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Commentary

Carbon Inequality: Resolving Contradictory Results From Two Different Approaches

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Lucia Tamburino[1], Philip Cafaro[2], Giangiacomo Bravo[3,4]

1. Institute for Globally Distributed Open Research and Education (IGDORE), Tallinn, Estonia; 2. Philosophy Department, Colorado State University, United States; 3. Department of Social Studies, Linnaeus University, Kalmar, Sweden; 4. Center for Data Intensive Sciences and Applications, Linnaeus University, Kalmar, Sweden

Two approaches to assigning responsibility for global carbon emissions provide complementary insights. Individual-level analyses highlight the disproportionate emissions of the wealthy, and country-level ones highlight the growing importance of emissions from middle-income countries. We propose the concept of reasonable vs. excessive consumption as a way to integrate these approaches into a synergistic and less divisive perspective on how to address the current climate challenge. Commonly advocated efficiency improvements should be supplemented by cutting excessive consumption and acknowledging the role of population in sustainability goals in both high-income and poorer nations.

Corresponding author: Giangiacomo Bravo, giangiacomo.bravo@lnu.se

1. Introduction

To formulate fair and effective policies to reduce carbon emissions, it is crucial to identify their main drivers. Unfortunately, some results provided in the scientific literature and activist reporting can end up confusing rather than clarifying the issue and possibly hindering the process of reaching a consensus on the best policies to address them.

On the one hand, several studies emphasize the disproportionate emissions generated by the wealthy[1][2]. An often-quoted report, commissioned by Oxfam and carried out by the Stockholm Environment Institute, claims that the richest 10% of the world population (about 800 million people) is responsible for 50% of global greenhouse gas (GHG) emissions, while the poorest 50% (about 4 billion people) only accounts for 8% of GHG emissions[3]. While this report was not peer-reviewed, the result is confirmed by scholarly work. In a study published in *Nature Sustainability*, Chancel shows that, between 1990 and 2019, the bottom 50% by income of the world population emitted, on average, 1.4 t of CO_2 per person and year (leading to 11.5% of global emissions), the middle 40% emitted 6.1 t (40.5%), and the top 10% emitted 28.7 t (48%)[2]. Chancel also finds that the top 1% emitted, on average, 101 t CO_2 per person and year, 16.9% of the total, showing how just 80 million wealthy individuals had an impact larger than the poorest half of the human population.

On the other hand, the most recent IPCC assessment report attributes substantial emission increases to the growth of a global consumer class, numbering several billion and capable of generating substantial carbon emissions due to newfound prosperity[4]. According to the same report, population growth is one of the main drivers of increased global GHG emissions. This is confirmed by a recent study showing that this factor drove 40.2% of global carbon emission increases over the last three decades[5]. Moreover, the same study found that middle-income countries are currently the largest emitters of GHGs and were the main cause of global emission increases in the last 30 years, which is also consistent with the analysis of the global value chain by Meng et al.[6]. Per capita emissions declined in high-income countries during this period, so the slight increase in their total emissions was actually caused by population growth.

To sum up, some voices claim that a relatively small, wealthy elite is responsible for most global GHG emissions. They also consider the role of population growth negligible, arguing that most population growth occurs in poor countries with low per capita emissions. Other research, however, indicates a variety of multiple and interconnected factors, including population growth, as main drivers of global carbon emissions, along with increased wealth. In this work, we show that these outcomes derive from two different yet complementary approaches and that, when correctly interpreted, the apparent contradiction vanishes.

The remainder of the paper is organized as follows. Section 2 presents the difference between individual and country-level approaches along with their advantages and limits. Section 3 warns against possible misinterpretations and simplistic conclusions, which may lead to the illusion of easy solutions to the climate emergency. Finally, Section 4 suggests an alternative approach, which may have the potential to go beyond divisive perspectives and address climate change in a more effective way.

2. Individual- vs. country-level approaches

The studies above crucially differ in their level of analysis. The ones emphasizing the role of inequality and economic disparities, such as[2] and[3], usually take an individual-level approach; the ones resulting in a multiplicity of factors affecting climate change, such as[4][5][6], take a country-level approach. Both compare carbon emissions from different income groups but use different data to define them: estimates of individual income (usually at the household level) vs. country-level Gross Domestic Product (GDP) statistics. As a consequence, the expression "income group" takes a different meaning in the two approaches: people with a given income regardless of where they live, in the former, and populations living in countries with a given per capita GDP, in the latter. For instance, adopting an individual-level approach, "the rich" are high-income people living in any of the world's countries, while adopting a country-level approach, "the rich" are people living in high-income countries. Although there is some overlap between these two groups, they remain conceptually and practically different.

