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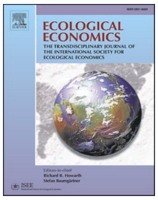

The limits to degrowth: Economic and climatic consequences of pessimist assumptions on decoupling

Rikard Hjorth Warlenius

Environmental Social Science, School of Global Studies, University of Gothenburg, Sweden

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ABSTRACT

In the debate between proponents of green growth and degrowth, the core issue is whether decoupling carbon emissions and resource use from GDP growth is possible, and if so, possible at a rate fast enough to achieve policy goals such as global warming of maximum 1.5 °C or 2 °C. In this paper, the claims by degrowth scholars on the limits of decoupling growth and carbon emissions are critically examined by assessing the economic and climate consequences of their claims. It is claimed that their pessimistic view on decoupling is not based on robust arguments but rather mystifications of what decoupling is. Following the assumptions by leading degrowth scholars – that decoupling (decrease of the emission intensity of GDP) are unlikely to be larger than 4% and that levels of GDP need to converge in a degrowing world – indicates that the 1.5 °C target is ruled out altogether and that in order to reach the 2 °C target, the economies of the global north would have to be reduced with over 90% and for middle income countries with around 70%. This appears as very unlikely to happen. Yet, there might be alternatives, which are discussed by sketching a realist and dynamic theory of decoupling.

1. Introduction

Whether environmental sustainability is compatible with continuous economic growth has been debated at least since the publication of *The Limits to Growth* (Meadows et al., 1972), and the idea that climate change goals, such as the 2 °C temperature target, could not be met under continuous economic growth was popularized in Tim Jackson (2009, 2017) book *Prosperity without growth.*

The core issue of the debate regards decoupling – the claim that the positive correlation between economic growth and increasing environmental harm can be broken. A substantial amount of research, spanning many types of decoupling, has tested this claim. While growth is generally measured as GDP, many types of environmental indicators have been explored on different geographical scales and in different sectors of the economy.

It is common to distinguish between *resource decoupling* (focusing on levels of energy and matter used) and *impact decoupling* (focusing on levels of pollution, such as carbon emissions) (UNEP, 2011). The former is, by some researchers, seen as more indicative of the long-term sustainability of a society, while impacts can be mitigated without a change of the social metabolism, by technologies such as carbon dioxide removal (CDR) (Ward et al., 2016; Wiedenhofer et al., 2020). On the other hand, it could be argued that it is the impacts that cause problems and therefore should be measured; it is not energy use per se that changes the climate, for instance, but the release of CO_2 into the atmosphere.

Decoupling is usually measured as change in the resource or impact intensity of GDP. In the example of carbon emissions, it is measured as $gCO_2/\$$. If there is strong co-variation (*coupling*), both variables increase (*positive* coupling) or decrease (*negative* coupling) in tandem. If the two variables do not co-vary over time, they are *de*coupling. Also decoupling can occur in several forms, but what is commonly meant is a reduction of the resource or impact intensity of GDP (for a complete framework, see Vehmas et al., 2003; Tapio, 2005). Either the intensity reduction is slower than GDP growth, resulting in *relative* decoupling; or the intensity decreases faster than growth, which is referred to as *absolute* decoupling (Jackson, 2009, p. 67). Only in the latter case is the resource use or impact declining in absolute terms. That does not necessarily equal to what is sometimes referred to as *sufficient* decoupling, which is a reduction rate of impacts compatible with stringent environmental targets, such as the 1.5 °C temperature goal (c.f. Parrique et al., 2019, p. 14–15). Results also differ if the environmental indicator is *production-*

E-mail address: rikard.warlenius@gu.se.

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based (related to gross impacts such as CO_2 emissions within an economy) or *consumption-base*d (where the global environmental impacts is related to national growth rates) (Wiedenhofer et al., 2020).

The decoupling literature is massive and expanding and, in the following, I will concentrate on two recent literature reviews. Vadén et al. (2020) review 179 articles on decoupling published 1990–2019, and their main finding is that out of those, 170 reported on the existence of decoupling. 97 articles presented evidence of absolute decoupling – the majority (79) of absolute impact decoupling, while some (23) reported instances of absolute resource decoupling. Of the former, most articles (56) focused on GHG gases or airborne pollutants.

In a two-part article, 835 empirical studies on the relationship between economic growth, resource use and greenhouse gas emissions are reviewed. The first part (Wiedenhofer et al., 2020) focus on what kind of indicators of decoupling that are examined in the papers. The most common are primary energy (42% of the papers) and industrial fossil fuel emissions (34%). In the second part (Haberl et al., 2020), the results of the examined papers are synthesized. Overall, production-based relative decoupling is frequent, while absolute decoupling is rare and usually only visible during periods of low GDP growth, and never on the global level. Consumption-based studies suggest that decline of production-based indicators is often compensated by increases in global footprints. Despite this generally bleak picture of the possibilities of absolute decoupling, there are some recent studies that report of absolute (although not sufficient) decoupling between GDP and CO_2 or GHG emissions in some countries (Ibid.). Particularly, Le Quéré et al. (2019) point to 18 countries where CO_2 emissions fell both in production-based and consumption-based terms over the years 2005–2015 and shows that these reductions were largely a result of policies that promote renewable energy and energy efficiency.

Evidence for absolute decoupling of carbon emissions from GDP does not, however, prove that sufficient decoupling is possible. Degrowth proponents, such as Victor (2008), Jackson (2009), Kallis (2018), Parrique et al. (2019), and Hickel (2020) are pessimistic about such claims. Hickel and Kallis (2020), for instance, conclude that "absolute decoupling from carbon emissions is highly unlikely to be achieved at a rate rapid enough to prevent global warming over 1.5°C or 2°C". Looking at the historical record, there are certainly good reasons for their pessimism. Yet, as pointed out already by van den Bergh (2011) and further discussed below, history is a poor measure of what could be done in the future.

