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Permanent Absolute Decoupling of Economic Growth from Resource Consumption in the EU-15, 1970-2019

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Abstract: In its targets for sustainable development, the UN urges to decouple economic growth from environmental degradation, stemming to a very large part from resource use and CO_2-emissions. The EU implemented a number of political measures to foster such decoupling and also advocates the concept of "green growth". In this study, we analyse the development of important consumption-based indicators of resource use (including domestic material consumption, raw iron and energy) for the EU-15 from 1970 to 2019. We show that they have all absolutely decoupled from economic growth (i.e. GDP) in the last 15-20 years. Unlike many studies before, we thus do find absolute, permanent decoupling of important resource uses in a prominent economic region of the world. In many cases, the development over the past 50 years actually follows an inverted U-shape. We also compare today's per-capita-levels of resource use of EU-15 to the world average; we find that - despite the striking difference in industrial output and standard of living – they are actually quite similar, with the exception of energy use. Finally, we stress that, while our findings strongly support the feasibility of green growth, decoupling of CO_2-emissions at a rate much faster than today remains of central importance to a sustainable economic development of the EU-15 countries.

Keywords: Decoupling, Resource Use Assessment, Footprint Accounts, Sustainable Development Goal 12, Sustainable Development Goal 8.4

1. Introduction

In the past decades, there has been an ever-growing body of research on the question of the so-called "decoupling" of economic growth from resource use and environmental pressures. It has been stressed that this issue is of central relevance to one of the most important political questions of our time: Is the political aim of "green growth" - often advocated by the UN as well as by the EU - really achievable? If one could show that such decoupling is possible or, even better, that it is already happening, this would constitute an important argument in favour of such political conceptions. For a more thorough account of the background of the work presented here, we refer to the excellent and comprehensive introductions in two studies [1, 2].

In the study by Vaden et al [2], the authors present a very valuable account of the existing literature on decoupling, analysing close to 200 articles along a number of important categories. Their conclusion is this: "We found that none of the articles claimed robust evidence of international and continuous absolute resource decoupling…With regard to the goal of ecological sustainability, the empirical evidence on decoupling is thin… The evidence does not suggest that decoupling toward ecological sustainability is happening at a global or even regional scale". A similar and even broader survey of the research literature on decoupling has just recently been published in an article by Haberl et al [3]. The conclusion there is similar to the findings of the older study [2]: "Absolute reductions of material flows are generally only found in periods of very low economic growth or even recession".

In this paper, we show precisely what the authors in the study [2] were looking for: In the past two decades, in the EU-15 there has been a clear decoupling between economic growth and many important resource uses. These decouplings are - to take up the useful categorizations in the articles [2, 4],

1) absolute (not only relative/weak);
2) permanent (not only temporary/not only during recessions);
3) and consumption-based aka footprint-based (not only production-based / territorial-based).

EU-15 represents an international, regional scale. The decoupling presented here is obviously not global, but such an exigence would be inadequate: the question at stake is whether in *mature* economies, resource efficiency, advanced recycling schemes and technological developments lead to decoupling, and a positive answer to this question is all that is needed as the first step to support the concept of green growth.

This is also the reason why we decided to focus on EU-15 rather than EU-27 or EU-28: EU-15 are particularly mature, highly industrialized economies, looking back on 50 years of essentially continuous economic development. EU-27 or EU-28, on the contrary, is actually a mixture of the mature EU-15-economies and eastern European economies which have undergone a major break in their economic development around 1990, changing the basic market structure.

Now, the authors Vaden et al [2] are right in pointing out that there is a second step necessary to fully support the possibility of green growth: i.e. to show that the levels of resource use in the EU-15 after decoupling are such that they are - extrapolated to the world population - indeed sustainable.

This remains to be shown; but at least the data presented here clearly contradict rather premature claims (also widespread in popular discussions in the media) like: "Farewell to green growth… the decoupling hypothesis appears highly compromised if not clearly unrealistic" [4].

Of course, there have been studies on decoupling in the EU before, notably and most recently by Sanye-Mengual et al [1]. The results presented here differ from that 2019-study in two important aspects:

1) That study covers the period 2005-2014, which is too short to capture long-term structural changes in resource use, all the more since the economic downturn 2008/2009 heavily influences the results pertaining to this period. We study the period 1970-2019, i.e. 50 years.
2) That study focuses on environmental impacts rather than on resource use and therefore takes total domestic material consumption (DMC) as the only indicator of resource use. We analyse the decoupling of the DMC subcategories and of 3 more independent and important indicators of resource use.