This difference is highlighted in Figure 1, which compares the outcome of two different analyses. Panel A shows Chancel's individual-based approach, and Panel B shows our analysis using country-level data from the World Bank database[7]. To perform this analysis, we first ranked countries based on their per capita GDP, then created groups using the same splits as in[2] to facilitate comparison. Thus, in Panel B, "top 10%" includes the first countries in the

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ranking whose combined population covers 10% of the global population, "middle 40%" includes the next countries in the ranking whose combined population covers 40% of the global population, and "bottom 50%" includes all other countries.

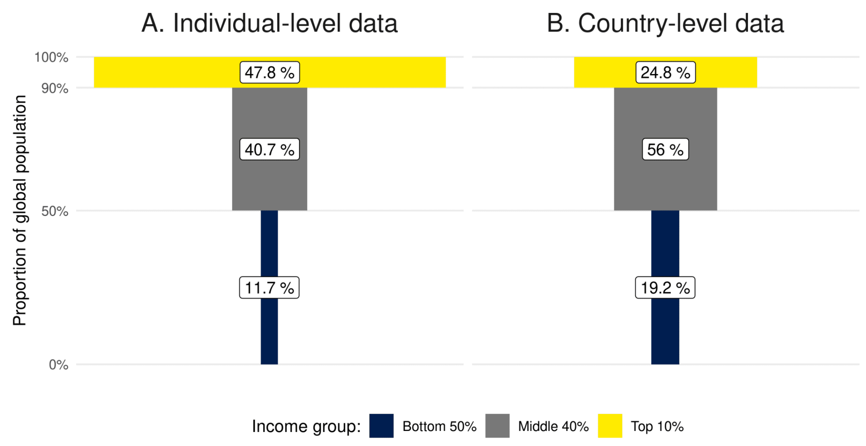

Figure 1. Distribution of 2019 emissions by income group defined using an individual-level approach (Panel A) and a country-based one (Panel B). Areas in the figure are proportional to emissions. Data sources: Panel A[2], Panel B[7].

These different ways to compute emissions result in relatively similar global emission estimates. The country-level approach leads to a total emission estimate of 48.1 Gt CO_2-equivalent for 2019, while the individual-level approach leads to 46.3 Gt CO_2-equivalent. Nevertheless, the distribution of these emissions is significantly different (Fig. 1), although considerable inequality is still present. The reason for such contrasting results is that economic disparities exist not only *between* countries but also *within* countries, as rich people live not only in high-income countries but also in middle-income and even low-income ones. Likewise, poor people also exist outside low-income countries. In fact, while economic disparities between countries have decreased in recent decades, those within countries are increasingly relevant today[2][8].

Besides producing different outcomes, these two approaches have different advantages and disadvantages, as well as technical strengths and weaknesses, which must be carefully considered when dealing with the results of the analyses.

2.1. Advantages and limits of the country-based approach

This approach is probably the most common for studies linking development and GHG emissions[4][5][9]. Its main advantages rely on the fact that it is based on well-established and regularly updated data from internationally recognized sources. For instance, the World Bank data used in the analysis shown in panel B of Fig. 1 include the consolidated emissions for the six main GHGs from most major sources and sinks. In addition, the country level is the one where most political decisions are actually made, which makes research results easier to translate into policymaking.

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This comes at the cost of losing focus on what happens within each country, most noticeably on income differences. This may be especially problematic since the last 20–30 years have seen a parallel decrease in between-country income inequality and an increase in within-country inequality[8], with within-country differences now accounting for almost two-thirds of global emissions inequality, according to[2].

2.2. Advantages and limits of the individual-based approach

Individual-level data are usually derived from household consumption surveys and require extensive processing to estimate the related GHG emissions. For instance, Chancel[2] uses self-reported consumption expenditures from the World Bank's Global Consumption Database[10], which are then transformed into emissions using an Environmental Multi-Regional Input-Output (EMRIO) model.