This paper will discuss decoupling pessimism, examine some consequences of it, and propose an alternative theory. A well-known example of climate change-related criticism of decoupling is Tim Jackson's book *Prosperity without growth* (Jackson, 2009, 2017). He was not the first to criticize growth from a climate change perspective (see e.g., Kelly and Kolstad, 2001, Booth, 2004, ch. 5, Victor, 2008, p. 76–81) but developed it and made it the centrepiece of his argument. In chapter 5, "The myth of decoupling", Jackson acknowledges the need for absolute decoupling if climate goals are to be met, also in degrowth scenarios, yet, after evaluating both historical evidence and making an arithmetical exploration (see section 2.1), reaches the conclusion that there are limits to decoupling and thereby implies that continuous economic growth is incompatible with climate and fairness goals; "there is as yet no credible, socially just, ecologically sustainable scenario of continually growing incomes" (2009, p. 86, 2017, p. 96–100). This implicit conclusion is expressed more clearly by other degrowth proponents. For instance, Parrique et al. (2019, p. 51) claim that Jackson's arithmetic examples expose "extreme" and "highly unlikely" rates of decoupling.

Robert Pollin (2019) explores the other side of this argument, also by using "simple arithmetic". Without decoupling, he explains, the only way to reduce emissions is to reduce the economy itself to the same degree. Pollin points out that if, according to a degrowth scenario, GDP would contract with 10% over 20 years (which is much more than during the 2007–2009 financial crisis), it would still only lead to a reduction of emissions with 10% – which is not anywhere near what is needed to reach the climate goals. Following the argument through leads to the conclusion that zero-emissions without decoupling requires a zero-economy.

Neither Jackson nor other degrowth proponents usually claim that *no* decoupling is possible or necessary. Rather, they argue that the levels assumed in most scenarios are unlikely, but without specifying what is likely. "The question is", Jackson (2009, p. 75) asks,"[h]ow much decoupling is technologically and economically viable?". He, as most other degrowth proponents, does not give an exact answer to the question, perhaps because they do not regard it as possible. In a seminal article by the high-profile degrowth proponents Hickel and Kallis (2020), a precise answer is however given. According to them, an annual reduction of the carbon intensity of the economy larger than 4% per year is hardly possible. We will return to how they came to that figure in section 4.1.

A central question that is not addressed in their paper (or by other degrowth scholars) is *how much economies would need to decline as a result of their pessimistic view on decoupling,* under the assumption that stringent climate targets are to be met. This is done in this paper. A further aim is to show that their pessimism is not based on solid argumentation, and that therefore climate goals probably could be attainable without massive degrowth. The methods and the data sources are discussed in the second section. The results are presented in the third section. In the fourth section, the results are discussed and an alternative theory on decoupling is briefly sketched.

2. Materials and methods

In this section, the methods used by degrowth scholars to establish the relation between decoupling, growth and carbon emission are described, as well as other assumptions on which their calculations are based, including estimations of what emissions pathways that are compatible with the climate targets. Finally, the method used for examining the economic consequences of these assumptions is explained.

2.1. Decomposing decoupling

To quantify decoupling, Jackson (2009, p. 78) departs from the Ehrlich and Holdren (1971) or "IPAT" equation, according to which environmental impact (I) is the product of population (P) times affluence (A) times technology (T). Jackson adapted the formula to carbon emissions (C), which is then the product of population (P) times affluence (A, GDP in \$ per capita, which means that P × A is GDP in \$) times the carbon intensity of the economy (T, measured in $gCO_2/\$$):

$C = P \times A\ (\$/capita) \times T\ (gCO_2/\$)$, or, if population is solved out of the equation,

$C = GDP\ (\$) \times T\ (gCO_2/\$)$

Decoupling, then, is the percentual negative change of T. In the tables presented in the next section, population is withdrawn from Jackson's formula, so that carbon emissions (C, gCO_2) are regarded as the product of wealth (W, GDP in \$) and carbon intensity (T, $gCO_2/\$$).

In Table 2, change in carbon emissions is the dependent variable, varying through a given level of emission reduction multiplied with a row of different levels of decoupling. In Table 1, change in GDP, expressed in percent, is dependent on a given change in emissions divided by different levels of decoupling:

$GDP = 100 \times (C / T) - 100$

Table 1
The relation between the decoupling rate (percentual change of $gCO_2/\$GDP$), and economic development (percentual change of $GDP) given a 10% annual reduction of carbon emissions (gCO_2). Annual decoupling rates from 0 to −15% results in annual GDP change from −10 to +5.9%. The third column shows the accumulated GDP change after 30 years, when emission have been reduced with 95%.

Annual decoupling rate (%)	Annual GDP change (%)	GDP after 30 years (%)
0	–10	−96
−1	−9.1	−94
−2	−8.2	−92
−3	−7.2	−89
−4	−6.2	−86
−5	−5.3	−80
−6	−4.3	−73
−7	−3.2	−63
−8	−2.2	−48
−9	−1.1	−28
−10	0	0
−11	1.1	40
−12	2.3	96
−13	3.4	177
−14	4.7	291
−15	5.9	456

Table 2
The relation between emissions (percentual change of gCO_2), and economic development (percentual change of $GDP) given that decoupling (change of $gCO_2/\$GDP$) is 4% per year. The third and fourth column exposes the accumulated result for C and GDP after 30 years, when T is 29% of the original carbon intensity.