The study closest to our contribution here is one that dates back to 2013 [5]. It also covers (among other countries) EU-15, the period 1970-2004, and employs DMC per capita as the central indicator. While these authors found absolute decoupling of DMC per capita in some countries – notably Germany -, its final conclusion reads: "We observe nothing consistent with an actual decline [of environmental resource use] at higher.. incomes. …There is no empirical evidence for …dematerialisation at higher economic growth rates or incomes".

In contrast, here we extend the time span to 2019, which turns out to be decisive, since absolute decoupling mainly happened from 2000 onwards. In addition, we study the material flows in much more detail and take the absolute flows instead of per capita indicators, which yields stronger decoupling claims. Thus, we obtain a very different picture.

In short, then, we present here an analysis of resource uses in the EU-15 from 1970-2019, covering the following indicators:

1) DMC – total and in its four subcategories;
2) consumption-based raw iron use;
3) "biomass ecological footprint";
4) consumption-based energy use.

We have chosen iron as the representative for metals for two reasons: it dominates the environmental impacts stemming from metal extraction (as discussed in a recent relevant UN-report [6]), and data availability is sufficient.

As DMC is of central importance in this study, we must discuss it here more thoroughly; in particular the question whether it can be considered to measure the true – i.e. the consumption-based – use of materials in a given country or region. In general, DMC does contain the (direct) imports and exports of materials, and it can thus be classified as to measure the "apparent consumption" of resources, but it does not contain the so-called "hidden material flows".

Let us look at the four subcategories of DMC:

(1) DMC biomass

Here, there are practically no hidden flows, so that DMC biomass can be considered to actually measure the (consumption-based) biomass footprint.

(2) DMC metal ores

DMC does not take into account the metals contained in final products (cars, machines etc.); in order to obtain a truly consumption-based picture, the import/export-balance of these final products has to be considered. This is what we do here in the case of the most important metal (in terms of volume and in terms of environmental impact), iron.

(3) DMC fossils

DMC fossils does not take into account the energy (mostly fossil energy) that is needed to produce final products that are being traded; this, however, is of great relevance due to the crucial importance of CO_2-emissions connected to the use of fossil energies. This is why we study here the "consumption-based" (or "trade-adjusted") energy use of EU 15.

(4) DMC non-metallic minerals (construction materials)

Here, the difference between DMC and a fully footprint-based account turns out to be most important: while direct trade of these materials is negligible, the use of such materials for producing exported goods can be very relevant. This has been pointed out in particular by Wiedmann et al in an important study of 2015 [7], who therefore call the use of DMC as a valid concept into question altogether.

From our point of view, that study is indeed a major step in understanding the complex effects of globalization on national economies with respect to resource use, and therefore has lasting merits. In other words, the material

footprint of nations (MF) introduced by Wiedmann et al is an indicator worth studying and monitoring.

On the other hand, what we are interested in in the end is ecological sustainability and the possibility of green growth; and thus we are interested in resource use (not in itself, but) insofar it pertains to these issues. The problem is that MF, being primarily influenced by construction materials, is not a useful indicator in this respect: a) construction materials are not potentially scarce, unlike metal ores and fossils; b) as pointed out in the UN-report mentioned above [6], their mining has quite limited environmental impacts: "..the area of land occupied and the resulting biodiversity impacts are small in comparison to the impact of biomass harvesting".

In sum,

1) DMC is certainly not an ideal, but the much better indicator compared to MF in the context of ecological sustainability and green growth; DMC continues to be used in many recent studies; and it is for this reason that the decoupling of DMC from GDP remains an important question answered in this study.
2) The study of DMC should be complemented by looking at other indicators which are fully consumption-based, except for the case "non-metallic minerals" due to the limited environmental relevance of this type of resources. This is what we do in the following.

2. Methods

The main methodological challenge lies in the fact that, while data from 1990/1995 onwards are in most cases reliably available, data prior to 1990/1995 sometimes have to be reconstructed or estimated from a variety of sources. The employed method, thus, depends on the indicator in question.

2.1. Economic Growth

As in most studies, we measure economic growth with inflation adjusted GDP of the EU-15, to be found in the UN database [8].