The main advantage of using this kind of data is that it allows for a consumption-based perspective (also called *environmental or carbon footprint*), where the environmental cost of the consumption of a given good or service is attributed to the individual who actually benefits from it, not to its producer[11]. In addition, they highlight within-country income disparities, which means that high-income emitters in middle- and low-income countries no longer remain hidden behind moderate national averages.

One limit of this approach is the poor reliability of household survey data[12][13]. Moreover, the robustness of input-output tables and other models needed to translate them into GHG emissions is sometimes questioned[14], especially because of their reliance on several simplifying assumptions[15], e.g., fixed production structures and proportional relationships between inputs and outputs[16][17]. This means that its outcomes are more uncertain and should be taken with care.

Moreover, in the framework developed in[2] and also used in the Oxfam report[3], individual emissions are generated by three different factors: private consumption, public spending, and investments. While the attribution of the environmental cost of private consumption to the consumer is straightforward, the other two are problematic.

Emissions from public spending are linked to the provision of infrastructure and services of public interest. It is not always evident how to attribute the related emissions to individuals, as specific groups may benefit differently from specific infrastructure or services, but a reasonable strategy is to split them equally among all residents in a given country. This was the baseline strategy used by Chancel, although he also tried alternative splits, which did not drastically change the final picture.

Investments have two sides. From the point of view of the investor, they are mainly a way to produce a rent from existing financial capital. However, when adopting the point of view of the investee—usually companies or countries—the picture becomes more complicated. Countries use the invested capital to provide infrastructure and services to citizens. Companies use it to buy equipment and services to produce goods sold on the market, which requires consumers willing to buy them for the investment to become profitable. Chancel attributes the whole environmental cost of investments to investors[2], which is a simple and practical way to account for it but hides the fact that investments are ultimately driven by the final demand for goods and services[15].

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An alternative accounting is to attribute the emissions from investments to the individuals who consume the final goods[15], which would also be more consistent with a consumption-based perspective. Since investments represent a large part of the emissions of the richest people, such an alternative attribution would lead to a very different outcome from the one found by Oxfam and Chancel and more similar to the country-level approach.

In short, while the individual-level approach has the advantage of taking a consumption-based perspective, it presents significant methodological challenges, and its outcomes are strongly dependent on several debatable assumptions.

3. Risks of Misinterpretations and Simplistic Conclusions

Despite their different perspectives, the results of the individual-level approach are sometimes misinterpreted as providing country-level information. For instance, the opening of Oxfam's report states: "The richest people, corporations *and countries* are destroying the world with their huge carbon emissions"[3].

Similar arguments, sometimes combined with a poor knowledge of the technical background of the analyses, may lead to an oversimplified debate about how to reduce carbon emissions. The conclusions emerging from this debate create the illusion of easy solutions, without the need to take a more comprehensive approach. Two of the most common conclusions are presented below.

3.1. "Cutting the Consumption of the Wealthy Is the Solution"

On any plausible account, the wealthy do generate a large share of GHG emissions. This suggests that cutting their consumption will lead to a significant reduction in GHGs. However, most wealthy people's emissions are not due to consumption. While[3] assumes that the elasticity of the carbon footprint with respect to income is equal to 1,[15] criticizes this assumption and shows that such an elasticity is actually significantly lower (usually between 0.5 and 0.8).[1] This means that, *focusing on consumption alone*, high-income households emit proportionally less per unit of income than low-income ones[18][19] and therefore GHG emissions are more evenly distributed than generally thought, implying that the emission reduction achievable by cutting the top 10% consumption is more limited than generally expected and possibly insufficient to solve climate change. This is because the proportion of income that is spent on consumption typically decreases when income increases because a larger share of income goes to savings and investments.

In fact, as explained in Section 2.2, a large part of the emissions of wealthy people is linked to investments[2]. Such emissions are totally attributed to the investors in Chancel's and Oxfam's approach but are ultimately driven by the consumers of the final goods and services produced through investments. As a consequence, even if the richest stopped investing, other investors might exploit the existing demand for these goods and services. Shifting investments from wealthier to poorer individuals would make societies more equal but would not necessarily lower overall GHG emissions.

Also note that reducing the investments of wealthy people may have negative consequences for the general population, such as higher prices and reduced employment opportunities. This does not mean that wealthy people do not have

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to cut their emissions; however, it is important to recognize these potential spillover effects.