Annual emission reduction (%)	Annual GDP change (%)	Emission reduction after 30 years (%)	GDP change after 30 years (%)
0	4.2	0	240
–1	3.1	−26	152
−2	2.1	−45	86
−3	1.0	−60	36
−4	0	−71	0
−5	−1.0	−79	−27
−6	−2.1	−84	−47
−7	−3.1	−89	−61
−8	−4.2	−92	−72
−9	−5.2	−94	−80
−10	−6.2	−96	−86
−11	−7.3	−97	−90
−12	−8.3	−98	−93
−13	−9.4	−98.9	−95
−14	−10.4	−99.2	−96
−15	−11.5	−99.5	−97

I will now analyse what values to assert to the variables C, GDP, and T.

2.2. Carbon emissions (C)

To calculate how much each variable need to change to achieve a particular result, Jackson used “a rule of thumb” (2009, p. 79) in which the percentual changes were added together. He noted that between 1990 and 2007, global population (P) had increased with in average 1.3% per year, average per capita income with 1.4%, while carbon intensity had declined with 0.7% annually. By adding changes in P, A, T, change in C was established. Thus, emissions (C) had increased with 2% per year (since 1.3 + 1.4–0.7 = 2).

Yet, according to the then latest IPCC (2007, p. 20) estimation, reaching the 2 °C target meant that emissions needed to decrease 4.9% every year until 2050. Accepting the forecasts for population (+0.7%/year) and extrapolating historical GDP growth (+1.4%/year), technological development to reduce carbon intensity (decoupling) would have to increase *tenfold*, from 0.7 to 7% annually (since 0.7 + 1.4–7 = −4.9).

Since then, further procrastination and the Paris agreement (UNFCCC, 2015) sharpening of the temperature goal to “well below 2°C", even 1.5 °C, has led to a need for more drastic actions. To make that feasible, not only deep reductions of emissions are necessary, but most scenarios now include large amounts of negative emissions, called CDRs (Carbon Dioxide Removals) or NETs (Negative Emission Technologies) – up to a level regarded as unrealistic by many scientists, including degrowth scholars (see e.g., Anderson and Peters, 2016; Minx et al., 2018, Fuss et al., 2018, Hickel, 2020, p. 129–134). In IPCC's special report on the 1.5 °C target, the two scenarios which do not apply massive amounts of CDR technologies, P1 and P2, require global emissions to roughly halve until 2030 and to decrease with 93–95% until 2050 (IPCC, 2018, p. 14.) Over 30 years that would amount to an annual reduction of circa 10% per year. This is also the figure used by Jason Hickel (2020, p. 296) for a 66% chance of staying below 1.5 °C. In the 2017 update of Jackson's *Prosperity without growth*, global emissions reductions of 90 or 95% until 2050 are also discussed (Jackson, 2017, p. 99; see also the update in Antal and van den Bergh, 2016). For the industrialized world, reductions need to be even more stringent. Hickel and Kallis (2020) refer to estimates by Kevin Anderson, according to which Annex 1-countries would need to reduce emissions with 12% annually to comply with a scenario of 50% chance to stay below 2 °C without negative emissions.

Table 3
GDP per capita development after 30 years for a selection of countries and groups of countries under contraction and convergence of per capita income levels and a decoupling rate of 4%. In scenario 1.5 °C, global emissions are decreased 10% annually, in scenario 2 °C with 4%.

	GDP per cap. 2021	Sc. 1.5 °C (change of GDP per cap. After 30 years, %)	Sc. 2 °C (change of GDP per cap. After 30 years, %)
Argentina	10,729	−87	−8
Australia	59,934	−98	−84
Brazil	7519	−82	31
China	12,556	−89	−21
Egypt	3876	−64	155
Germany	51,204	−97	−81
India	2277	−39	334
Indonesia	4292	−68	130
Japan	39,313	−96	−75
Kenya	2007	−31	392
Nigeria	2085	−34	373
Poland	17,841	−92	−45
Russia	12,173	−89	−19
U.K.	47,334	−97	−79
U.S.A.	69,287	−98	−86
EU	38,234	−96	−74
LCD	1177	17	739
World	12,263	−89	−19

Source (GDP per capita 2021, current US$): World Bank, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.
Global GDP 2021 (current US$): World bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

In Table 1, an annual carbon reduction of 10% is assumed for 30 years, corresponding to a 1.5 °C goal with moderate overshoot and use of CDR. In Table 2, the speed of reduction is made dependent on GDP development. In Table 3, two scenarios compatible with 1.5 °C and 2 °C for a number of countries are explored.

2.3. GDP

GDP is of interest both in relative terms – whether it increases (growth) or decreases (degrowth) – and in absolute terms, i.e., how large decreases in absolute GDP that will follow from the assumptions made by degrowth scholars.

With fixed rates of decoupling and emission reductions (to meet the climate targets), the dependent variable is GDP development. If we are also “serious about fairness” (Jackson, 2009, p. 80) we should allow the world's 9 billion people to enjoy an income comparable to EU citizens by 2050. Jackson's normative call for global equality is even more valid in degrowth scenarios. A steep decrease in the standard of living distributed proportionally across the world's population would be very problematic from an ethical point of view. Those who are near the poverty line would then be pushed below it, and some would even be pushed to starvation. Degrowth is therefore ethically unthinkable without strong measures for equality. This normative assumption, based on Jackson's call, is operationalized as a global convergence of the GDP of all countries in 30 years.

For the sake of simplicity, GDP is not measured per capita in Table 1 and 2. It is worth to keep in mind, therefore, that world population is expected to rise the entire century, yet at a slowing pace. During the coming decades, UN (2022) expects world population to rise with two billion, from 7.98 billion in 2022 to 9.75 in 2051, which is an annual mean of 0.7%. Therefore, any given level of GDP will be shared by more people. In a steady state (GDP change =0), for instance, affluence (A, GDP per capita) will be slightly negative. For A to be constant, GDP needs to increase slightly. As a rule of thumb, subtract 0.7 from GDP change to get GDP per capita change.

