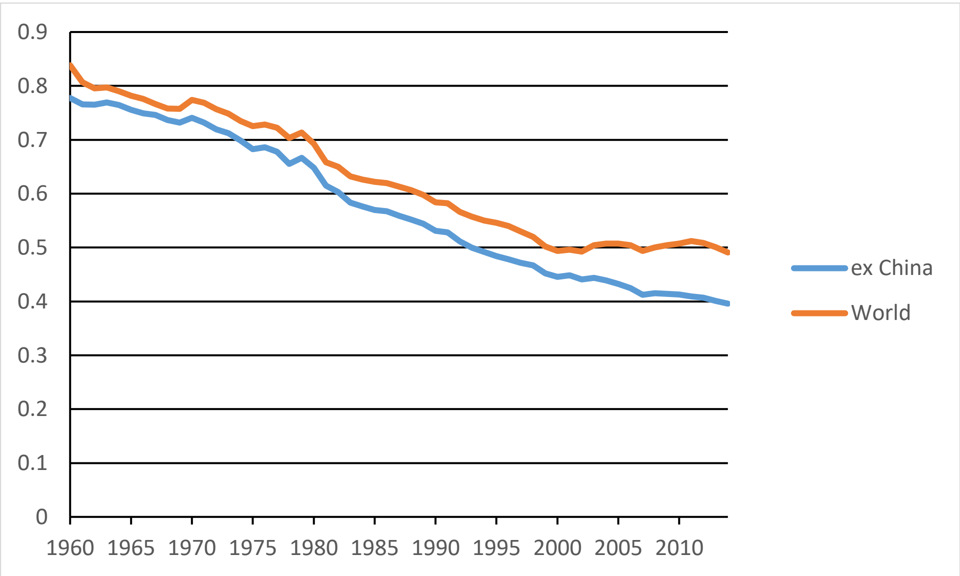


Figure 1: World CO_2 emissions (kg per 2010 US$ of GDP) 1960-2014 with and without China. Data from the World Bank.

In the World Bank sample there are 190 countries, but not all are represented for the entire 1960-2014 period (the countries and the years they are represented are listed in the Appendix). Looking at the time trend of CO_2 intensity across countries, we find that most of 36 countries with a GDP per capita of more than 23,000 dollars have a negative time trend, but for five the trend coefficient is insignificant. Below 23,000 dollars of GDP per capita a significantly positive time trend begins to show up, and then we are down to what may be termed medium rich countries; the richest ones of those with a positive time trend are Greece, Portugal and Saudi Arabia. For the remaining 154 countries, which may be characterized as medium rich or poor, we get a significantly positive time trend for about a half (69), while for 58 we get a significantly negative time trend, and for 28 we get no significant trend at all. The CO_2 intensity has thus tended to rise rather than fall for medium rich and poor countries, contrary to what has happened in rich countries.

CO_2 intensity and GDP per capita

One reason why the CO_2 intensity has been falling over time in many countries is that GDP per capita has been increasing. If CO_2 intensity falls as GDP per capita increases, for reasons already mentioned, this will show up as a falling time trend of CO_2 intensity. We now turn to investigating the relationship between CO_2 intensity and GDP per capita. We focus attention on countries with a negative relationship between these two and ask in particular whether there is a tendency for CO_2 intensity to fall at a declining rate when countries get richer, as Figure 1 indicates might be the case.

The results of a regression analysis of individual countries are summarized in the Appendix. We get a significantly negative correlation between CO_2 intensity and GDP per capita for 94 countries, a significantly positive one for 48, while 48 coefficients are insignificant. The negative correlation is most prominent for rich countries. Ordering countries by GDP per capita, the first countries to appear with a positive correlation are Greece and Portugal, and thereafter positive correlation begins to appear with an increasing frequency. The countries with a negative time trend and a negative correlation with GDP per capita are mostly the same. There are far fewer countries with a positive correlation between CO_2 intensity and GDP per capita (48) than those with a significantly positive time trend (69), so there are more countries with no significant correlation between CO_2 intensity and GDP per capita (48) than those with an insignificant time trend (33).

Does CO_2 intensity fall with GDP per capita at a diminishing rate? To investigate this, we regressed CO_2 intensity on GDP per capita and GDP per capita squared, for the 94 countries that showed a negative relationship between CO_2 intensity and GDP per capita. The results are shown in the Appendix. If CO_2 intensity falls at a diminishing rate, the coefficient of the GDP-squared term should be positive. We get a significantly positive coefficient for about a third of the countries (35), and a positive but not significant coefficient for another third (28). For ten countries both regression coefficients are negative but insignificant, giving no support to the diminishing decline of the CO_2 intensity as countries become richer.

Then there are 21 cases where the regression coefficient of GDP per capita is positive while that of the squared GDP-term is negative. In that case, the CO_2 intensity would increase with GDP per capita up to a certain level and fall thereafter. A pattern like that is consistent with energy intensity of economies increasing as countries industrialize and become richer, but as they pass a certain point it falls. Does it do so at a diminishing rate? To investigate that we add a cubic term of GDP per capita to the regression for those countries. The results are shown in the Appendix. For a little over a half (13) of those countries we get a significantly positive regression coefficient, indicating that in the decline phase the CO_2 intensity does indeed fall with a rising GDP per capita at a diminishing rate and might even rise. For five countries we get positive but insignificant coefficients, but for three we get negative but insignificant coefficients.

Hence there appears to be strong support for the hypothesis that CO_2 intensity falls with GDP per capita at a diminishing rate. We find significant statistical support for this for about a quarter of the world's countries and a weak (right sign but insignificant coefficient) support for about 30 others. More importantly, the strongest support is provided by the richest and largest economies in the world; the United States, China, Germany, the United Kingdom, and many others. But even some poor countries also follow this pattern.

A potential explanation of why the CO_2 intensity of world GDP has fallen more slowly after 2000 is that many enough countries may have reached the level of GDP per capita where further gains in declining CO_2 intensity are small. While many countries are still so poor that they are unlikely to have reached that level, what happens in rich countries, which are responsible for most CO_2 emissions, may be decisive.