Moreover, cutting investments is not always positive for the environment, as certain investments can actually result in lower GHG emissions in the medium to long term (e.g., renewable energy, renovation of obsolete infrastructure).

3.2. "Population Growth Is Not Relevant"

Oxfam's champagne-coupe graph is often used to support the argument that population growth is irrelevant for climate change, since population is mainly growing in poor countries, while carbon emissions mainly come from rich countries where population does not grow. However, this argument only holds assuming that humanity's richest 10% all live in the world's richest countries, which is incorrect and not even supported by the considerations included in the Oxfam report itself[3].

Our country-level analysis adjusts this picture. The 10% of people living in the richest countries are not responsible for half of global emissions, but for about one-fourth (see Fig. 1, panel B). They do have higher average individual emissions than citizens of poorer countries, but the difference is less extreme and the champagne coupe shape of the graph is lost, replaced by a glass of "vin ordinaire".

Crucially, most current global emissions (56%) are produced by countries in the "middle 40%" group (Fig. 2), a set of 77 countries that includes the entire upper-middle-income group of the World Bank and includes parts of high- and lower-middle-income countries as well (Fig. 2). Nearly a quarter of these 77 countries have fertility rates above the replacement rate, and this group's population growth is significant, amounting to more than 182 million people in the last 10 years, fully 24% of global population growth[7].

This shows that Oxfam's report does not actually support the argument above. Moreover, as the IPCC notes in its *Sixth Assessment Report*, "modest population increases in wealthy countries may have a similar impact on emissions as high population increases in regions with low per capita emission levels"[4].

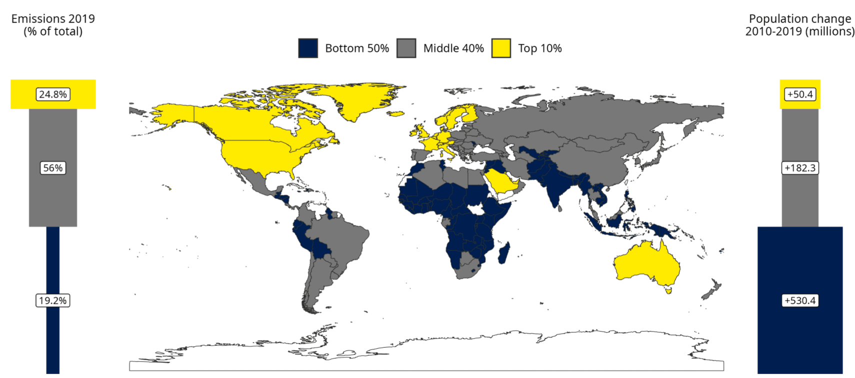

Figure 2. Geographical distribution of country income groups. The left panel reproduces the results presented in Figure 1B. The right one shows total population changes per group in the 2010–2019 period. Data source:[7].

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4. A More Comprehensive Approach

The socially and politically most accepted approach to mitigating climate change and other environmental challenges relies on a technology-driven greening of both consumption and investments[20][21]. Reorienting the choices of both final consumers and investors toward options less damaging to the planet represents a necessary step for sustainability[22]. However, this may not be sufficient to meet the current environmental challenges[20][23], and further, complementary strategies should also be explored.

To reduce the risk of misinterpretations discussed above and highlight a fuller range of climate mitigation options, we propose a shift from *who* is consuming to *what* is being consumed, distinguishing between *reasonable* and *excessive* consumption. Reasonable consumption can be defined as consumption needed to maintain decent living standards, such as the set of goods and services needed to support a level of human well-being that meets the Sustainable Development Goals of the United Nations[24][25]. Excessive consumption would then be consumption exceeding this level.

In practice, a division between reasonable and excessive consumption is difficult to make, beyond extreme cases such as private jets or luxury yachts[26][27]. Yet much excellent ethical work has been done on this distinction in recent decades, from the perspective of capabilities theory[28], human needs theory[29][30], political limitarianism[31] and sufficiency theory[22][32]. Any detailed distinctions between necessary and excessive consumption for any particular society will have some subjective elements. Still, three fundamental questions can always be deployed to discipline and limit this subjectivity: *(i)* Is the consumption in question necessary for human health or survival? *(ii)* Is it useful for enriching human life? *(iii)* Is it possible for large numbers of people given regional and global ecological realities?