2.4. *Decoupling (T)*

Decoupling, or the percentual change of T, is defined as the change of the intensity of resource use or environmental impact to the size of the economy (GDP). In this study, the relation between economic growth and climate change is the centrepiece, and the decoupling we focus on is change of carbon intensity ($gCO_2/\$$).

Jackson's arithmetic argument shows that if both climate and fairness goals are to be met under conditions of population growth and economic growth, the pressure on decoupling becomes very high. Just to meet the then IPCC climate goal, the historical decoupling level of 0.7% per year must increase tenfold, to 7% per year (Jackson, 2009., p. 80). Taking fairness into consideration (see section 2.3), growth needs to be even higher and thereby, decoupling too. Then, the carbon intensity needs to decline with 11% per year (Ibid., p. 81). In his 2017 update of the book, the prospects have become even more difficult because of both continuous global procrastination on climate action and more stringent climate goals adopted by UNFCCC (Jackson, 2017, p. 97–101).

Although degrowth scholars and ecological economists have remained sceptical towards the "green growth" and "environmental Kuznets curve (EKC) hypotheses (e.g., Krausmann, 2017 and several other chapters in Spash, 2017; Tilsted et al., 2021, as well as Victor, 2008, Jackson, 2009, Parrique et al., 2019, Hickel and Kallis, 2020, Hickel, 2020, p. 21, etc.), *how much* decoupling that is possible had only seldom been discussed (Anderson, 2013 is an exception) until Hickel and Kallis (2020) seminal article "Is green growth possible?". Their 4 % decoupling limit is the result of an inventory of the economic literature on empirical models quantifying emissions reduction scenarios. The most optimistic decoupling scenario in those models was found in C-ROADS, developed by Climate Interactive and MIT Sloan. In this policy simulator, decoupling can be turned up to 4 %, during the most "aggressive" actions imaginable: subsidies of renewable energy and nuclear power plus carbon taxation. Hickel and Kallis conclude that higher rates of decoupling than 4 % are "beyond what existing empirical models indicate is feasible" (this conclusion will be discussed further in section 4.1).

As the most specific suggestion about decoupling by degrowth scholars, 4 % of decoupling is used in Table 2. Yet note that according to Hickel and Kallis, this is the most optimistic scenario. If decoupling would be set at a lower rate, its influence on GDP development would be even more drastic.

3. Results

In the following, the adapted IPAT equation is operationalized to discuss how pessimist assumptions on decoupling influences, first (section 3.1) future GDP, and then (3.2) climate goals. In the last part (3.3), the assumptions are applied to a selection of countries to see, in concrete terms, how their GDP would be affected in 30 years.

3.1. *The economic consequences of low decoupling rates*

In Table 1, we see what combinations of decoupling and GDP change that are compatible with 10% annual cuts of carbon emissions for 30 years. It reveals how crucial decoupling is for GDP growth under the very ambitious – yet arguably worthwhile – 1.5 °C climate goal. With no decoupling (that is, unchanged carbon intensity of the economy), decarbonization of 10% annually is only possible with an annual degrowth of the economy at the same rate. In 30 years, that would result in an economy that is 96% smaller than the current. But degrowth scholars are usually not that pessimistic about the possibility of decoupling.

Reaching the climate targets with continuous economic growth would, in this scenario, mean decoupling rates of over 10%. At 12%, for instance, the economy would grow at a "normal" 2.3% per year, leading to a wealth increase of 96% in 30 years. A decoupling rate of 10% would absorb the entire emission reduction, resulting in an economy in a steady state mode. Thus, a steady state proponent who claims that it is impossible or infeasible to reach the climate targets under economic growth should consider why, if 10% annual decline in emission intensity is possible, 11 or 12% is impossible. Or, if not 10% is feasible either, how much degrowth that is needed. 7% of annual decoupling means that incomes would have to decrease 3.2% per year, which is about the same as the global GDP loss during the crisis year of 2020 (−3.3%, World bank, 2023a). In this scenario, however, the decline would have to continue for 30 years and lead to a 63% decrease of the world economy.

If 7% of decoupling is not credible (cf. Jackson, 2009, p. 86), we could look at the effects of what Hickel and Kallis regard as the maximum possible decoupling rate of 4%. Still aiming at the climate targets, this corresponds to a yearly GDP loss of 6.2%. This decrease is steeper than during most of the post-Soviet, Russian collapse. From 1989 to 1998, Russia's GDP decreased 44% before it started turning upward again (World bank, 2023b). During the worst years (1992–94), annual GDP losses were 8.7 – 14.5%, the other years the decline stayed between 3 and 5% (World bank, 2023c). In this case, the recession would last for 30 years, ending with a GDP 86% smaller than initially.

Are these immense reductions of GDP regarded as achievable by degrowth scholars? Or are they rather giving up on the 1.5 °C climate goal? We cannot give a general answer to these questions, but at least one of them, Jason Hickel, pursue along the second alley. Because of his pessimistic opinion on the possibilities of decoupling, he rules out the 1.5 °C target as "out of scope". A target compatible with 66% chance of staying under 2° is deemed as feasible, but only if the economy does not grow (Hickel, 2020, p. 296). What combinations of emissions reductions and economic decline that are compatible with Hickel and Kallis maximum rate of 4% decoupling is explored in the next section.

Deducing from above, the GDP effects of five decoupling rates – 0, 4, 7, 10, and 12% – given 10% annual reduction of carbon emissions, are detailed in Diagram 1.