An illustration

It would require too much space to illustrate the modeling results for all countries, but it is of interest to compare them with the actual development in the largest economies of the world. After all, these countries have, by their sheer size, most effect on world GDP and also on world emissions of CO_2, even if the CO_2 intensity of GDP varies considerably between them (the CO_2 intensity of China's GDP is about four times that of the United States). Figure 2 shows the development of the CO_2 intensity for the eight countries with the highest total GDP in 2014 and compares it with our modeling results. The model reproduces the actual development in the United States, Germany, France and the United Kingdom quite well (note that we only have data from Germany after 1991). The result is less good for China; in that country the CO_2 intensity has had a rickety ride, with a rapid fall in the 1960s, then a rise, and a fall again from the late 1970s. For China we use a function including both squared and cubed GDP per capita (see Appendix). The modeled CO_2 intensity stays fairly flat for the first two decades. Then, as GDP begins to increase, the negative squared term produces a fall in the CO_2 intensity, but in the last years the positive cubic term weighs more heavily and actually produces an increase instead of merely slower decline or stagnation, so obviously this term overcompensates.[1]

The model for Japan, which also has a cubic term, fits rather well. The CO_2 intensity of the Japanese GDP increased to the mid-1970s and has fallen thereafter. The model captures this quite well. The negative squared term produces a decline in CO_2 intensity after the mid-1970s until the Japanese economy stagnated in the 1990s, while the positive cubic term produces a slight increase in the last years and may thus exaggerate how the CO_2 intensity falls at a diminishing rate when GDP per capita increases. The mid-1970s were a watershed in more than one sense. This was the time of the first energy crisis, but Japan was also at that time emerging from a period of rapid economic growth and industrialization implying possibly a rising CO_2 intensity of GDP. An argument against this being valid in general is the fall in the Chinese CO_2 intensity after the late 1970s, which coincided with rapid economic growth and industrialization.

Lastly there are Brazil and India. In Brazil the CO_2 intensity has fluctuated without trend, and in India it rose until the early 1990s, but has fallen since. The model simulations shown in the diagrams for these countries explain very little or nothing of what has happened.

[1] Using a logarithmic model for China gives a much better fit and still produces diminishing rate of falling CO_2 intensity as GDP per capita rises.

Figure 2: Actual and simulated CO_2 intensity (kg per dollar GDP) in the six largest economies of the world.

The results for Japan, Brazil and India suggest that there may be a phase in the development of poor and medium rich countries where the CO_2 intensity of GDP increases with GDP per capita, in order to fuel rapid industrialization. Figure 3 shows the CO_2 intensity and the GDP per capita in two countries, Singapore and Thailand, that have experienced rapid economic growth. Singapore appears to have had a phase of increasing and then high CO_2 intensity during its first phase of rapid development up until about 1980. After that the CO_2 intensity has fallen rather evenly, but seems recently to have reached a plateau. In Thailand the CO_2 intensity grew with GDP per capita until 1997, but has since been fairly steady.

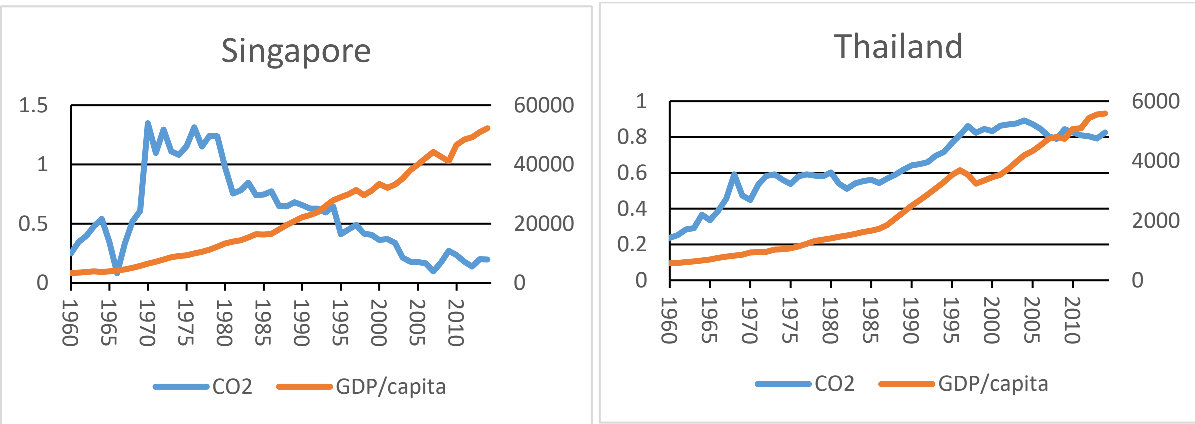


Figure 3: CO_2 intensity (left axis) and GDP per capita (right axis) in Singapore and Thailand.

A panel data approach

For the majority of countries, CO_2 intensity appears to fall as they get richer, and for these the relationship is non-linear in the majority of cases, implying that the CO_2 intensity falls at a diminishing rate. This is supported by estimating the second degree equation for the entire panel of data, with country-specific dummy variables. The results are shown in Table 1, with dummies omitted.

Table 1

Results from estimating the equation $y = a + b_1 x + b_2 x^2$, where *y* is CO_2 intensity and *x* is GDP per capita, with t-values in parentheses.

a	b_1	b_2	R^2
1.028136 (25.07)	-.0000147 (-13.49)	7.23e-11 (6.54)	0.8244

The estimated curve is shown in Figure 4, together with the CO_2 intensity in selected countries, adjusted to the level of the United States, which is used as base for the dummies. The data for Thailand, the United States, the United Kingdom and Singapore were shown in Figures 2 and 3 and commented on in the previous section. Thailand and Singapore do not follow this overall tendency at all in their early phase. Data for the three richest countries in the world in 2014, Luxembourg, Norway and Switzerland, are also shown. The CO_2 intensity for the latter two is fairly flat. The CO_2 intensity for Luxembourg falls rapidly in the beginning, but is fairly flat in later years. Luxembourg is an example of a country that has developed rapidly towards a service-based, wealthy economy.

It could be argued that the results in Table 1 are biased because we have an unbalanced panel. For many countries data are not reported for the early years; there is a large influx of countries in the early 1990s, associated with the downfall of the Soviet Union and the disappearance of the iron curtain. Estimating the equation for data from 1992 onwards still gives significant coefficients with the same sign, but their numerical values now produce a U-shaped curve with a minimum at a GDP per capita of about 70,000 dollars. It is unlikely that the CO_2 intensity will begin to increase again at higher GDP levels, so we take this as a further evidence that the CO_2 intensity does indeed fall with GDP per capita, but at a diminishing rate.

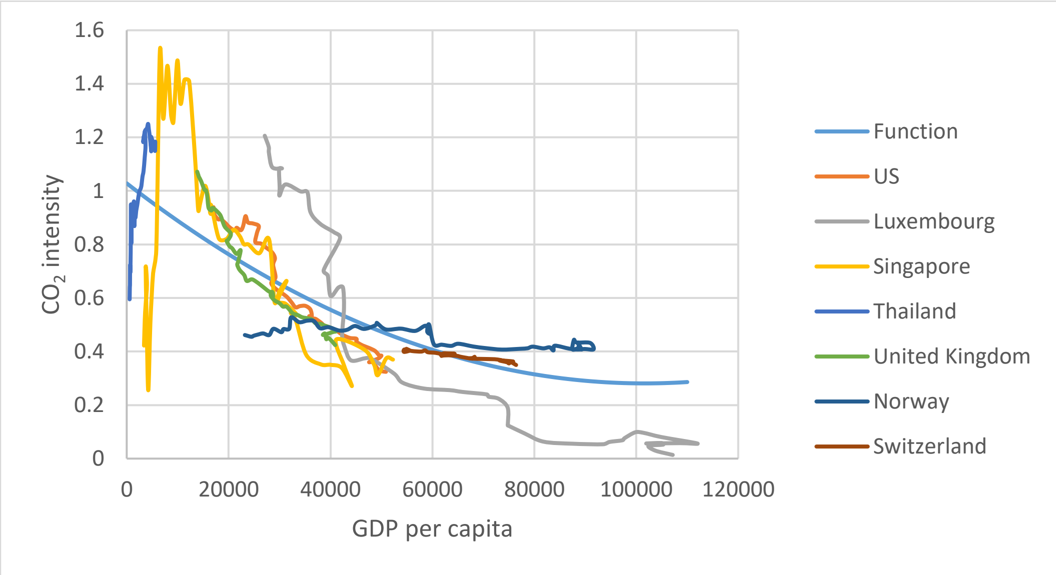


Figure 4: The equation $y = a - b_1 x + b_2 x^2$ (y = CO_2 intensity, x = GDP per capita), as estimated for the entire panel of countries, and the CO_2 intensity of 7 selected countries.

