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Beyond the Question "Is there Decoupling?" A Decoupling Ranking

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This study shows that neither decoupling CO2 emissions from production, consumption and GDP, nor reducing emission intensity is good per se. Instead of analyzing decoupling cases, it proposes two orderings: one that balances economy and carbon emissions and, if there is conflict, prioritizes GDP increase, and another that gives priority to the environment. Each country has its own "rank". The result is that even if the two orderings differ, there are no substantial differences between the decoupling ranking of countries based on production and consumption emissions, and between the ordering that gives priority to the economy over the environment.

JEL codes: Q54, Q56

Keywords: decoupling; CO2 emissions; decoupling indicators; consumption emissions; territorial emissions.

I. Introduction

Paris Agreement´s main objective is to keep the average increase of global temperature at least below 2 degree Celsius with respect to pre-industrial levels by the end of the century, in order to avoid massive damages due to climate change. Several research groups analyze the gap between the emissions levels needed to honor that goal and the Parties´ climate policies. They conclude that the attainment of the 2 degrees goal requires emissions´ reductions of 40% to 70% by 2050, with respect to 2010 (IPCC, 2014). Estimations state that, with current policies, the world average temperature would increase not by 2 but by 3.6 degrees, and if national contributions proposed to the Paris Accord are fulfilled, the temperature would change in 2.8 degrees CAT, 2016). Hence, more effort has to be done if the international community wants to avoid climate change impacts.

However, there are all kinds of difficulties in being able to agree on stricter emissions´ reduction goals, one of which is that countries argue they prioritize economic growth to the environment in their agendas. There is in fact a literature that deals with the link between growth and nature with three distinct views on this relationship (Jakob and Edenhofer, 2014). One supports degrowth as a way to solve environmental pressure on the Planet (Georgescu-Roegen 1971 and Daly 1973, and the review in Weiss y Cattaneo 2017). A second one states that green growth is possible (OECD 2009; UNEP 2011): it is feasible to reduce "environmental bads" and increase "economic goods". A third one favors a-growth. The latter is represented by "growth agnostics": what is valuable is not economic growth, but rather social progress (van den Bergh 2011; van den Bergh y Antal, 2014). The problem in this latter case is that, as stated by Fleurbaey y Blanchet (2013), the difficulty in measuring welfare is that there is no agreement on how it can be assessed.

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In parallel to these lines of thought, there are studies dealing with indicators used to measure how GDP and carbon emissions decouple. To date, three of them are the most employed. One is the decoupling factor introduced in OECD (2002), defined by the rate of growth of emissions´ intensity (emissions/GDP). It states that there is decoupling if emissions´ intensity decreases. It has clear limitations. Decoupling is only associated to a reduction in emissions' intensity, but that scenario can coexist with emissions increasing while the economy is expanding and with emissions decreasing but economic activity falling. The second indicator was introduced by Tapio (2005) and is defined as an emissions-to-economic activity elasticity (rate of emissions´ change/rate of GDP change). Depending on the value of this elasticity, there are several types of decoupling scenarios, whose description is the main contribution of Tapio (2005). A third measure of decoupling was introduced by Lu et al (2011) and its formula includes, in addition to GDP growth, the emissions´ intensity decreasing rate. Those three indices can be compared and, in fact, as shown in Conte Grand (2016), Lu et al (2011) and Tapio (2005) indicators are one a linear transformation of the other. Hence, there is no loss of generality by using one or the other.

Decoupling indicators have been used in several studies to analyze the link between energy, environment and economy. For example, Lu et al (2007) calculate decoupling in Germany, Taiwan, South Korea and Japan on a yearly base between 1990 and 2003 using the OECD indicator. They find coupling between environmental pressure (transportation CO2 emissions and energy demand) and GDP except for several years in the first two countries. Freitas and Kaneko (2011), using the same indicator, examine the case of Brazil from 1980 to 2009 and uncover substantial separation between economic activity and CO2 emissions from energy consumption. Conrad and Cassar (2014) calculate the OECD indicator for several endpoints in the small island of Malta and uncover relative decoupling for greenhouse gases from 1995 to 2011. Gupta (2015) uses that same index to study decoupling for several environmental (not only carbon emissions) endpoints in OECD countries.

Ren and Hu (2012) find different degrees of decoupling for the Chinese nonferrous metals industry in the period 1996-2008 using the Tapio (2005) decoupling index. Zhang and Wang (2013) employ it for decoupling between CO2 emissions of the whole industry and primary, secondary and tertiary industries in a province of China (Jiangsu) from 1995 to 2009. A similar analysis is done by Wang and Yang (2015) for carbon emissions in the Beijing-Tianjin-Hebi economic band. Wang et al (2013) using all three decoupling indicators mentioned for materials use, energy use and SO2 in China, Russia, Japan and the United States during the 2000-2007 period, conclude that decoupling was stronger in the two OECD nations than in the two BRIC countries because of their different development stages. There are more analysis of this type for different sectors, cities, regions, nations and groups of countries.