3.2. *The climatic consequences of low decoupling rates*

In Table 2, the 4 % decoupling limit set up by Hickel and Kallis (2020) is held constant, while combinations of carbon reduction and economic development compatible with that level of decoupling are presented. As in Table 1, a reduction of carbon emissions at 10 % per year in combination with 4 % decoupling will result in an annual GDP loss of 6.2%, or a GDP decline of 86% over 30 years. That would be compatible with the 1.5 °C target but economically “out of scope”, as we understand Hickel.

If carbon emission reductions are 4% annually, or 71% in 30 years, this is quite far from the IPCC 1.5 °C scenarios P1 and P2 that demand net zero emissions by 2050, but could just be compatible with 2 °C. According to Hickel (2020, p. 296), a 66% chance of staying under 2 °C requires annual reductions of 4.1%. Assuming 4% of decoupling, it would be achieved under a steady GDP level. The figure, however, refers to a global mean. According to Hickel, high-income countries need to reduce emissions 12% per year. Given 4% of decoupling, “it requires degrowth” (Ibid.). How much is not revealed by Hickel, but as shown in Table 2, it corresponds to an 8.3% fall in GDP per year, or a 93% decrease after 30 years.

Keeping economic growth at a “normal”, 2.5% level, would have dire consequences for the climate. Emissions would only be reduced by 1.6% annually or 37% in 30 years, which is far from compatible with the 1.5 °C or 2 °C temperature goals without significant overshoot.

Thus, assuming a maximum decoupling rate of 4 % has consequences. It pushes the observer to either give up on ambitious climate targets, on development and fairness goals – or to assume that developed countries would crash their economies.

In Diagram 2, three scenarios for emissions reductions and GDP development are illustrated under the assumptionsof 4%'s annual decoupling: “1.5 °C”, “2 °C”, and “BAU”. They first two were chosen since they can be regarded as marking the ends of ambitious climate policies – the first being very ambitious and most likely compatible with temperature stabilization at 1.5 °C, the latter more risky but, perhaps, compatible with 2 °C. The BAU scenario is chosen as a comparison showing what 4% of decoupling will achieve during “normal” GDP growth of 2.5%.

3.3. *Contraction and convergence of affluence*

The GDP decline necessary if climate goals are to be met under pessimistic assumptions of decoupling, would, as discussed above (2.3), be ethically very problematic without sharp reductions of inequality. According to Jackson (2009, p. 81), the wealth of national economies should therefore converge at the same level. It is not explained how, and it appears as unlikely that it will ever happen down to the last dollar, but from a normative standpoint it nonetheless makes sense to take it seriously.

The consequences of this ideal, for a selection of countries and groups of countries, is illustrated in Table 3. There, two scenarios are explored. In both, Hickel and Kallis maximum decoupling rate of 4 % is applied. In the first, annual emission reductions of 10%, compatible with the 1.5 °C goal, is assumed. That corresponds to an annual wealth degrowth of 6.2%, or totally 86% after 30 years. Since global GDP 2021 in current US$ was 96.1 trillion (World bank, 2023d), and population is expected to grow to 9.735 billion by 2050 (UN, 2022), the contraction and convergence of affluence corresponds to a global, mean per capita GDP of $1382 by mid-century.

The second scenario, barely compatible with the 2 °C target, is considerably slacker. There, decoupling of 4% translates directly into emission reductions of 4%. GDP stays the same, but because of increased population, GDP per capita declines. By mid-century, mean GDP per capita would be $9872 in current dollars.

According to the 1.5 °C scenario, all industrialized countries will have their GDP per capita reduced with over 90%. Semi-developed countries such as Argentina, Russia or China will also have their mean incomes severely reduced, with close to 90%. Even developing countries such as India and Kenya will have their GDP reduced with 30 to 4%, while only the group of least developed countries would be allowed a small economic growth – much smaller than their current growth rates, however.

The second, 2 °C scenario, is quite attractive for low-income countries. If current wealth is smeared out equally, most countries in Africa and southern Asia would experience tremendous growth, with a factor 7 for the LDC-group. That would be welcome from a distributive justice standpoint. From a political feasibility standpoint, it would be more complicated, however. Even in this scenario, high-income countries would need to cut down dramatically – with 86% in the U.S., and 74% in E.U., compared to 2021. Further, middle income countries such as China and Russia would also have to degrow with around 20%.

As mentioned, these two scenarios were chosen as end marks of ambitious climate policies, under the most favourable assumptions of decoupling put forward by the degrowth community. That is not to say that there are no degrowth proponents that are more optimistic about the prospects for decoupling than Hickel and Kallis, but to my knowledge, they have not put forward any figures and therefore defy quantification. Yet, other assumptions would of course produce other results. If we, for instance, would allow a decoupling rate of 7% (although it has been dismissed as not credible by Jackson, 2009, p. 86), the 1.5 °C compatible scenario above would result in a global GDP per capita loss of 70% (EU: −90%, India: 60%), while the barely 2 °C scenario would double GDP in 30 years (EU: −35%, India: 1093%).

4. Discussion: demystifying decoupling

If degrowth scholars are right in their pessimistic assumptions about decoupling, in their scepticism towards the possibilities of using CDRs, and in their support for stringent emission reduction targets, they are right in that the only way to avoid dangerous climate change is through degrowth. They just have not spelled out exactly *how much* degrowth their assumptions translate into, if we follow Hickel and Kallis (2020): 86% over 30 years (89 if measured per capita) globally, and, if we take fairness seriously, over 95% for most developed countries. Even less stringent emission targets, which are probably not compatible with 1.5 °C, lead to massive levels of degrowth for most parts of the world.

If this is the only way to avoid disastrous climate change, it should be done. The prospects of runaway climate change are arguably worse than an equalization of global incomes around a level that is low, but still would allow people to survive. The main problem is, however, that these scenarios must be regarded as very unlikely. The prospect of countries like the US to voluntarily cut their per capita income with 98 or 86%, or China with 8 or even 21%, just not seems great. These scenarios, if anything, are “out of scope”.