3. World mineral production

One reason why world emissions of CO_2 falls at a declining rate is that the "dematerialization" of GDP is less easy than looking at the rich countries of the world might lead one to believe. It is well known that the share of minerals and industrial production in GDP (gross domestic product) declines as countries get richer (Radetzki and Wårell, 2017; Humphreys, 2013). Looking at the material content of GDP in rich countries may, however, exaggerate the possibilities of "dematerialization" of GDP for the world as a whole, because rich countries have outsourced their industrial production and even extraction of minerals to the so-called developing countries.[2]

How far can dematerialization of GDP be pushed? Some economists take a sanguine view:

> "A central question of environmental policy is whether it will be possible to reach an absolute decoupling of economic growth measured in monetary terms at constant prices from the extraction of natural resources measured in physical units." (Meyer, Meyer and Distelkamp, 2012, p. 145).

[2] Helm (2012) discusses outsourcing of CO_2-intensive production to developing countries and shows how a decrease in CO_2 emissions for the UK turn into an increase if one accounts for emissions on basis of consumption rather than production.

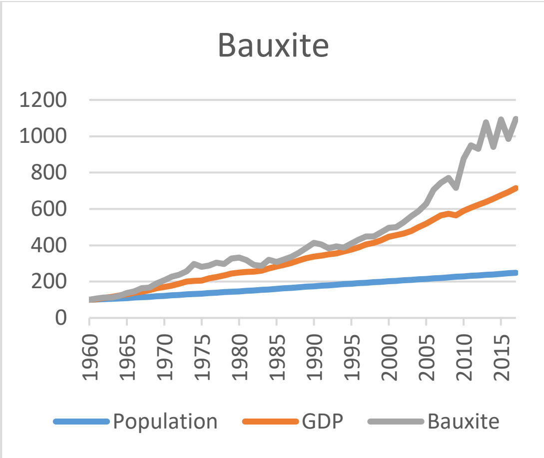
Were this to happen, our material needs would have to be already satisfied, so that further economic growth would all be about immaterial things. In a world where the population is still growing and millions of people are still living in poverty, we seem to be far from such "absolute decoupling." In this section we look at the extraction of eleven minerals important for industrial production and compare it with the development of world GDP and population.

The data cover the period 1960-2017. Data on mineral extraction are from the US Geological Survey.[3] The minerals we examine are bauxite, copper, cobalt, iron ore, lead, magnesium, molybdenum, nickel, platinum, tin and zinc. Of these, iron ore is probably the one most closely related to industrialization, while minerals such as magnesium, molybdenum, nickel and platinum are used in industrial processes and blended in with iron to produce steel of specific qualities. Bauxite is the raw material for aluminum, which we find in a variety of uses. We leave out precious minerals (gold and silver), which are not closely related to industrialization, and some minor minerals used in industrial processes and steel alloys (vanadium, for example).

Figure 5 compares the development in extraction of the aforementioned eleven minerals with the development of GDP and world population. There is limited support of the hypothesis that the world economy is becoming less dependent on minerals. The extraction of five minerals (bauxite, cobalt, nickel, molybdenum and platinum) has grown faster or at about the same rate as GDP from 1960 to 2017. All of these are used in industrial processes. Cobalt is used in batteries, so its increasing use is related to the development of the digital age. Extraction of four minerals (copper, iron ore, magnesium and zinc) has grown more slowly than GDP, but faster than world population. Extraction of tin and lead has grown at about the same rate as world population. In 2017 world population was 2.5 times larger than in 1960, while world GDP was more than seven times larger.

A conspicuous feature of Figure 5 is that the extraction of most minerals began to grow more quickly in the late 1990s or early 2000s. For cobalt and copper this began in the mid-1990s, and for bauxite, magnesium, molybdenum and zinc a little later (around 2000). It is tempting to see this as a result of the rapid economic growth in China and some other poor countries from the 1990s onwards. For iron ore we have particularly clear evidence. The production of iron ore took a sudden leap upwards 2002-2009, but has had a relatively stable growth after that. China's imports of iron ore rose from 70 million tonnes in 2000 to 620 in 2010, which coincided with a doubling of world production of iron ore (Hellmer and Ekstrand, 2013). As earlier discussed (see Figure 1), the stagnation of the CO_2 intensity of world GDP around 2000 is particularly noteworthy. China's industrialization has also left its indelible mark on time series of energy carriers (coal, oil, not discussed here) and emissions of carbon dioxide.