2.2. DMC

For the DMC, total and in the categories biomass, metal ores, fossils, non-metallic minerals, we rely on the respective EUROSTAT data:

1) For 1970-2000, they are documented in an older study [9].
2) For 2000-2019, they can be taken from the online EUROSTAT database [10].

2.3. Iron

The tool of material flow analysis for metals shows that the actual resource use of (raw) iron is essentially equal to the use of steel in final products minus old scrap recovered and introduced back into the material flow.

The (consumption-based) use of steel in final products between 2002 and 2019 is documented as "true steel" in the Steel Statistical Yearbooks [11]; for the period 1970-2002, it can be very well estimated using "apparent steal" from these Yearbooks together with the data in the report [12], with an error of ±10%. The data for old scrap are available from a recent study [13] for EU-28; for EU-15, we employ the percentage that stems from the average relation EU-15/EU-28 with respect to true steel use, i.e. 75%.

2.4. "Biomass Ecological Footprint"

Here, we take the well known concept of the ecological footprint ([14]) as the starting point and then substract the carbon footprint and buildup-footprint from the total. The resulting footprint contains the footprints of cropland, grazing land, fishing grounds and forest products and might therefore be called the "biomass ecological footprint". It is a good measure of the actual, consumption-based use of biomass resources. This footprint for the EU-15 between 1970 and 2018 can be calculated from the country data provided in the Global Footprint Network database [15].

2.5. Energy

The primary energy consumption (PEC) of EU 15 is readily available from the BP-database [16], but as such it is territorial-based and not consumption-based. The net energy imports from trade (i.e. the difference between consumption-based and production-based energy consumption) are documented by the OurWorldinData-Site [17] for the years 1995-2019. For the years prior to 1995, we assume that the development of the relation "net energy imports / PEC" follows the development of the relation "trade volume / GDP", the latter being documented on the same site [18]. This is a good approximation, since the (virtual) net energy imports only amount to around 10% of the resulting total energy consumption, and so even an inaccuracy of ±30% in the above calculation yields an error of less than ±5%.

3. Results

3.1. DMC Total

Figure 1 shows the decoupling of total DMC – it is impressive to see that ever since 1980, DMC has been practically stable, and has actually been falling for the past 15 years, reaching a level today which is lower than in 1970. It is also interesting to note that, on this highly aggregated level, the trade component of DMC has basically stayed constant since 1970 at 15-20%.

The DMC of EU-15 follows a slightly inverted U-shape, and this pattern also holds true for most of the individual countries. Figure 2 shows the inverted U- shape of DMC for seven countries with a peak between 1980 and 1990; among them the four big European economies: Germany, France, UK and Italy. Figure 3 shows the same pattern, but with a peak between 2000 and 2010, for the three southern European economies. Finally, for Denmark and Austria, the development of DMC shows essentially stability over the past 15 years; only for Ireland and Sweden we do not see a clear case of absolute decoupling (Figure 4).

3.2. DMC Subcategories

Zooming in on the DMC-subcategories and on the past 15 years, Figure 5 shows that since 2005, the decrease of EU 15 - DMC has been mainly caused by a significant decline of the use of nonmetallic minerals as well as fossil energy carriers, whereas biomass use was stable and use of metal ores showed a slight upward trend.

3.3. Metals

As Figure 6 shows, EU-15 actually uses less raw iron today than it did 50 years ago, and that a permanent, absolute decoupling started about 20 years ago. (The relevant data for EU-28 – not shown here - suggest that there is a similar decoupling also in the case of copper; whereas for aluminium, the available data are incomplete but lead to the assumption that there is, so far, no decoupling at all).

3.4. Biomass Resources

For biomass resources, the consumption-based indicator "biomass ecological footprint" shows a similar trend: Figure 7. The Europeans in EU-15 use about the same amount of biomass resources as they did in 1970: absolute, permanent decoupling. The trade component here is quite small at below 10%.

3.5. Energy

The situation with respect to energy is similar to the other indicators – consumption-based energy use has been rising up until 2005, albeit at a much slower rate than GDP, and absolute decoupling has been achieved over the past 15 years, Figure 8. Taking into account the ambitious climate targets and energy efficiency goals of the EU, this decoupling will surely continue and accelerate in the next decades. (The DMC fossils is also decoupled, as we have seen in Figure 5, but of course so far not nearly sufficiently; in view of climate protection it should reach a level close to 0 until 2050).