In a less academic vein, several think tank and international agencies evaluate if there is decoupling at the world and at the country level. They assess decoupling without using indicators but by simply looking at the rate of growth of carbon emissions and the rate of growth of GDP. The International Energy Agency, for example, concludes that carbon dioxide global emissions generated by the energy sector have decoupled from the world GDP since those emissions stayed basically stable in the last three years while GDP increased at a 3% rate approximately (IEA, 2016). Think tanks as World Resources Institute (WRI, 2016) and Carbon Brief (2016) have compared CO2 emissions and GDP of several countries and conclude that there was green growth (the equivalent of strong decoupling: GDP increases while carbon emissions decrease) for several of them between 2000 and 2013. More precisely, WRI uses CO2 territorial emissions from the BP Statistical Review of World Energy and GDP (dollars of 2009) from the World Development Indicators for 67 countries. They find that 31% (= 21/67) of the countries in their dataset decreased their emissions between 2000 and 2013 and expanded economically during those years. For the same period, Carbon Brief broadened the sample by using production generated CO2 data from CDIAC (Carbon Dioxide Information Analysis Center) and GDP in each countries´ local currency for 181 nations and consumption CO2 emissions for the same source, which was available for 118 countries. They find that 19% (=35/181) nations increase GDP while they decrease territorial emissions, and 18% (=21/118) attain green growth when considering consumption emissions.

The question is if green growth is happening and where, but also if a ranking of such decoupling results can be established. The literature on growth and environment centers on the likelihood of a desirable link between economy and the environment, the studies on decoupling indicators stress the types of decoupling they encounter, while the non-academic assessments on decoupling mainly signal those countries that are capable to increase their GDP while decreasing their carbon emissions but do not use indicators. The main innovation of this work is to construct two decoupling rankings for countries in the world using a well-known decoupling indicator. Instead of discussing which country fits within each type of decoupling pattern, I construct two rankings. Both balance the economy and the environment, but when there is conflict among those two goals, one of them (Ordering I) gives priority to economic growth while the other (Ordering II) prioritizes the environment. We illustrate this decoupling ordering with the same figures used by Carbon Brief for 2000/2013. Such calculations quantify the extent of decoupling by each country.

This article is organized as follows. In the second section, we review conceptually (and mathematically) the different values the three decoupling indicators can take and the resulting decoupling cases. Then, in the third section, we discuss how would be the decoupling ranking that balance economy and nature and prioritize one goal over the other in the conflicting cases. The last section concludes.

II. Decoupling Indicators

The "word" definition for decoupling is "separate" one variable from another. But, along time, several quantitative indicators were used to describe such phenomenon. The first decoupling indicator introduced in the literature was the one by OECD (2002, p.19):

$$D_o = 1 - \frac{\frac{E_n}{GDP_n}}{\frac{E_o}{GDP_o}} \qquad (1)$$

Where *E* is emissions, *GDP* is gross domestic product, and the subindices ($_o$ and $_n$) indicate the beginning and the end of the period respectively.

It is straightforward to write D_o as:

$$D_o = -t. \qquad (2)$$

Where t is the growth rate of emissions´ intensity:

$$t = \frac{\frac{E_n}{GDP_n} - \frac{E_O}{GDP_O}}{\frac{E_O}{GDP_O}} = \frac{\frac{E_n}{GDP_n}}{\frac{E_O}{GDP_O}} - 1 \qquad (3)$$

Then, according to this first indicator, when $D_0 > 0$, there is decoupling because emissions´ intensity decreases ($D_0 > 0, t < 0$). On the other side, when $D_0 \leq 0$, there is no decoupling ($t \geq 0$). Hence, for this indicator, decoupling is synonymous of decreasing emissions´ intensity.