[3] These refer to production from mines. An exception is cobalt, where there is serious disagreement between data for the periods 1960-1986 and 1983-2017. We have instead used data on production of refined metal. Data for this are missing for 1960-1968, but we have calculated these from mine production data, which are closely correlated with production of refined metal.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Population
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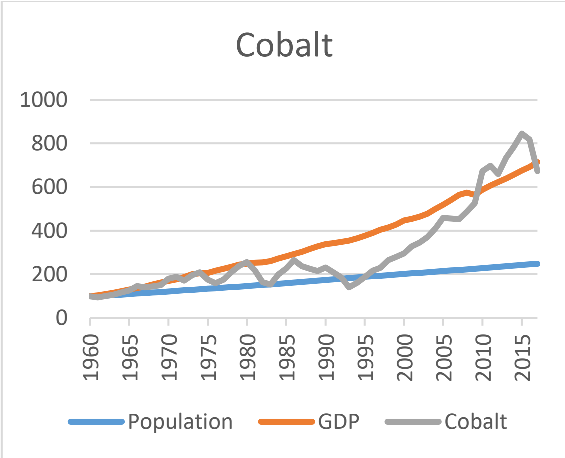
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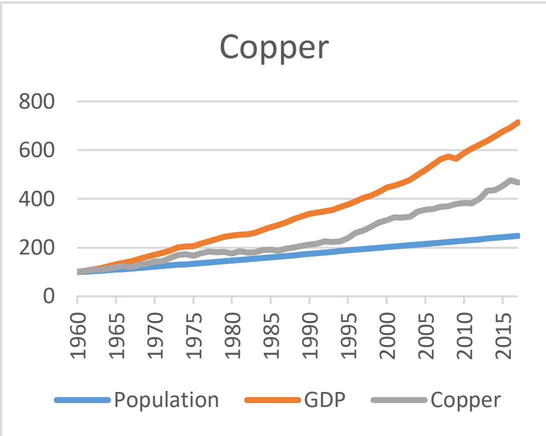
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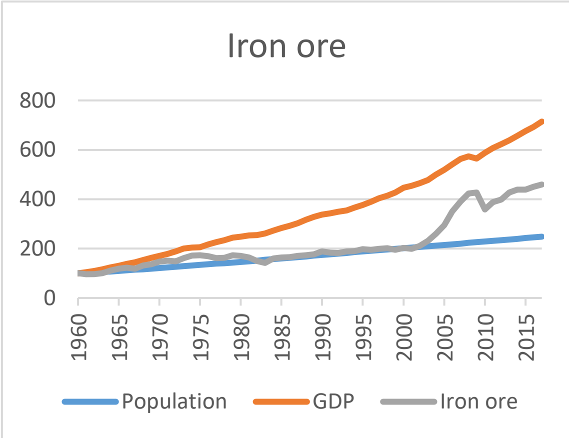
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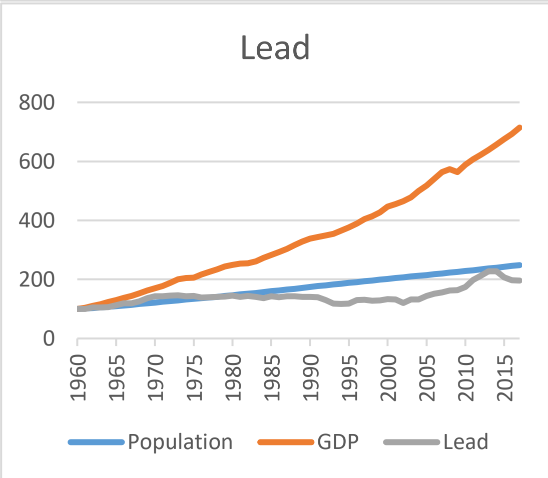
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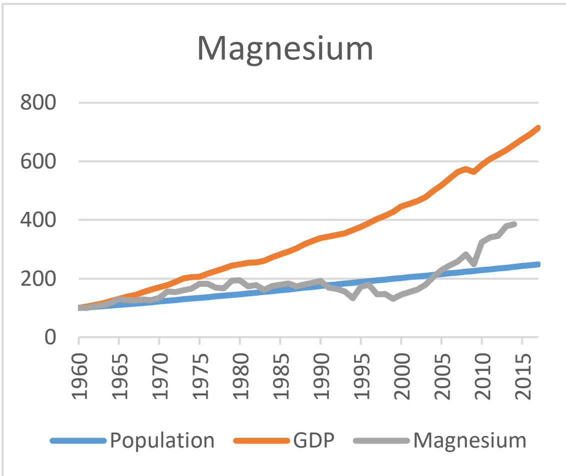
Magnesium
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Population
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Magnesium

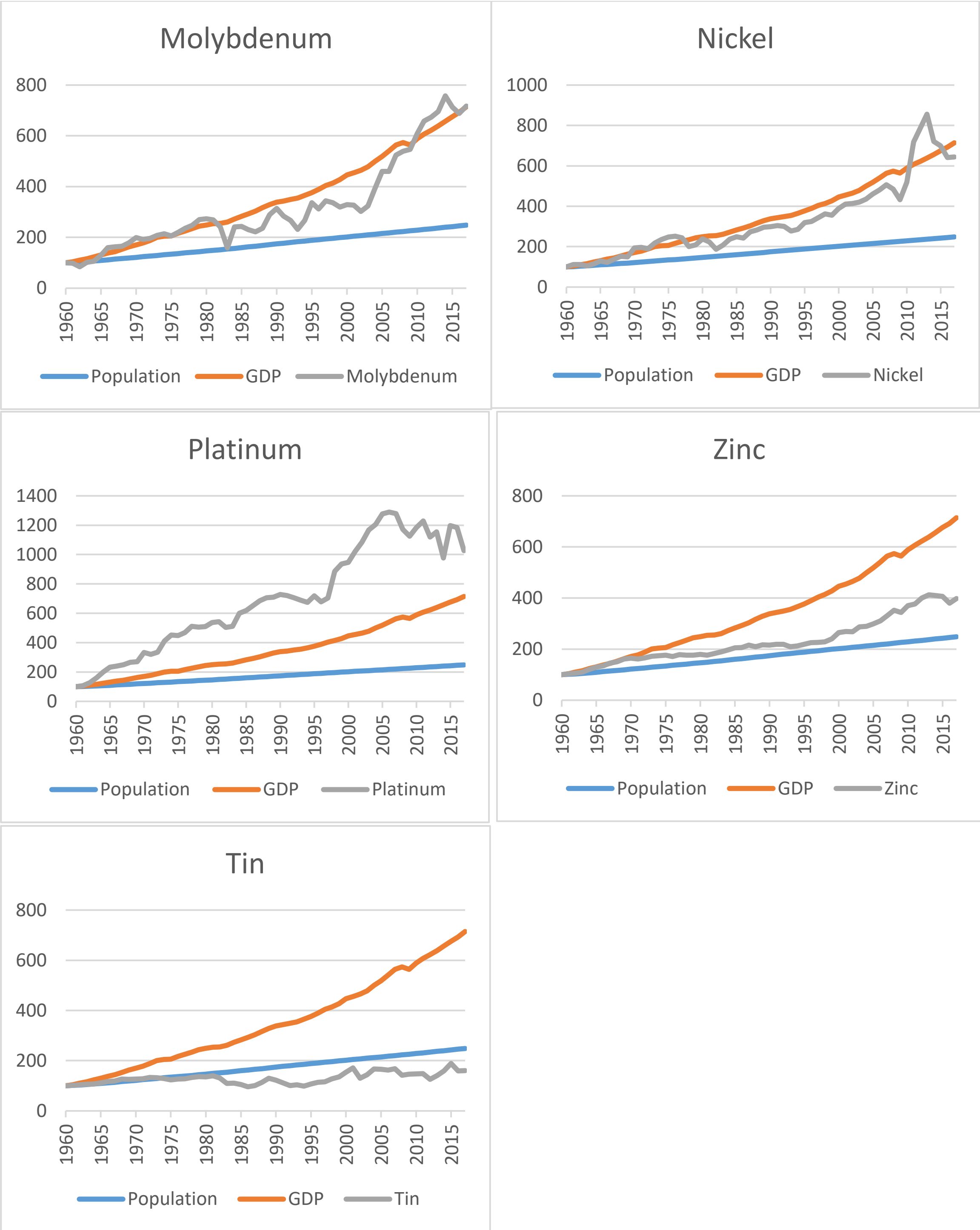

Figure 5: Production of eleven minerals, world population and world GDP. Index numbers, with 1960 at 100.