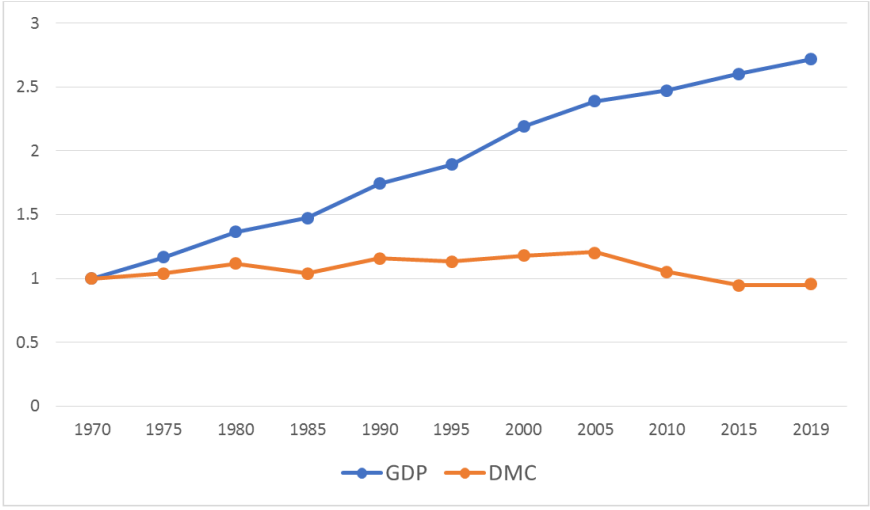

Figure 1. *Development of DMC vs. GDP of the EU 15, 1970-2019. 1970 = 1. (GDP originally in 2015 US$ (inflation-adjusted), DMC in tons).*