Tapio (2005) introduces a decoupling index that refers to the changes in emissions to changes in the economic activity. More precisely:

$$D_\varepsilon = \frac{e}{g} \qquad (4)$$

Where *e* is emissions´ growth, described as:

$$e = \frac{E_n - E_O}{E_O} = \frac{E_n}{E_O} - 1 \qquad (5)$$

And *g* is the rate of growth of economic activity (usually proxied by the Gross Domestic Product, GDP), characterized as:

$$g = \frac{GDP_n - GDP_O}{GDP_O} = \frac{GDP_n}{GDP_O} - 1 \qquad (6)$$

According to Tapio (2005, p.139), there are eight "logical possibilities" (or concepts) depending on the values of D_ε (and *e* and *g*). Coupling refers to the situation where D_ε is close to 1 (that is equivalent to saying $e \cong g$). When D_ε departs from 1, there is decoupling. If $D_\varepsilon < 0$ strong decoupling occurs (this means that *e* and *g* have opposite signs), if $0 < D_\varepsilon < 1$ decoupling is weak (this implies that *e* and *g* have the same sign), and if $D_\varepsilon > 1$, it is just decoupling (and, again *e* and *g* have the same sign since $D_\varepsilon > 0$). In the latter case, when both emissions and economy change in the same direction, if they increase this is called "expansive", and when both variables decrease, it is "recessive". Hence, the denomination "expansive" or "recessive" does not come from the value of D_ε > 1, but from the sign of *g* in such case. The term "negative" is used in all cases that emissions´ intensity increases.

The third indicator was introduced by Lu et al (2011) and employed by Wang et al (2013). The original article is in Chinese, but Wang et al (2013, p. 620) defines this indicator as:

$$D_t = \frac{t'}{t_c} \qquad (7)$$

Where t' is the decreasing rate of change of emissions' intensity (this means that $\frac{E_n}{GDP_n} = \frac{E_O}{GDP_O} \cdot (1 - t')$ and so t'= - *t*), t_c is the "critical" condition on emissions´ intensity growth (the one that allows emissions to remain constant when GDP grows) and is:

$$t_c = \frac{g}{1+g} \qquad (8)$$

If $t' = t_c$ emissions remains constant, if $t' > t_c$ emissions decrease, and if $t' < t_c$, emissions increase.[1]

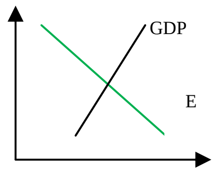
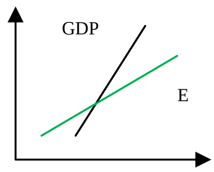
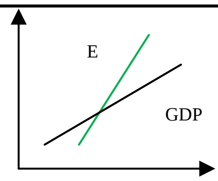
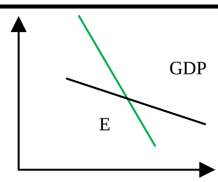
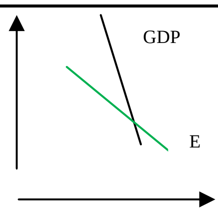
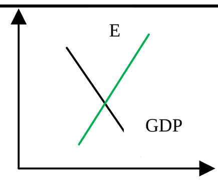
When *g > 0*, if $D_t > 1$ ($\rightarrow t' > t_c$), there is absolute decoupling because economic activity increases while emissions decrease. Similarly, when $D_t = 1$ ($\rightarrow t' = t_c$), emissions remain constant when GDP increase and this is considered an absolute decoupling between

[1] Note that this has to do with the fact that emissions´ change (e) is $e = g + t + g \cdot t$.

them. Relative decoupling occurs when $0 < \mathrm{D_t} < 1$ because this implies that $t' > 0$, emissions will increase but less than GDP. Finally, there is no decoupling when emission intensity remains constant ($t' = 0 \rightarrow \mathrm{D_t} = 0$: *e = g*) or $\mathrm{D_t} < 0$ ($\rightarrow\ t' < 0$: emissions' intensity increases because emissions increase more than what GDP increases).

To summarize, there are three indicators, with their own values to designate different kinds of possible coupling/decoupling between emissions and GDP and six relevant cases if we discard the very unlikely cases that emissions, GDP and/or emissions´ intensity rates of change are zero. Table 1 describes those 6 scenarios.

Table 1. Relevant coupling/decoupling cases

e	G	t	$D_o = -t$	$D_\varepsilon = \frac{e}{g} = \frac{g+t+g\cdot t}{g}$	$D_t = -\frac{t}{g/1+g}$	**Emissions and GDP along time**
< 0	> 0	< 0	$D_o > 0$ Decoupling	$D_\varepsilon < 0$ Strong decoupling	$D_t > 1$ Absolute decoupling	
> 0	> 0	< 0	$D_o > 0$ Decoupling	$0 < D_\varepsilon < 1$ Weak decoupling	$0 < D_t < 1$ Relative decoupling	
> 0	> 0	> 0	$D_o < 0$ Non Decoupling	$D_\varepsilon > 1$ Expansive negative decoupling	$D_t < 0$ Non decoupling	
< 0	< 0	< 0	$D_o > 0$ Decoupling	$D_\varepsilon > 1$ Recessive decoupling	$D_t < 0$ Non decoupling	
< 0	< 0	> 0	$D_o < 0$ Non Decoupling	$0 < D_\varepsilon < 1$ Weak negative decoupling	$0 < D_t < 1$ Relative decoupling	
> 0	< 0	> 0	$D_o < 0$ Non Decoupling	$D_\varepsilon < 0$ Strong negative decoupling	$D_t > 1$ Absolute decoupling	

Source: Own elaboration based on OECD (2002, p.19-20) for D_o, Tapio (2005, p.139) for D_ε, and Wang et al (2013, p. 620) for D_t.