Does this mean that there is no way to avoid the dilemma of either climate disaster or economic collapse? Not if the decoupling pessimism of degrowth scholars is mistaken. In this discussion, I attempt to demystify the “myth of decoupling”.

Jackson (2009, 2017) makes no clear intellectual case for why high levels of decoupling are impossible. His chapter on the “myth of decoupling” points to the scarce historical evidence of absolute decoupling, which, he admits, does not make it less important nor “does it rule out the possibility entirely” (2009, p. 75). This is important and logical: Just because something has not happened does not imply that it *cannot* happen. It must be acknowledged that sufficient levels of emission reductions have only seldomly taken place during economic growth. But there is, on the other hand, no encouraging examples of deep decarbonization under conditions of degrowth either.

Thus, if we are looking at history for guidance, prospects are bleak. If it was not for all the human suffering, the collapse of the Soviet economy could have served as a positive example of degrowth, since Russia's CO_2-emissions were reduced very rapidly, with 42% over nine years. But there are also less discouraging examples of energy transitions where emissions were reduced almost as fast and under conditions of relative social stability. France reduced its emissions with roughly 25% during the 1980s, and Sweden with 40% during the 1970s and 80s. During the most intense period, 1979 to 1984, emissions fell with 32% under a period of (moderate) economic growth, which corresponds to an annual,

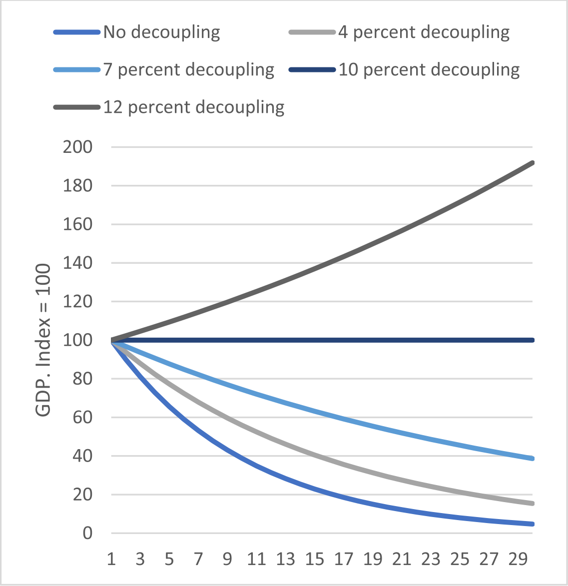

Diagram 1. If carbon emissions were reduced with 10% annually, this is how GDP would develop over 30 years according to 5 scenarios. In "No decoupling", GDP would decline with 10% per year, leading to a 95% decrease in 30 years. With 4% decoupling, GDP will fall 6.2% per year or 86% in 30 years. Decoupling of 7% per year leads to a GDP reduction of 3.2% per annum or 63% in 30 years. If decoupling is 10% per year, it compensates for emission reductions and stabilizing GDP. The scenario with a "normal" GDP growth of 2.3% (96% in 30 years) requires 12% of decoupling.

mean decoupling rate of 9%.[1] Even stretched out over a longer period, the 20 years from 1970 (when Swedish emissions peaked) to 1989, the mean annual decoupling rate was 4.5%[2] – more than Hickel and Kallis' model regard as feasible. In more recent years, from the 1990s until today, Denmark has more than halved its fossil CO_2 emissions. From Denmark's peak emission in 1996 to 2018, the mean annual decoupling rate was 5.1%.[3]

None of these cases (see Fig. 1) are as far and wide reaching as to serve as raw models for the climate transition necessary, and we should be humble about that. As stated by IPCC, 2018 (p. 15), the "systems transitions" needed to limit global warming to 1.5 °C with no or limited overshoot "are unprecedented in terms of scale, but not necessarily in terms of speed". The path we need to take has not been taken before. But that does not mean that it is impossible to walk.

After the peek at history, Jackson turns to the arithmetic argument described above: he shows that in order to meet the climate targets, the rate of decoupling needs to increase to levels that seem incredible: from 0.7% to 7%, but if fairness should be considered and more stringent targets are to be met, to at least 10%. Such an increase – tenfold or more – is massive and therefore appears as unlikely, but Jackson provides very few, if any, factual arguments for why it should be impossible. His conclusion, that there is "no credible" (Ibid., p. 86) scenario of continuous growth and ecologically sustainability is mainly based on the arithmetic argument: that increases of the rate of decoupling of factor 10 or more just seem unrealistic.

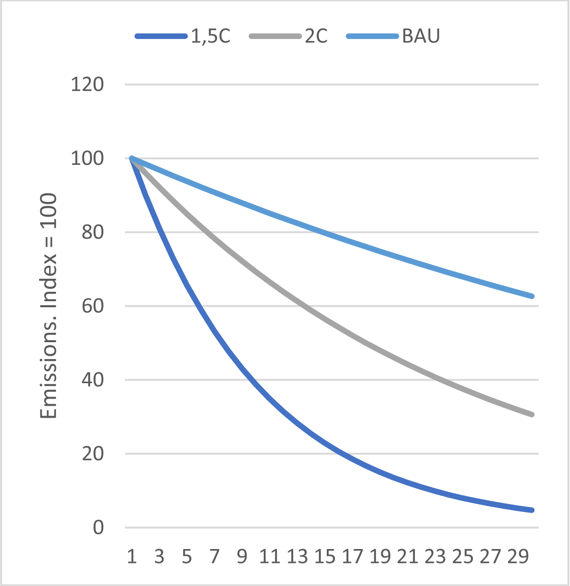

Diagram 2. If an annual decoupling of 4% is assumed, this is how emissions would develop over 30 years in three scenarios. In scenario "1.5 °C", emissions will be reduced 10% annually or 95% over 30 years, which is probably compatible with the 1.5 °C temperature target. GDP would be reduced 6.2%/year or 86% in 30 years. In scenario "2 °C", emissions are reduced 4% annually or 71% in 30 years, which might be sufficient for keeping temperature under 2 °C. Then, GDP has to be kept stable. In "BAU", GDP is kept at a normal level of 2.5% annually. Then, emissions would only be reduced with 37% in 30 years and temperature goals not met.