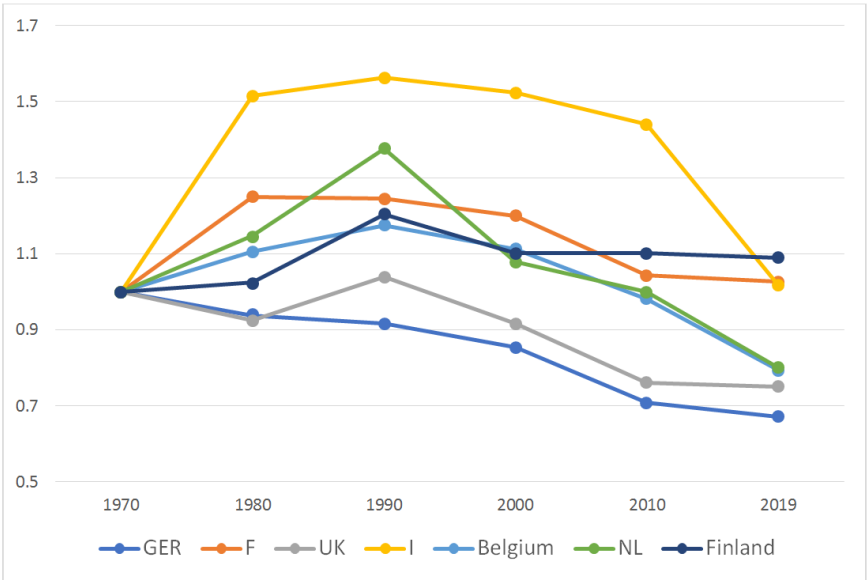

Figure 2. *Development of DMC in seven countries of EU 15, 1970-2019. 1970 = 1.*

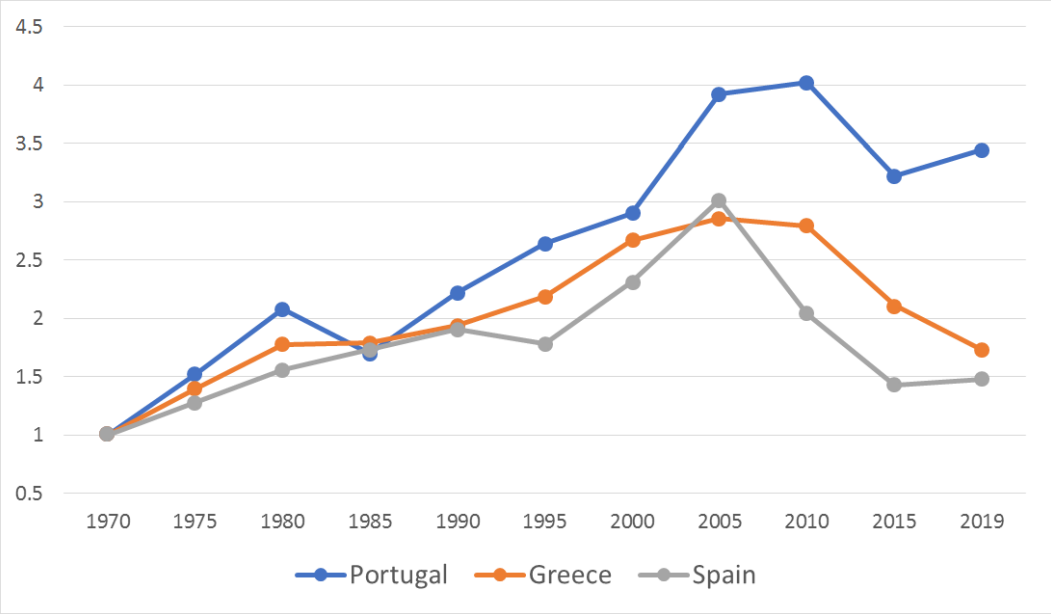

Figure 3. *Development of DMC in three countries of EU 15, 1970-2019. 1970 = 1.*

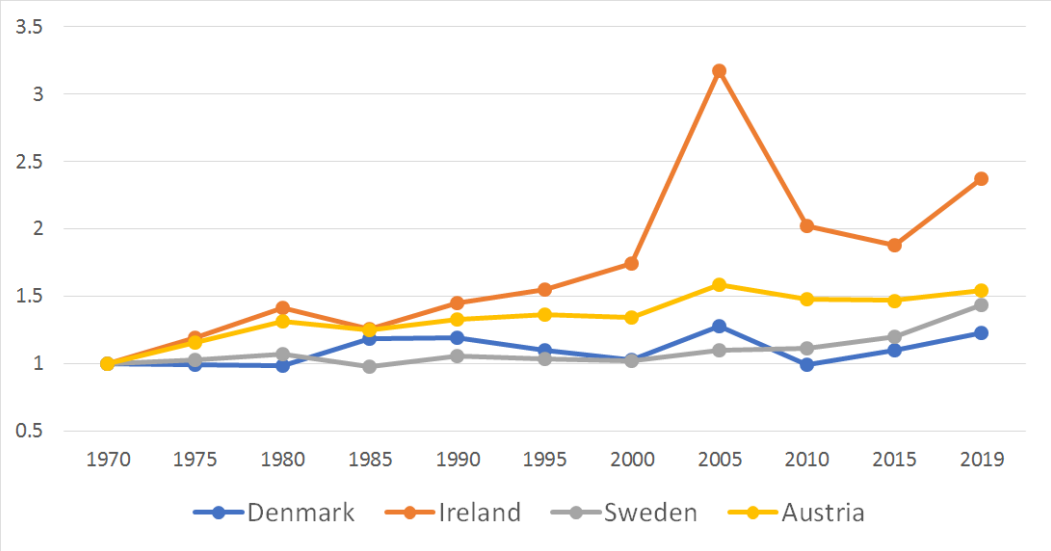

Figure 4. *Development of DMC in four countries of EU 15, 1970-2019. 1970 = 1.*

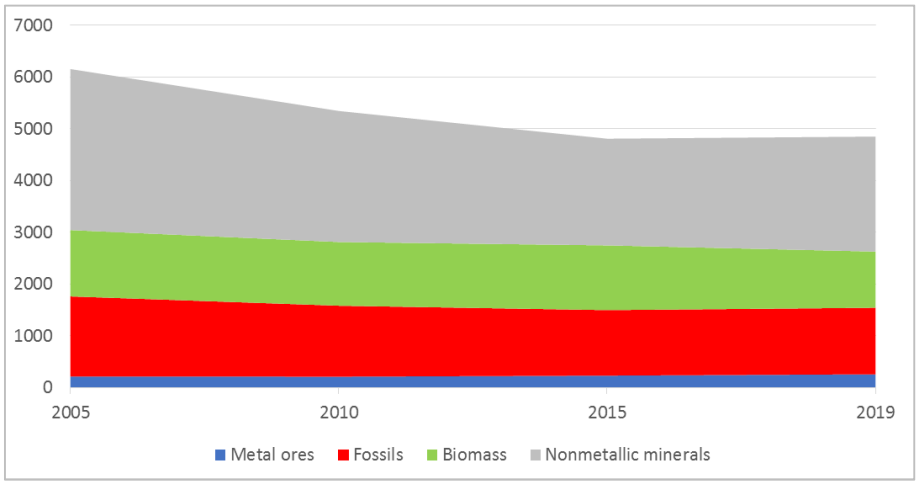

Figure 5. *DMC of EU 15, 2005-2019, in the four subcategories, in million tons.*