As shown in Conte Grand (2016), there is a direct linear relationship between Tapio (2005) and Lu et al (2011) indicators: $D_t = 1 - D_\varepsilon$. However, D_ε categorizes recessive as a decoupling case, whereas they are non decoupling ones according to D_t. We are closer to the position of Tapio (2005) since, for declining economies, the most desirable state is *green degrowth* ("recessive decoupling"). In such a situation, GDP, emissions and emissions´ intensity decrease. Both issues, and the fact that OECD (2002) does only differentiate among decoupling and coupling without characterizing situations within those categories, should convince the reader that it is general enough to use Tapio (2005) D_ε for a decoupling ranking.

III. Decoupling ordering

III.1. Ranking among values for each indicator

Neither emissions´ intensity decrease nor decoupling (separation between emissions and GDP) are good per se if there are assessed together with the objective of reducing greenhouse gases. It can happen that emissions separate from product while emissions increase ($e > 0$ in Rows 2, 3, and 6 of Table 1). And, it can perfectly occur that emissions´ intensity diminishes at the same time that emissions augment (Row 2 of Table 1, with $t < 0$ and $e > 0$). This implies that not all cases of decoupling as measured by indicators are equally desirable.

In Fact, Table 1 is organized on purpose according a ranking that attempts to balance economy and nature, but if there is conflict, puts in the first place economic growth and in the second place the environment. That is why the order is:

1. Strong decoupling (GDP increases and emissions decrease)
2. Weak decoupling (GDP increases and emissions increase less that GDP)
3. Expansive negative decoupling (GDP increases and emissions increase more than GDP)
4. Recessive decoupling (GDP decreases and emissions decrease more than GDP)
5. Weak negative decoupling (GDP decreases and emissions decrease less than GDP)
6. Strong negative decoupling (GDP decreases and emissions increase).

Hence, with actual data, after considering the rate of growth of emissions and of GDP (in constant terms), the ordering can be attained in two steps:[2]

i) Separate countries that grow (g>0) of those that degrowth (g<0);
ii) For the first category, order from the smallest (< 0) to the highest D_ε (> 1) and, for the second category, order from the highest (> 1) to the smallest D_ε (< 0).

For the case of growing economies, the order just described (called *Ordering I*, from now on) is considered when analyzing data and explicitly stated in several publications (see OECD 2002), and the order for economies in recession is made explicit in Conte Grand (2016).

On the other side, when there is conflict among the goals of economic growth and environmental protection, the latter is given priority, the corresponding ranking (called here *Ordering II*) would be:

1. Strong decoupling (emissions decrease and GDP increases)
2. Recessive decoupling (emissions decrease more than GDP, which decreases)
3. Weak negative decoupling (emissions decrease less than GDP, which decreases)
4. Weak decoupling (emissions increase less that GDP, that increases)
5. Expansive negative decoupling (emissions increase more than GDP, that increases)
6. Strong negative decoupling (emissions increase, and GDP decreases)

[2] Note that it is not enough to use the value of the decoupling indicator. It has to be combined with the rate of growth of GDP (g).

III. 2. Decoupling ranking for countries

Carbon Brief concludes that slightly less that 20% of the countries decouple strongly their CO_2 emissions from their GDP between the years 2000 and 2013. Hence, green growth would be restricted to these countries. When calculating decoupling indicators, a different story can be told. First, as Table 2 shows, there are other almost 50% nations that decouple weakly: they grow and their emissions increase less than their GDP. And, only 30% of countries behave without taking much care for the environment.[3] This latter group of countries grows and, in doing so, increases emissions and emissions´ intensity (because emissions increase more than GDP).

Table 2. Decoupling cases using the same data as Carbon Brief

Decoupling cases	Emissions by Production (2000-2013)		Emissions by Consumption (2000-2013)	
Strong e < 0, t < 0	37	21%	21	18%
Weak e > 0, t < 0	83	46%	58	49%
Expansive negative e > 0, t > 0	54	30%	36	31%
Recessive e < 0, t < 0	2	1%	2	2%
Weak negative e < 0, t > 0	2	1%	0	0%
Strong negative e > 0, t > 0	2	1%	1	1%
No. De países	180		118	

Source: Own elaboration based on same data as Carbon Brief (2016).
Note: Japan is not included due to the suspicion of a data problem. The data has a "0" for changes of CO_2 emissions over the period, but that does not match actual registers. Hence, there are 180 countries instead of 181.