4. Conclusion

A falling CO_2 intensity as GDP per capita grows would contribute to reconciling economic growth and reduction in CO_2 emissions. But there is considerable evidence that this is primarily the case in rich countries and that the effect becomes smaller and smaller as countries get still richer. This will increase the burden on alternative technologies to deal with emissions. Furthermore, the need for alternative technologies will increase if the poor and medium rich countries of the world must go through a phase of increased energy use as they grow out of poverty. Hence, reconciling economic growth and reduction in CO_2 emissions would seem to depend critically on the development of energy sources other than fossil fuels. Economic growth by itself will not sweep this problem away.

The fall in CO_2 intensity as countries get richer may in fact exaggerate the effect of getting richer and developing a service economy. Parallel to this, rich countries are increasingly importing their energy intensive goods from poorer countries. The development in mineral extraction since 1960 shows few signs of dematerialization of world GDP. The production of nine out of eleven minerals important for industrial production has grown faster than world population, and five have grown faster than world GDP. Rather than decline, the growth of mineral production accelerated from the 1990s onwards, while in recent years growth has declined slightly. Mineral production is unlikely to become stabilized in the near future, provided that abatement of poverty in the world will continue. This is not going to make reductions in CO_2 emissions any easier.

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APPENDIX

Table A1

Countries in the sample, their GDP per capita (2010 US dollars in 2014), results for linear model ($y = a + bx$), a model with a squared ($y = a + bx + cx^2$) and a cubic term ($y = a + bx + cx^2 + dx^3$), where y is CO_2 intensity, x is GDP per capita, and with t-values in parentheses.

			$y = a + bx$		$y = a + bx + cx^2$			$y = a + bx + cx^2 + dx^3$			
	GDPcapita	Period	*b*	R^2	*b*	*c*	R^2	*b*	*c*	*d*	R^2
Luxembourg	107152.9	1960-2014	-.0000124*** (14.73)	0.8037	-.0000494*** (15.53)	2.72e-10*** (11.74)	0.9462				
Norway	89274.96	1960-2014	-1.25e-06*** (8.76)	0.5916	1.39e-06 (1.52)	-2.25e-11** (2.92)	0.6491	.0000245*** (7.59)	-4.61e-10*** (7.65)	2.54e-15*** (7.30)	0.8285
Bermuda	79251.78	1960-2013	-3.72e-07 (1.99)	0.0708							
Switzerland	76410.86	1980-2014	-2.30e-06*** (23.53)	0.9438	-3.59e-07 (0.17)	-1.48e-11 (0.94)	0.9453				
Macao	69749.16	1982-2014	-2.52e-06*** (14.12)	0.8655	-3.91e-06** (3.59)	1.63e-11 (1.29)	0.8725				
Qatar	67901.22	2000-2014	-.0000433*** (7.49)	0.8120	-.0001377 (0.61)	7.17e-10 (0.42)	0.8147				
Denmark	59437.93	1960-2014	-6.67e-06*** (18.28)	0.8632	2.38e-06 (0.85)	-1.07e-10** (3.26)	0.8864	.0000532** (3.61)	-1.40e-09*** (3.78)	1.04e-14** (3.50)	0.9084
Australia	54546.2	1960-2014	-4.67e-06*** (13.55)	0.7760	.0000101*** (5.67)	-2.00e-10*** (8.37)	0.9045	.0000347** (3.65)	-9.16e-10** (3.35)	6.59e-15* (2.63)	0.9159
Ireland	54052.95	1970-2014	-8.20e-06*** (24.31)	0.9322	-.0000179*** (8.23)	1.47e-10*** (4.50)	0.9543				
Sweden	53561.89	1960-2014	-9.81e-06*** (16.33)	0.8342	-.0000197*** (4.52)	1.34e-10* (2.30)	0.8495				
Singapore	52244.44	1960-2014	-.0000143*** (5.36)	0.3515	.000011 (1.07)	-5.00e-10* (2.54)	0.4231	.0001354*** (6.28)	-6.32e-09*** (6.64)	7.34e-14*** (6.19)	0.6707
United States	50871.67	1960-2014	-.0000184*** (32.85)	0.9532	-.0000299*** (7.10)	1.66e-10** (2.75)	0.9591				
Netherlands	50497.24	1960-2014	-7.11e-06*** (17.31)	0.8496	-5.47e-07 (0.19)	-9.36e-11* (2.32)	0.8637				
Canada	50221.84	1960-2014	-.0000107*** (20.73)	0.8902	-1.29e-06 (0.34)	-1.36e-10* (2.53)	0.9022				

Austria	47922.34	1960-2014	-5.65e-06*** (24.69)	0.9200	-7.72e-06*** (5.23)	3.29e-11 (1.42)	0.9230				
Japan	46484.16	1960-2014	-4.05e-06*** (10.73)	0.6848	3.99e-06 (1.87)	-1.39e-10*** (3.82)	0.7539	.0000428*** (7.37)	-1.71e-09*** (7.50)	1.89e-14*** (6.93)	0.8733
Greenland	46443.76	1970-2014	-.0000102*** (6.56)	0.5001	-.0000473*** (4.62)	5.80e-10** (3.66)	0.6208				
Finland	45239.37	1960-2014	-5.45e-06*** (6.99)	0.4797	.0000121** (2.86)	-2.85e-10*** (4.20)	0.6114	.0001114*** (7.20)	-3.84e-09*** (7.05)	3.90e-14*** (6.55)	0.7890
Germany	45022.57	1991-2014	-.0000113*** (19.34)	0.9445	-.0000556*** (5.19)	5.67e-10*** (4.14)	0.9694				
Iceland	44775.64	1996-2014	-7.71e-06*** (9.73)	0.8477	-.0000339** (2.41)	3.33e-10 (1.86)	0.8749				
Belgium	44676.66	1960-2014	-.0000175*** (29.52)	0.9427	-.0000359*** (10.99)	3.04e-10*** (5.68)	0.9646				
France	41374.76	1960-2014	-.0000129*** (28.69)	0.9395	-.0000141*** (4.28)	2.15e-11 (0.37)	0.9397				
United Kingdom	40908.75	1960-2014	-.0000208*** (25.05)	0.9221	-.0000644*** (22.75)	7.83e-10*** (15.51)	0.9862				
Andorra	40785.05	1990-2014	-3.95e-06*** (5.64)	0.5800	-.0000108 (0.97)	8.33e-11 (0.61)	0.5871				
United Arab Emirates	39146.11	1975-2014	-1.65e-06** (2.73)	0.1643	-6.92e-06 (1.78)	3.58e-11 (1.37)	0.2047				
Kuwait	36259.67	1995-2014	-9.40e-06*** (4.56)	0.5362	.0000645 (1.65)	-8.73e-10 (1.89)	0.6170	.0001131 (0.14)	-2.04e-09 (0.10)	9.29e-15 (0.06)	0.6171
New Zealand	36142.52	1970-2014	-2.96e-06** (3.50)	0.2218	.0000547*** (5.59)	-1.02e-09*** (5.90)	0.5744	-7.57e-06 (0.08)	1.25e-09 (0.37)	-2.71e-14 (0.68)	0.5792
Hong Kong	35717.68	1961-2014	-4.98e-06*** (13.04)	0.7657	-3.51e-08 (0.02)	-1.35e-10** (3.34)	0.8077				
Italy	33615.97	1960-2014	-3.27e-06*** (6.29)	0.4271	.0000133*** (4.20)	-3.28e-10*** (5.28)	0.6269	.0001052*** (11.25)	-4.28e-09*** (10.81)	5.29e-14*** (10.03)	0.8744
Brunei	33313.83	1974-2014	6.21e-06 (1.36)	0.0455							
Israel	32661.29	1960-2014	-3.11e-06*** (4.36)	0.2639	1.72e-06 (0.37)	-1.16e-10 (1.05)	0.2792	-.0000637** (3.26)	3.30e-09** (3.29)	-5.53e-14** (3.43)	0.4142
Spain	29496.38	1960-2014	-9.57e-07 (1.32)	0.0317							
Bahamas	27246.48	1960-2014	-.0000985*** (5.73)	0.3828	-.0002906 (1.46)	3.87e-09 (0.97)	0.3938				