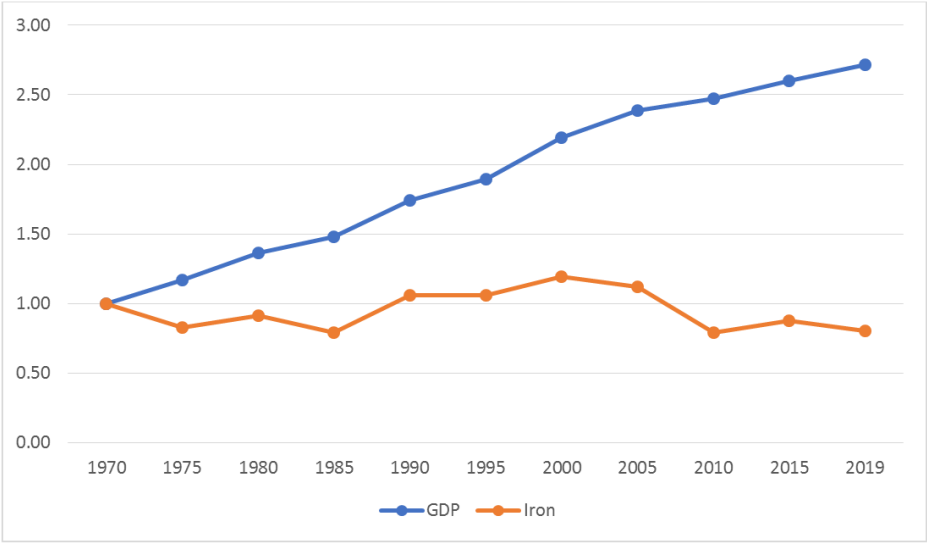

Figure 6. *Development of raw iron use vs. GDP of the EU 15, 1970-2019. 1970 = 1. (GDP originally in 2015 US$ (inflation-adjusted), raw iron use in tons).*

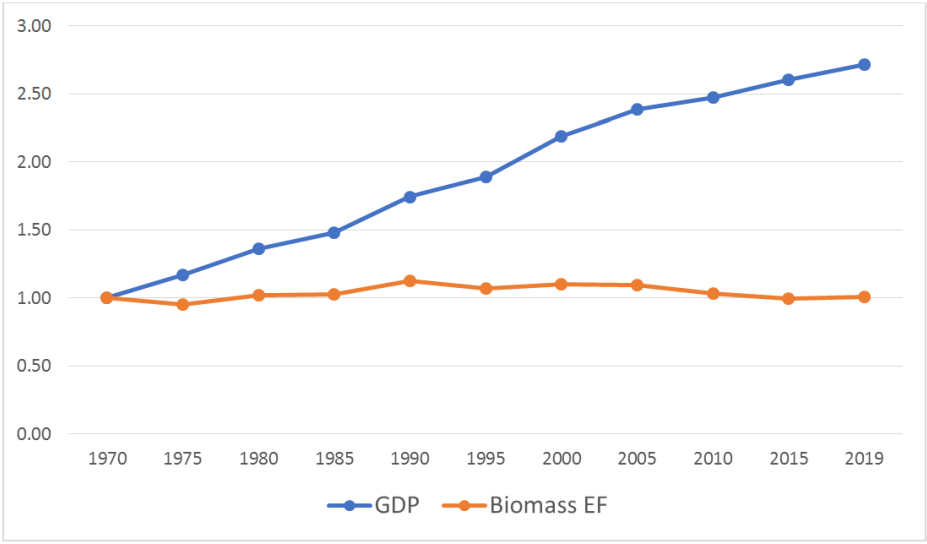

Figure 7. *Development of the biomass ecological footprint vs. GDP of the EU 15, 1970-2019. 1970 = 1. (GDP originally in 2015 US$. Biomass ecological footprint in global hectars; we assume here that the difference between 2018-data and 2019-data (not yet published) is negligible).*