It is also clear that few nations saw their economy contract between 2000 and 2013. When analyzing the different decoupling degrees for countries that grow, considering the region where they belong as well as their income level, it becomes clear that decoupling behaviors differ on those two grounds. As can be seen on Table 3, on one side, nations with high income levels have been able to strongly decouple carbon territorial emissions from production (69% of high income nations belonging to OECD), but this was not the case of low income nations (58% of them have increase greenhouse gases emissions more that GDP). These proportions are of the same order of magnitude for consumption emissions. On the other side, Europe and Central Asia seems to be the region with a best decoupling behavior (54% decouple strongly) whereas East Asia and Pacific and Sub-Saharan Africa are the places where decoupling is worse (more than 50% of countries in those areas augment their emissions more than their GDP when comparing the beginning to the end of the period).

[3] Table in Appendix A reports each country and its decoupling case considering territorial and consumption emissions respectively.

Table 3. Decoupling cases by region and income level

	Decoupling cases						Number of countries
	Strong		Weak		Expansive negative		
Production emissions							
East Asia & Pacific	2	8%	11	42%	13	50%	26
Europe & Central Asia	26	54%	20	42%	2	4%	48
Latin America & Caribbean	3	10%	20	67%	7	23%	30
Middle East & North Africa		0%	10	56%	8	44%	18
North America	3	100%					3
South Asia		0%	6	75%	2	25%	8
Sub-Saharan Africa	3	7%	16	39%	22	54%	41
Low income	2	8%	9	35%	15	58%	26
Lower middle income	3	7%	26	59%	15	34%	44
Upper middle income	6	13%	27	57%	14	30%	47
High income: nonOECD	6	21%	12	43%	10	36%	28
High income: OECD	20	69%	9	31%		0%	29
Consumption Emissions							
East Asia & Pacific	2	13%	6	38%	8	50%	16
Europe & Central Asia	18	49%	16	43%	3	8%	37
Latin America & Caribbean			14	70%	6	30%	20
Middle East & North Africa			9	69%	4	31%	13
North America	1	50%	1	50%			2
South Asia			3	60%	2	40%	5
Sub-Saharan Africa			9	41%	13	59%	22
Low income			3	23%	10	77%	13
Lower middle income			17	65%	9	35%	26
Upper middle income	2	7%	17	61%	9	32%	28
High income: nonOECD	2	11%	11	58%	6	32%	19
High income: OECD	17	59%	10	34%	2	7%	29