S Korea	24323.57	1960-2014	-.0000154*** (10.18)	0.6618	-7.51e-06 (1.22)	-3.46e-10 (1.33)	0.6729				
Malta	23676.03	1970-2014	-.0000133*** (7.36)	0.5576	-.0000125 (1.26)	-3.16e-11 (0.09)	0.5577				
Slovenia	23224.4	1995-2014	-.000019*** (10.53)	0.8604	-.000073* (2.90)	1.34e-09* (2.15)	0.8902				
Greece	22565.68	1960-2014	7.43e-06*** (6.82)	0.4673							
Bahrain	22390.68	1980-2014	-.0000564*** (4.83)	0.4144	-.0010144** (3.45)	2.41e-08** (3.26)	0.5602				
Portugal	21533.49	1960-2014	3.05e-06*** (5.44)	0.3580							
Saudi Arabia	21183.46	1968-2014	-.0000196*** (6.25)	0.4650	.0000307 (0.93)	-9.33e-10 (1.54)	0.4922	.0005384** (3.75)	-2.16e-08** (3.76)	2.67e-13** (3.61)	0.6103
Czech Republic	20343.68	1992-2014	-.0000606*** (17.42)	0.9353	-.0001912** (3.41)	3.93e-09* (2.33)	0.9491				
Cyprus	20009.06	1975-2014	-.0000111*** (11.43)	0.7746	-.0000263*** (4.14)	4.91e-10* (2.41)	0.8052				
Slovak Republic	18003.54	1992-2014	-.0000619*** (16.85)	0.9311	-.0002066*** (8.81)	5.59e-09*** (6.19)	0.9764				
Estonia	17453.37	1995-2014	-.0000718*** (7.83)	0.7729	-.0003915*** (7.26)	1.26e-08*** (5.96)	0.9265				
Oman	17167.05	1965-2014	.0000358*** (5.69)	0.4026							
Trinidad and Tobago	16641.74	1960-2014	.0000679*** (3.80)	0.2140							
Equatorial Guinea	16028.25	1980-2014	-8.85e-07 (0.824)	0.0015							
Barbados	15901.9	1974-2014	.000023*** (7.45)	0.5875							
St. Kitts and Nevis	15029.62	1977-2014	9.97e-06*** (7.21)	0.5907							
Lithuania	14935.54	1995-2014	-.000046*** (8.64)	0.8058	-.0001993*** (6.63)	7.68e-09*** (5.14)	0.9239				
Chile	14681.33	1960-2014	-.0000171*** (7.35)	0.5044	-.0000515** (3.47)	2.00e-09* (2.34)	0.5518				
Hungary	14119.07	1991-2014	-.0000631*** (18.08)	0.9369	-.0001514* (2.34)	3.93e-09 (1.36)	0.9421				

Poland	14090.62	1990-2014	-.0001256*** (13.00)	0.8801	-.0004851*** (14.62)	1.86e-08*** (10.91)	0.9813				
Uruguay	13856.7	1960-2014	-.0000218*** (6.61)	0.4520	-.00011*** (5.40)	4.95e-09*** (4.37)	0.5994				
Latvia	13758.96	1995-2014	-.000041*** (7.66)	0.7653	-.000205*** (6.17)	8.59e-09*** (4.96)	0.9041				
Venezuela	13709.04	1960-2014	-.0000607*** (12.08)	0.7334	-.0001989* (2.53)	5.32e-09 (1.76)	0.7484				
Croatia	13651.99	1995-2014	-.00002*** (5.44)	0.6218	.0000528 (0.91)	-3.09e-09 (1.25)	0.6538	.0008233 (1.75)	-7.02e-08 (1.72)	1.92e-12 (1.65)	0.7043
Turkey	13312.46	1960-2014	.0000134*** (5.43)	0.3570							
Seychelles	12850.49	1963-2014	.0000613*** (7.39)	0.5217							
Antigua and Barbuda	12403.53	1977-2014	-.0000508*** (3.92)	0.2989	-.0002597** (3.68)	1.11e-08** (3.00)	0.4426				
Brazil	11870.15	1960-2014	1.41e-07 (0.18)	0.0006							
Russia	11865.03	1992-2014	-.0001394*** (13.55)	0.8973	-.0003123* (2.70)	9.97e-09 (1.50)	0.9077				
Kazakhstan	10646.03	1992-2014	-.0001602*** (4.35)	0.4743	-.0005437 (1.77)	2.77e-08 (1.25)	0.5126				
Malaysia	10398.23	1970-2014	.0000282*** (7.22)	0.5477							
Panama	10350.4	1960-2014	-.0000234*** (5.17)	0.2020	-.0000474* (2.09)	2.00e-09 (1.08)	0.3503				
Argentina	10323.21	1960-2014	-7.82e-06* (2.20)	0.0840	.000101** (3.14)	-6.71e-09** (3.40)	0.2506	.0006925* (2.37)	-8.25e-08* (2.22)	3.16e-12* (2.04)	0.3071
Palau	9692.272	2000-2014	-.0000805*** (4.85)	0.6444	-.0004123 (0.69)	1.69e-08 (0.55)	0.6533				
Mexico	9536.6	1960-2014	.0000125*** (3.79)	0.2135							
Gabon	9508.285	1960-2014	.0000433*** (5.44)	0.3581							
Romania	9227.437	1990-2014	-.0001598*** (9.22)	0.7872	-.0004402 (1.91)	2.09e-08 (1.22)	0.8008				
Caribbean small states	9169.713	1966-2014	.000038* (2.50)	0.1170							