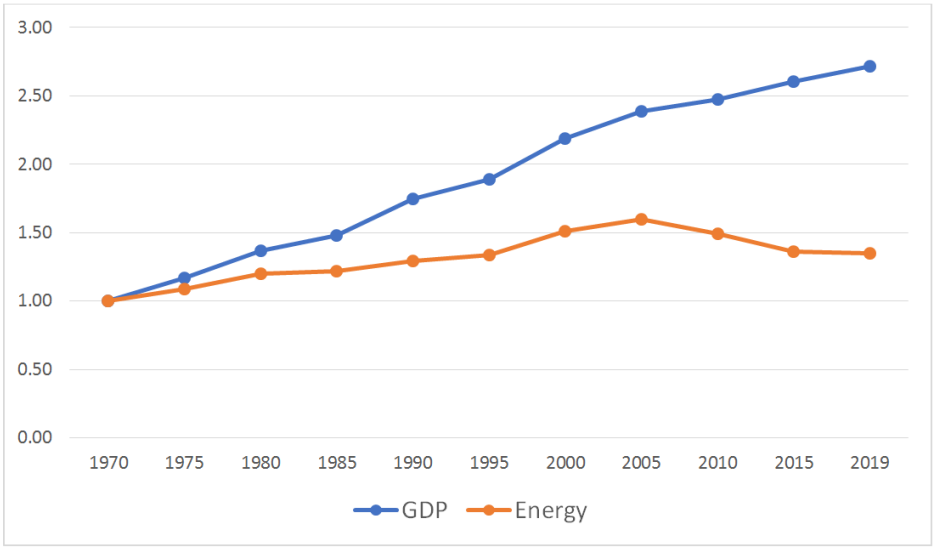

Figure 8. *Development of energy use vs. GDP of the EU 15, 1970-2019. 1970 = 1. (GDP originally in 2015 US$ (inflation-adjusted), energy use in kWh).*

4. Discussion

The results of this study are clear: In the past 15-20 years, consumption-based resource use in the EU-15 has in many important cases absolutely and permanently decoupled from economic growth (measured in GDP). In fact, we do observe the pattern that is required to substantiate the political concept of green growth, Figure 9. In other words: decoupling of resource use is not a singular phenomenon due to specific circumstances, but a broad pattern within EU-15.

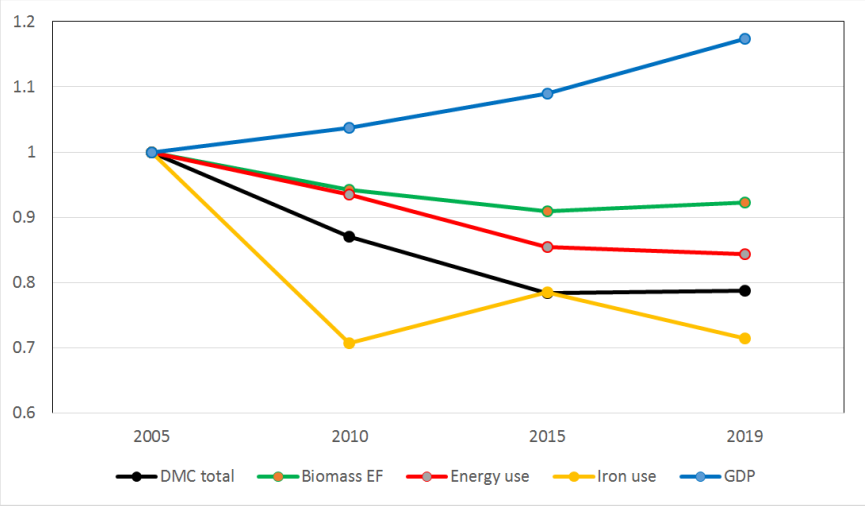

Figure 9. *Development of important resource uses vs. GDP in the EU 15, 2005-2019. 2005 = 1.*

As is obvious from readily available world statistics, the decoupling does not hold true on a global level; the developments are summarized here in Figure 10.