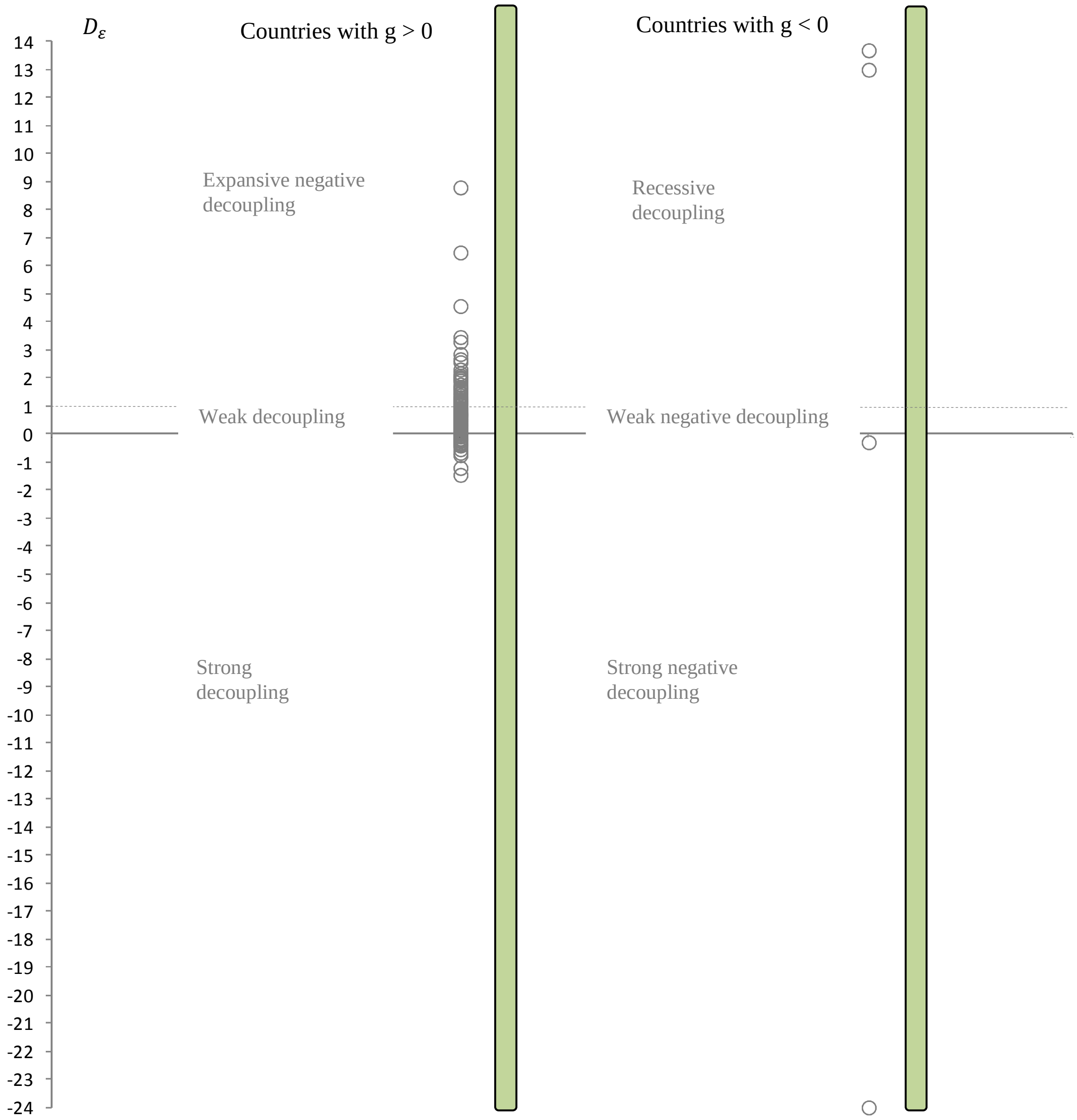
Source: Own elaboration.

Second, in addition to describing the decoupling cases, it is possible to differentiate the extent of decoupling within each situation. Figure 1 depicts the decoupling ranking for consumption emissions.[4] Each marker indicates if the country belongs or not to the category of those that had economies in expansion between the years 2000 and 2013 and the value of its decoupling indicator (D_{ε}). It is another way to show the result in Table 2: about half of the countries are located under the case of weak decoupling.

Table 4 shows each country with its corresponding indicator for consumption emissions, decoupling case and hierarchy in ordering I and II. As it is clear in this Table, among countries in the top of the decoupling ranking are several of the founders of the European Union. For example, The Netherlands in number 3 in both ranking, Germany is ranked 4, and France appears in the 6th place. On the other side, among nations that have the worse conduct in terms of decoupling their greenhouse gases emissions from their GDP, are many of major oil producers. For example, Venezuela and United Arab Emirates are ranked over 100 in 117 nations, Kuwait and Norway appear around to the 100th place.

[4] Figure 1 is similar for production emissions, but it is not reproduced here because its aspect is be very similar, given the results in Table 2. The correlation coefficient for the ranking between territorial and consumption emissions is 0.81. The same occurs with Table 4.

Figure 1. Decoupling ranking based on territorial emissions 2000-2013



Source: Own elaboration.