Mauritius	9163.633	1976-2014	.0000236*** (6.70)	0.5484							
Costa Rica	9065.026	1960-2014	8.90e-06*** (3.80)	0.2141							
Suriname	8942.961	1975-2014	-.0000894*** (5.15)	0.4108	-.0003837 (1.44)	2.06e-08 (1.11)	0.4296				
St. Lucia	8147.524	1977-2014	.0000126** (3.17)	0.2183							
Maldives	8124.708	1995-2014	.0000445*** (5.60)	0.6354							
Grenada	7932.668	1977-2014	.0000297*** (8.13)	0.6476							
South Africa	7582.553	1960-2014	-.0000259 (0.85)	0.0133							
Botswana	7574.282	1972-2014	5.10e-06 (0.50)	0.0061							
Lebanon	7447.364	1988-2014	-.0000483** (3.35)	0.3100	-.0000759 (0.79)	2.19e-09 (0.77)	0.3124				
Bulgaria	7299.549	1980-2014	-.0004044*** (7.63)	0.6383	-.0017293* (2.73)	1.25e-07* (2.10)	0.6821				
Colombia	7291.692	1960-2014	-.0000615*** (20.07)	0.8838	-.0000944*** (5.24)	3.69e-09 (1.85)	0.8910				
Montenegro	7045.116	2005-2014	-.0000336 (0.71)	0.0589							
Dominica	6951.032	1977-2014	.0000289*** (9.56)	0.7175							
Libya	6697.103	1999-2014	-.0000908*** (11.47)	0.9038	-.0001665** (3.19)	4.32e-09 (1.47)	0.9175				
Belarus	6664.097	1992-2014	-.0003874*** (8.84)	0.7882	-.0014156*** (4.91)	1.18e-07** (3.59)	0.8712				
St. Vincent and the Grenadines	6467.158	1960-2014	.0000455*** (14.29)	0.7939							
Turkmenistan	6399.271	1992-2014	-.0004186*** (9.67)	0.8165	-.0006845* (2.27)	3.36e-08 (0.89)	0.8235				
Dominican Republic	6203.726	1960-2014	.0000202 (1.95)	0.0669							
Cuba	6182.774	1970-2014	-.0001385*** (9.34)	0.6700	-.0002693* (2.35)	1.56e-08 (1.15)	0.6801				

Iran	6161.104	1960-2014	-.0000387 (1.63)	0.0477							
Azerbaijan	6122.98	1992-2014	-.0005284*** (8.47)	0.7735	-.0015485** (3.47)	1.40e-07* (2.31)	0.8211				
China	6108.239	1960-2014	-.0006465*** (8.85)	0.5966	-.0019432*** (10.95)	2.50e-07*** (7.62)	0.8094				
Namibia	5901.243	1990-2014	.0000148 (0.335)	0.0405							
Peru	5825.198	1960-2014	3.13e-06 (0.59)	0.0066							
Serbia	5593.061	2006-2014	-.0005605** (3.93)	0.6879	-.0004153 (0.06)	-1.38e-08 (0.02)	0.6879				
Thailand	5591.106	1960-2014	.0000999*** (13.28)	0.7690							
Ecuador	5428.714	1960-2014	.0001344*** (9.04)	0.6067							
Iraq	5253.627	1968-2014	-.000293*** (10.51)	0.7105	-.0008558*** (5.86)	8.76e-08*** (3.91)	0.7851				
Bosnia and Herzegovina	4992.949	1994-2014	.0000665** (3.24)	0.3564							
Macedonia	4920.216	1992-2014	-.0005975*** (21.34)	0.9559	-.0003798 (0.69)	-2.78e-08 (0.40)	0.9563				
Jamaica	4714.861	1966-2014	.0000113 (0.27)	0.0016							
Algeria	4675.885	1960-2014	.0002051*** (6.19)	0.4197							
Albania	4413.562	1980-2014	-.0001537* (2.48)	0.1574	.0004372 (0.95)	-1.01e-07 (1.30)	0.1998	.0046676* (2.45)	-1.73e-06* (2.41)	1.94e-10* (2.28)	0.3149
Belize	4411.856	1960-2014	-.0001038*** (9.03)	0.6063	.000061 (0.81)	-2.95e-08* (2.20)	0.6398	.0005138 (1.60)	-2.11e-07 (1.68)	2.20e-11 (1.45)	0.6542
Tunisia	4271.327	1965-2014	-3.19e-06 (0.28)	0.0017							
Fiji	4084.2	1960-2014	-.0000159 (1.12)	0.0230							
Swaziland	3980.774	1970-2014	-.0001052*** (5.46)	0.4098	-.0006246*** (5.16)	1.02e-07*** (4.33)	0.5918				
Mongolia	3901.867	1981-2014	-.0000532 (0.37)	0.0043							

Georgia	3851.723	1992-2014	-.0001869 (1.98)	0.1578							
Armenia	3827.343	1992-2014	-.0001845*** (4.39)	0.4781	-.0008747** (3.16)	1.49e-07* (2.52)	0.6036				
Paraguay	3761.912	1960-2014	.0000304*** (5.45)	0.3593							
Angola	3746.66	1980-2014	.0000233 (1.17)	0.0402							
Indonesia	3692.943	1960-2014	.0000882*** (9.03)	0.6058							
Guyana	3595.925	1960-2014	-.0001406** (3.41)	0.1803	.0004233 (1.32)	-1.17e-07 (1.78)	0.2272	.0072403** (3.67)	-3.02e-06** (3.63)	3.94e-10** (3.50)	0.3766
Tonga	3581.837	1981-2014	.0000675*** (4.22)	0.3580							
Samoa	3524.596	1982-2014	-.0000188*** (4.01)	0.3414	-.0001796 (2.01)	2.75e-08 (1.80)	0.4058				
Sri Lanka	3506.871	1961-2014	-.0000411** (3.65)	0.2043	-.0002013*** (4.28)	4.37e-08** (3.49)	0.3578				
Cabo Verde	3369.643	1980-2014	.0000132 (0.97)	0.0278							
Jordan	3348.827	1975-2014	-6.72e-06 (0.13)	0.0004							
Marshall Islands	3333.361	1990-2014	.0001477* (2.46)	0.2084							
El Salvador	3272.74	1965-2014	.0000945* (2.65)	0.1275							
Tuvalu	3196.979	1990-2014	-.0000265 (0.79)	0.0262							
Morocco	3160.526	1966-2014	.0000594*** (5.29)	0.3728							
Pacific island small states	3116.11	1981-2014	-.0000742** (2.80)	0.1964	.0001736 (0.25)	-4.62e-08 (0.36)	0.1997	.009214 (0.69)	-3.40e-06 (0.69)	4.14e-10 (0.68)	0.2120
Guatemala	3007.9	1960-2014	.0000865*** (7.41)	0.5092							
Ukraine	2967.213	1992-2014	-.001246*** (6.20)	0.6467	-.0034351 (1.28)	4.43e-07 (0.82)	0.6580				
Congo, Rep.	2922.973	1960-2014	-.0000162 (0.70)	0.0092							