Although further research is needed to develop this approach, these questions and their answers could help world leaders negotiate a fair international division of labor in fighting climate change, beyond divisions among opposing social groups or nations, which have historically hindered effective agreements and policies[33][34].

4.1. Cutting excessive consumption: part of the solution

While cutting reasonable consumption is neither realistic nor in line with the SDGs, excessive consumption can and should be cut, regardless of who is doing it and where they live. Significantly cutting excessive consumption is crucial[1], both because it represents a significant percentage of the total and because most people will not sacrifice to cut their own emissions without a positive example from the world's top consumers.

Wealthy consumers must do their part. Nevertheless, middle-income people are responsible for a comparable, if not larger, proportion of consumption-related emissions (see Section 3.1) and will also have to cut their excessive consumption if we are to avoid catastrophic climate change. This can be accomplished indirectly, through a general carbon tax, or directly by prohibiting excessive consumption, starting with the most obvious[35]. Meanwhile, many of the world's poorest people should likely increase their consumption to meet the

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SDGs. This will lead to a more fair and equitable world[20][36], but it makes the overall reduction of GHGs even more challenging.

Given these limits on possible consumption cuts, a logical question is whether cutting excessive consumption and improving efficiency will be enough to meet the Paris agreement's goals. Moreover, it is difficult to convince people to significantly cut their consumption and, where successful, it will have real costs and externalities (see Sections 3.1 and 4.1). This suggests that we should adopt a more integrated approach, taking into account all important emission drivers[5][37][38][39].

4.2. Reducing human numbers: part of the solution

Population growth is recognized as one of the two main drivers of increased GHGs[4]. As the IPCC's Sixth Assessment Report states, "globally, GDP per capita and population growth remained the strongest drivers of CO_2 emissions from fossil fuel combustion in the last decade"[4]. As long as the population keeps growing, we have to expect a growing demand for goods and services. As long as there is a demand, someone will invest to satisfy it. This will result in an increase in investments, which represent the largest part of the GHG emissions of the wealthy (see Section 2.2).

In addition, there is overwhelming evidence that today's population of 8 billion people, mostly living with the benefits of industrial civilization, is already unsustainable[38][40][41]. Several scientific studies show that policies to limit population growth have a significant potential to reduce GHG emissions and would often do so with less cost and greater co-benefits than other options[40][42]. For example,[43] found that if the world population followed a low rather than a medium growth path scenario, global emissions would be reduced 15% by 2050 and 40% by 2100.

Policies aiming to reduce and possibly reverse population growth should, hence, be part of the solution[44], clearly avoiding coercion. It is worth noting that, unlike the deplorable one-child policy in China, there are many examples of effective and voluntary family planning programs, which did not violate but enhanced human rights and led to improvements in the quality of life for women and children[45][46]. Access to voluntary family planning services and modern contraception should be universally available and affordable[47].

5. Conclusion

While carbon inequality is an undeniable fact, the idea that climate change can be solved only by cutting the emissions of wealthy people is an oversimplification that neglects other undeniable facts, such as the deep interconnections between individual emissions, the large and increasing consumption-related emissions of the middle class, and the role of population growth in driving growing emissions. While cutting the consumption of the richest is necessary and ethically desirable, the search for climate culprits risks blinding us to a simple fact: a significant part of emissions is driven by a growing population demanding more and more.

We are in ecological overshoot, and there is no viable option but to return within planetary boundaries[38][48][49]. Simultaneously addressing all emission drivers, including population growth, and cooperating across economic and political divisions look like the most promising ways to mitigate climate change and achieve sustainability.

Statements and Declarations

Data availability

The data used for the country-level analysis in Figure 1 (panel B) and Figure 2 are publicly available from the World Bank Open Data repository[7]. Data for the individual-level analysis in Figure 1 (panel A) are derived from the work of Chancel[2].

Author contributions

LT: Original idea, Conceptualization, Writing, Visualization. PC: Conceptualization, Writing. GB: Conceptualization, Writing, Data curation and analysis, Visualization.

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Footnotes

[1] In economics, elasticity measures how responsive one variable (here, emissions due to consumption) is to changes in another variable (here, income). A more detailed explanation can be found in[15].

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