Table 4. Decoupling Consumption Emissions Ranking

	De	Case	Ord I	Ord II		De	Case	Ord I	Ord II		De	Case	Ord I	Ord II
Albania	0,51	WD	48	50	Ghana	0,71	WD	62	64	Oman	3,30	END	110	112
Argentina	0,69	WD	60	62	Greece	13,69	RD	115	21	Pakistan	0,68	WD	59	61
Armenia	0,28	WD	34	36	Guatemala	0,53	WD	49	51	Panama	1,64	END	95	97
Australia	0,69	WD	61	63	Guinea	2,86	END	109	111	Paraguay	1,11	END	82	84
Austria	-0,03	SD	20	20	Honduras	0,59	WD	54	56	Peru	0,85	WD	73	75
Azerbaijan	0,14	WD	27	29	Hong Kong	0,08	WD	25	27	Philippines	0,36	WD	40	42
Bahrain	0,29	WD	35	37	Hungary	-0,40	SD	8	8	Poland	0,05	WD	23	25
Bangladesh	1,30	END	89	91	India	0,59	WD	53	55	Portugal	-24,00	SD	1	1
Belarus	0,02	WD	21	22	Indonesia	1,60	END	94	96	Qatar	0,71	WD	63	65
Belgium	-0,17	SD	16	16	Iran	0,93	WD	77	79	Romania	-0,15	SD	17	17
Benin	3,47	END	111	113	Ireland	-0,40	SD	7	7	Russia	0,48	WD	46	48
Bolivia	0,74	WD	68	70	Israel	0,49	WD	47	49	Rwanda	0,21	WD	31	33
Botswana	1,05	END	80	82	Italy	13,00	RD	116	23	Saudi Arabia	1,50	END	93	95
Brazil	1,04	END	79	81	Jamaica	1,09	END	81	83	Senegal	1,39	END	91	93
Brunei Darussalam	8,80	END	114	116	Jordan	0,87	WD	75	77	Singapore	-0,03	SD	19	19
Bulgaria	-0,24	SD	13	13	Kazakhstan	0,35	WD	37	39	Slovak Republic	0,09	WD	26	28
Burkina Faso	1,12	END	83	85	Kenya	1,66	END	96	98	Slovenia	0,18	WD	30	32
Cambodia	1,98	END	101	103	Kuwait	1,92	END	99	101	South Africa	0,43	WD	43	45
Cameroon	1,92	END	100	102	Kyrgyz Republic	2,09	END	104	106	South Korea	0,42	WD	42	44
Canada	0,18	WD	29	31	Lao PDR	1,32	END	90	92	Spain	-0,66	SD	5	5
Chile	0,76	WD	70	72	Latvia	0,03	WD	22	24	Sri Lanka	0,76	WD	69	71
China	0,65	WD	56	58	Lithuania	0,26	WD	33	35	Sweden	-0,31	SD	12	12
Colombia	0,64	WD	55	57	Luxembourg	4,57	END	112	114	Switzerland	0,59	WD	51	53
Costa Rica	0,48	WD	45	47	Madagascar	2,04	END	103	105	Tanzania	1,69	END	97	99
Cote d'Ivoire	2,68	END	108	110	Malawi	0,90	WD	76	78	Thailand	1,15	END	84	86
Croatia	0,15	WD	28	30	Malaysia	1,25	END	88	90	Togo	6,48	END	113	115
Cyprus	-0,39	SD	9	9	Malta	0,85	WD	72	74	Trinidad and Tobago	0,68	WD	58	60
Czech Republic	-0,18	SD	15	15	Mauritius	0,36	WD	39	41	Tunisia	0,23	WD	32	34
Denmark	-1,45	SD	2	2	Mexico	0,81	WD	71	73	Turkey	0,73	WD	67	69
Dominican Republic	0,06	WD	24	26	Mongolia	1,24	END	87	89	Uganda	1,23	END	86	88
Ecuador	1,46	END	92	94	Morocco	0,73	WD	65	67	UK	-0,33	SD	11	11
Egypt	0,86	WD	74	76	Mozambique	1,16	END	85	87	Ukraine	0,32	WD	36	38
El Salvador	0,35	WD	38	40	Namibia	0,73	WD	66	68	United Arab Emirates	2,03	END	102	104
Estonia	-0,08	SD	18	18	Nepal	2,57	END	107	109	Uruguay	0,95	WD	78	80
Ethiopia	0,46	WD	44	46	Netherlands	-1,20	SD	3	3	US	-0,21	SD	14	14
Finland	-0,34	SD	10	10	New Zealand	0,37	WD	41	43	Venezuela	2,18	END	105	107
France	-0,53	SD	6	6	Nicaragua	0,54	WD	50	52	Vietnam	2,31	END	106	108
Georgia	0,71	WD	64	66	Nigeria	0,59	WD	52	54	Zambia	0,66	WD	57	59
Germany	-0,74	SD	4	4	Norway	1,77	END	98	100	Zimbabwe	-0,28	SND	117	117

Source: Own elaboration.

Note: SD, WD, END, RD, WND, SND refer to strong, weak, expansive negative, recessive, weak negative, and strong negative decoupling respectively. Ord I priority is given to economic growth and Ord II priority is given to the environment.

Finally, as can also be seen in Table 4, that there are no many differences in orderings I and II. In fact, the rank of each country is exactly the same for those cases where there is no conflict: strong and strong negative decoupling are the best and worst cases irrespectively of which dimension is considered. For the former, emissions decrease and GDP increases, while for the latter emissions increase and GDP decreases. For those cases, where goals go in opposite direction, ranking differs. However, they do not differ substantially because there are few decreasing economies. As a result, the correlation coefficient among the two rankings is 0.92 when decoupling is analyzed with territorial emissions and 0.93 when emissions derived from consumption are the reference.