But only staring at the numbers is not very convincing. A tenfold increase in decoupling rate certainly requires large efforts, but why should it be impossible? Why is 7 or even 10% impossible, when there are examples of sustained decoupling of 5%? Decoupling CO_2 from GDP is not about numerology, it is, at its core, the result of the efforts that society take to reduce the use of fossil fuels under GDP growth (which is the normal condition under capitalism). And there are several examples that shows that societies can transform their energy systems in very decisive ways (for more examples, see Sovacool, 2016). Actually, in the second edition of his book, Jackson (2017, p. 102) indicates that high rates of decoupling might be technically possible but not "without confronting the structure of market economies". That would mean that high levels of decoupling are contingent on economic reform, which is far from numerical mystifications and in accordance with the argument made here.

Hickel and Kallis's argument for an upper limit of 4 % of decoupling is another case of mystification. Their data are so-called empirical models that allow users to experiment with different scenarios for emissions reductions. The most optimistic scenario of decoupling they find is in a model called C-ROADS (see section 2.4). In C-ROADS, decoupling can be turned up to 4% per year during the most "aggressive" policies thinkable: subsidies of renewable energy and nuclear power plus carbon taxes. But, as noted by Hickel and Kallis (2020), 4 % is not compatible with the climate goals under conditions of economic growth, and therefore green growth "are beyond what existing empirical models indicate is feasible".

The question is, however, what bearing those models have on our actually existing possibilities for decoupling. An empirical model is a

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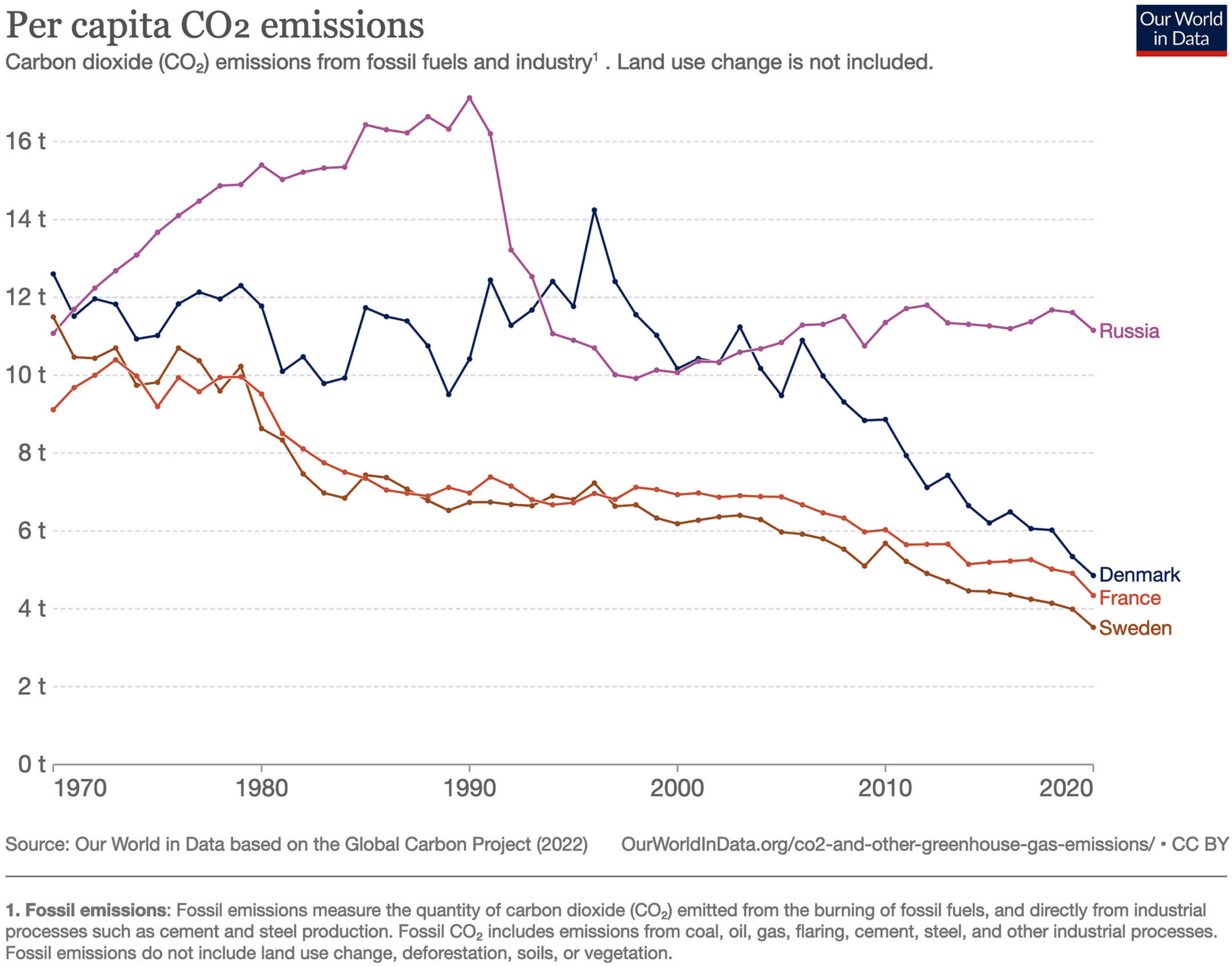
[1] From 1979 to 1984, Sweden's emissions fell from 84.87 to 57.31 $MtCO_2$, while GDP (international-$ in 2011 prices) rose from 194.62 to 211.40 billions; the intensity (gCO_2/$) thus sunk with 37% (data from Our world in data: https://ourworldindata.org/co2/country/sweden?country=~SWE and https://ourworldindata.org/grapher/gdp-world-regions-stacked-area?time=1970..1989&country=~SWE.