Vanuatu	2909.775	1979-2014	-.0000567 (1.81)	0.0882							
Micronesia	2716.323	1992-2014	.0001346 (1.38)	0.0831							
Egypt	2608.375	1960-2014	.0000182 (1.00)	0.0184							
Nigeria	2563.092	1960-2014	-5.34e-06 (0.1)	0.0002							
Timor-Leste	2547.159	2002-2014	-.0000294** (4.19)	0.6145	-.000018 (0.32)	-2.14e-09 (0.20)	0.6161				
West Bank and Gaza	2529.996	1997-2014	-.0000256 (0.37)	0.0090							
Philippines	2505.819	1960-2014	-2.22e-06 (0.07)	0.0001							
Bhutan	2500.26	1980-2014	.0000891* (2.33)	0.1410							
Papua New Guinea	2329.891	1960-2014	.0001971** (3.66)	0.2020							
Bolivia	2317.257	1960-2014	.0004785*** (4.84)	0.3062							
Honduras	2059.475	1960-2014	.000298*** (8.42)	0.5725							
Moldova	1986.941	1996-2014	-.0011563** (3.03)	0.3379	-.0040152 (1.00)	1.01e-06 (0.71)	0.3571				
Sudan	1837.138	1960-2014	-.0000578 (1.36)	0.0338							
Nicaragua	1812.995	1960-2014	-.0002158*** (6.78)	0.4642	-.0006532* (2.33)	1.25e-07 (1.57)	0.4885				
Uzbekistan	1744.491	1992-2014	-.0049982*** (21.27)	0.9556	-.012044*** (7.57)	2.99e-06*** (4.45)	0.9777				
Ghana	1659.797	1960-2014	-.0000489 (1.23)	0.0276							
India	1645.326	1960-2014	.0000117 (0.22)	0.0009							
Zambia	1620.823	1964-2014	.0004173*** (5.06)	0.3429							
Kiribati	1565.243	1970-2014	-.0000653*** (4.16)	0.2867	-.000298** (3.33)	4.22e-08* (2.64)	0.3880				

Vietnam	1565.02	1984- 2014	.0004117*** (6.82)	0.6159							
Solomon Islands	1475.528	1990- 2014	-.0001713*** (6.24)	0.6285	-2.37e-06 (0.00)	-6.23e-08 (0.35)	0.6306				
Laos	1470.5	1984- 2014	.0000906* (2.62)	0.1909							
Cameroon	1428.216	1960- 2014	.0002393*** (4.80)	0.3034							
Cote d'Ivoire	1384.91	1960- 2014	1.37e-06 (0.04)	0.0000							
Mauritania	1326.159	1960- 2014	.0000829 (0.24)	0.0011							
Lesotho	1323.238	1990- 2014	-.000699*** (23.13)	0.9588	-.0022598*** (18.77)	7.70e-07** (13.01)	0.9953				
Myanmar	1266.124	1960- 2014	-.0006129*** (10.53)	0.6764	-.0016077*** (6.28)	8.07e-07*** (3.97)	0.7516				
Sao Tome and Principe	1241.459	2001- 2014	.0000666 (1.02)	0.0793							
Pakistan	1111.196	1960- 2014	-.0000218 (0.34)	0.0021							
Yemen	1101.117	1990- 2014	.0004162** (2.99)	0.2800							
Kenya	1075.659	1960- 2014	-.0005825*** (9.95)	0.6512	-.0017443** (3.23)	7.69e-07* (2.17)	0.6800				
Senegal	1018.393	1960- 2014	-.0008218*** (3.75)	0.2097	.0084957 (1.63)	-4.98e-06 (1.78)	0.2553	-.0778848 (0.89)	.0000877 (0.93)	-3.30e-08 (0.99)	0.2693
Kyrgyzstan	1003.51	1992- 2014	-.0005907 (0.86)	0.0338							
Cambodia	972.9792	1993- 2014	.0000207 (0.41)	0.0082							
Chad	967.1028	1960- 2014	-.0000398 (1.91)	0.0644							
Zimbabwe	939.7803	1964- 2014	.0002865 (1.93)	0.0707							
Bangladesh	922.1611	1972- 2014	.0005531*** (10.61)	0.7332							
Tajikistan	892.64	1992- 2014	-.0007048 (1.77)	0.1292							

Benin	833.6409	1960-2014	.0022878*** (18.11)	0.8609							
Tanzania	782.6772	1988-2014	.0002226*** (4.55)	0.4529							
Comoros	779.8398	1980-2014	-.0006535*** (6.17)	0.5358	.0042805 (1.11)	-2.93e-06 (1.28)	0.5584	.2189843* (2.61)	-.0002595* (2.59)	1.02e-07* (2.57)	0.6357
Haiti	728.7803	1996-2014	-.0015115*** (5.81)	0.6652	.030579** (2.97)	-.0000222** (3.12)	0.7919	.2185652 (0.60)	-.0002844 (0.56)	1.22e-07 (0.52)	0.7599
Guinea	714.1633	1986-2014	.0001323 (1.51	0.0781							
Mali	705.7885	1967-2014	-.0000382 (1.97)	0.0774							
Nepal	675.7353	1960-2014	.000779*** (16.78)	0.8416							
Rwanda	672.6396	1960-2014	-.0000623 (0.54)	0.0056							
Uganda	642.8774	1982-2014	.0001271*** (4.34)	0.3780							
Burkina Faso	639.7096	1960-2014	.0003926*** (7.60)	0.5212							
Sierra Leone	562.8597	1960-2014	.0003473 (1.39)	0.0353							
Guinea-Bissau	545.8985	1970-2014	-.0000317 (0.24)	0.0014							
Togo	531.1561	1960-2014	-.000219 (0.55)	0.0058							
Gambia	530.3189	1966-2014	.0018157*** (10.95)	0.7183							
Eritrea	514.1796	1994-2011	.0006765 (1.22)	0.0856							
Mozambique	493.2533	1980-2014	-.0012262** (3.02)	0.2167	-.0071831** (2.78)	.00001* (2.33)	0.3306				
Malawi	484.3686	1964-2014	-.0007698*** (6.65)	0.4745	-.0010358 (0.89)	3.58e-07 (0.23)	0.4750				
Ethiopia	452.7782	1981-2014	-.0001569 (1.62)	0.0754							
Madagascar	408.661	1960-2014	-.0002075*** (3.87)	0.2204	-.0009911 (1.20)	6.96e-07 (0.95)	0.2338				

Congo, Dem. Rep.	397.582	1960-2014	.0000631*** (6.00)	0.4048							
Niger	386.7258	1960-2014	-.0005727*** (7.92)	0.5421	.0014242 (2.01)	-2.00e-06** (9.82)	0.6030	.0238315*** (5.26)	-.0000478*** (5.19)	3.01e-08*** (4.99)	0.7331
Liberia	376.5889	1960-2014	-.0001825** (3.21)	0.1628	-.0022406*** (10.36)	1.17e-06*** (9.64)	0.6997				
Central African Republic	302.5465	1960-2014	-.0002818*** (6.18)	0.4184	-.0011345* (2.21)	8.70e-07 (1.67)	0.4480				
Burundi	243.1019	1962-2014	.000259* (2.26)	0.0907							