IV. Conclusions

As shown clearly in this article, decoupling greenhouse gases from economic evolution is not good per se. It can perfectly happen that emissions and GDP trends separate from each other and emissions increase and/or GDP decreases. Neither augmentations in emissions nor GDP contraction can be an objective to pursue. Similarly, declines of emissions´ intensity are not good per se because they can be compatible with increasing emissions and/or GDP contraction.

There is an idealization of decoupling as a goal that has to be corrected. "Decoupling" as an aim has to be qualified. There is a "ranking" for decoupling. That ordering can be constructed trying to balance green and growth. Such ranking was constructed here using the decoupling indicator by Tapio (2005). Around 20% of countries in the world are strongly decoupling CO_2 from their economic activity. This means that in the last several years GDP increased and emissions decreased. This is the ideal decoupling state. But, there are around 50% more nations that have weakly decoupled (have increased emissions less than economic activity) and around 30% are in a worse situation. This article shows that each nation can be objectively ranked by its decoupling behavior and the order can be assigned based on its corresponding value of the decoupling indicator. As a result of that ordering, t becomes clear that high income countries tend to have high ranks of decoupling while low income ones usually are on the bottom of the list. In terms of geography, Europe and Central Asia nations are among those that are ranked better and East Asia and Pacific as well as Sub-Saharan Africa are in the last places. Among the latter there are many major oil producer countries.

There are no substantial differences in that ordering if decoupling cases are analyzed giving priority to either economic growth or to the environment when those two objectives enter in conflict.

The way the relationship between the magnitude of emissions´ and GDP activity changes evolved differently for each of the country in the world. This link clearly depends on what and how each of them produces (and consumes). For example, those that grow more their service sector tend to be able to decrease their greenhouse gases to a greater extent that those that are major oil producers. But, the profile of each economy is determined by many factors that include endowments as well as technology innovation and changes in consumers´ attitude toward the environment. In all those variables, public policies have a great role to play. Desirable decoupling (strong one) is not automatically attained, it has to be driven by both market and government policy forces. As clearly stated by Stavins (2016), "there has been no elimination of the relationship (between carbon emissions and GDP), although the nature and the magnitude of that relationship has changed".

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Appendix A. Countries by decoupling case

Cases decoupling	Consumption emissions						
Production emissions	**Strong**	**Weak**	**Expansive negative**	**Recessive**	**Weak negative**	**Strong negative**	**N.A.**
Strong	Austria Belgium Bulgaria Czech Republic Denmark Finland France Germany Hungary Ireland Netherlands Portugal Romania Singapore Spain Sweden UK US	Canada Croatia Lithuania Poland Slovak Republic Switzerland Ukraine	Cote d'Ivoire Jamaica				Andorra Belize Bermuda Burundi Eritrea Iceland Macao Macedonia Suriname Uzbekistan
Weak	Cyprus Estonia	Albania Argentina Armenia Australia Azerbaijan Bahrain Belarus Bolivia Chile China Colombia Costa Rica Dominican Republic Egypt El Salvador Ethiopia Georgia Ghana Guatemala Honduras Hong Kong India Israel Jordan Kazakhstan Latvia Malawi Malta Mexico Namibia New Zealand Nicaragua Nigeria Pakistan Peru Philippines Qatar Russia Rwanda Slovenia South Africa South Korea Sri Lanka Tunisia Turkey Uruguay Zambia	Botswana Brazil Burkina Faso Cambodia Kenya Kyrgyz Republic Lao PDR Luxembourg Mongolia Mozambique Nepal Norway Panama Paraguay United Arab Emirates Venezuela				Bhutan Cuba Djibouti Dominica Guyana Lebanon Maldives Mali Moldova Montenegro Myanmar Serbia Seychelles Sierra Leone Solomon Islands Swaziland Tajikistan Turkmenistan
Expansive negative		Iran Mauritius Morocco Trinidad and Tobago	Bangladesh Benin Brunei Darussalam Cameroon Ecuador Guinea Indonesia Kuwait Madagascar Malaysia Oman Saudi Arabia Senegal Tanzania Thailand Togo Uganda Vietnam				Afghanistan Algeria Antigua and Barbuda Bahamas Barbados Bosnia and Herzegovina Chad Comoros Congo, Rep. Democratic Republic of Congo Equatorial Guinea Fiji Gabon Gambia, The Greenland Grenada Guinea-Bissau Haiti Iraq Kiribati Liberia Marshall Islands Mauritania Niger Palau Papua New Guinea Samoa Sao Tome and Principe Sudan Tonga Vanuatu Yemen, Rep.
Recessive				Greece Italy			
Weak negative						Zimbabwe	Libya
Strong negative							Central African Republic Micronesia, Fed. Sts.

Source: Own elaboration.