[2] From 1970 to 1989, Sweden's emissions fell from 92.29 to 55.52 $MtCO_2$, while GDP (international-$ in 2011 prices) rose from 163.02 to 237.23 billions; the intensity (gCO_2/$) thus sunk with 59% (same sources as in footnote 1).

[3] From 1996 to 2018, Denmark's emissions fell from 74.87 to 34.72 $MtCO_2$, while GDP (international-$ in 2011 prices) rose from 180.66 to 268.32 billions; the intensity (gCO_2/$) thus sunk with 69% (data from Our world in data: https://ourworldindata.org/grapher/annual-co2-emissions-per-country?country=~DNK and https://ourworldindata.org/grapher/gdp-world-regions-stacked-area?time=1996..latest&country=~DNK.



Per capita CO2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry[1] . Land use change is not included.

Source: Our World in Data based on the Global Carbon Project (2022) OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Fig. 1. Per capita CO_2 emissions 1970–2020 for Russia, Denmark, France, and Sweden.

model, that is an attempt to reduce the complexity of reality into a manageable number of variables and relate them to each other in predefined ways. They are helpful tools for scenario-making but, and this should be self-evident for critical scholars, they are still reductionist and based on uncertain assumptions influenced by hegemonic discourses. Their output should therefore not be conflated with what is humanly possible. Indeed, it would be very surprising if not critical scholars such as Hickel and Kallis could imagine more “aggressive policies” than energy subsidies and carbon taxes. Just consider one policy that they have themselves proposed, resource caps (Mastini et al., 2021). If a resource cap for fossil fuels was inserted into the model, emissions could be turned down at the speed of their wish (it would certainly also influence GDP, but in contingent ways).

If we further contemplate that there are historical examples of sustained levels of decoupling higher than Hickel and Kallis suggest is possible, their upper limit of 4 % appears as outright strange. The very idea that such a limit exists is strange. While physical laws limit what is physically possible, decoupling is clearly a social phenomenon. To a large degree, it is what we make it into.

It deserves to be repeated, however, that impact decoupling, such as of CO_2, is generally more easily achievable than resource decoupling. Parrique et al. (2019) constructs no less than seven arguments against absolute decoupling, but many of them are not directly relevant for decoupling GDP and CO_2 emissions. Their conclusion is nonetheless stated with utmost clarity (Ibid., p. 10): “green growth, that is economic growth that is sufficiently decoupled from environmental pressures, is not possible”. Also, according to other degrowth scholars, such as Victor (2008), Jackson (2009), Kallis (2018) and Hickel (2020), continuous economic growth is most likely not compatible with climate stabilization. If they are right, the only way to reach the climate goals is by massive degrowth. In practice, at least Hickel therefore rule out the 1.5 °C target. But their defeatism is not based in robust arguments.

I have elsewhere (Warlenius, 2022, p. 259–267) sketched a realist, dynamic theory of decoupling. I there argue, against both the unfounded pessimism of degrowth scholars and the excessive optimism of many green growth advocates, that EKC-type of developments for carbon emissions does not follow from the spontaneous operation of the market forces, yet can be produced socially and politically, and will most likely require forceful state action based on popular support. The theory is supported by the detailed prospects for energy efficiency and a low- or zero emission energy and transportation infrastructure that have been put forward by e.g., IEA (2021), IRENA (2020), Pollin (2020), as well as the burgeoning literature on a 100% renewable energy system (for an overview, see (Hansen et al., 2019).

Upon closer analysis, the static relations between growth and environmental impacts that is suggested by e.g., the IPAT equation seems fraudulent; rather, the relations are dynamic. Under normal conditions, economic growth increases emissions (while carbon intensity declines), and degrowth (recession) stabilizes emissions. Yet at the same time, growth is probably more likely than degrowth to enable the conditions needed for intense climate transitions: the deeply transformative, costly transitions called for by e.g., IPCC (2018). Two main decarbonization pathways appears as possible. A low- or degrowth, slower but more fundamental transition, or a growth based, forceful and fast transition. The first risks to be too slow to avoid climate disaster or have intolerable social consequences, the second risks to be undermined by further economic growth. I nonetheless find the second more realistic and more likely to happen, and therefore worth fighting for, well aware of the likelihood for new contradictions between growth and environmental impacts to await down the road. Disregarded which is preferred, the two scenarios undo the claim that only degrowth can "save" the climate.

5. Conclusions

In this paper, the consequences of low decoupling rates on GDP levels and, indirectly, on the feasibility of climate targets, have been examined through an arithmetic analysis. It shows that the assumption of degrowth proponents Hickel and Kallis, that decoupling rates close to or over 4% are impossible, implies that ambitious climate targets can be reached only by massive economic contraction – over 90% in the global North. Since this would likely be politically unfeasible, the climate targets themselves would be put into risk.

It is, however, argued that their pessimism is unfounded. There are examples of absolute decoupling of carbon emissions to from GDP growth larger than their upper limit, and no convincing arguments are put forward for why strong policy measures would not be able to achieve higher rates of decoupling. Instead of fixed limits, a dynamic theory in which decoupling rates are contingent on technological development and political decisions is sketched.

There is much to be pessimistic about when it comes to climate mitigation; that there is a low and static cap on decoupling should not be one of those things, however.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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