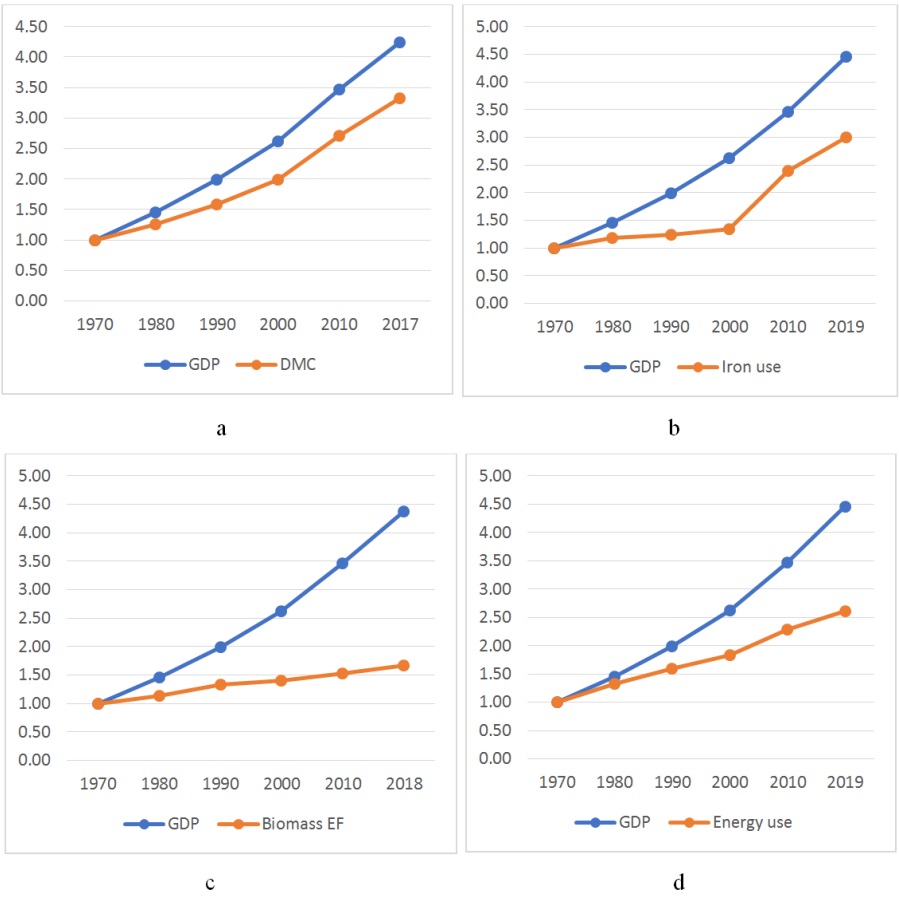

Figure 10. *Development of important resource uses vs. GDP in the world, 1970-2019, 1970=1.*

The interpretation of this remarkable contrast is straightforward and not new: decoupling is a phenomenon in mature industrialized economies, as it stems, among other factors, from high recycling rates (metals, minerals), only slowly growing populations combined with advanced agricultural techniques (biomass) and energy efficiency measures typically found in rich countries (energy). This interpretation is underlined by the observation that - without going into detail - similar decoupling results could probably be shown for the US: for DMC, see the UN-report [6]; for biomass, see the relevant database [15], for energy, see the relevant OurWorldinData-site [17]; compare also the recent book by A. McAfee "More from less" [19], although McAfee uses production-based data which are not sufficient to argue for the decoupling of resource use.

Looking at Figure 10 - rising resources use levels worldwide - and Figure 9 - decreasing resource use levels in the EU-15 -, the question suggests itself how *per-capital-levels of resource use* compare at the present point in time. The answer might be surprising (Table 1): per-capital-levels are - with the notable exception of energy/fossils – actually similar.

Table 1. *Per-Capita resource uses in the EU 15 and the world. Data from 2017 (DMC) and 2019 (energy (consumption-based), iron use).*

Indicator	EU-15	World
DMC (total), t/capita	11,8	11,7
Iron use (raw material), kg/capita	160	170
DMC biomass, t/capita	3,1	3,0
Energy, MWh/capita	47	22

5. Conclusion

The observation that energy is a striking exception from the general rule that overall resource consumption per capita in the EU-15 is hardly greater than in the world (and, if foreseeable trends continue, in the course of the next decades will probably fall *below* global levels) leads to our final point. As encouraging as the results presented here are for the strive for sustainable economic development, it is clear that the issue of "green growth" depends to large degree on the question whether climate neutrality is achievable for mature economies like the EU-15. While many studies show the technical and financial feasibility, and while the adequate political goals are set, the reality is still far away. Indeed, while the consumption-based CO_2 emissions of EU-15 have fallen ever since 2005 (due to the decoupling of consumption-based energy use and the decrease of DMC fossils, see above), and have thus also decoupled from economic growth, the decoupling rate so far is not nearly fast enough.

Still, we believe that "green growth" is a political concept which is worth working for.

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