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Green business: Growth or degrowth to meet IPCC targets? Discussion of an assessment tool: IPCC CAPRO change target

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ABSTRACT

This article questions the prospects for growth or degrowth of companies as a means of preserving the Earth's ecosystem. More specifically, we propose using a carbon productivity indicator in association with the IPCC Carbon Productivity Target (based on UNFCCC work) to assess the genuine ecological impact of corporate economic activity. This indicator was applied to data from 2015 to 2019 for a sample of companies in the SFB 120 index, and results from their classification are compared to the results obtained with indicators that do not take into account the IPCC targets based on UNFCCC work (Scopes). We highlight how a company's economic growth plays a key role in the fight against global warming. We found that a significant share of the companies that usually qualified as green using the Scope 1 and 2 emissions are, in fact, not green (63% and 43% of polluting and low-polluting companies, respectively). We underscore the fact that while green growth still seems possible, the same is true of green degrowth. More specifically, our results advocate for either controlled growth or for slight degrowth in business activity. Lastly, our results open a discussion on degrowth by highlighting how companies in this situation are over-represented among those that meet IPCC objectives.

1. Introduction

Since the industrial revolution, human activities have released ever-increasing amounts of carbon dioxide (CO₂), methane and nitrous oxide into the atmosphere, accelerating the greenhouse effect. This has resulted in global warming that could exceed the 1.5 °C this century (IPCC et al., 2022). In 2019 alone, total greenhouse gas (GHG) emissions represented the equivalent of 59.1 billion tonnes of CO₂e. One of the reasons for this considerable amount is that economic growth has been accompanied by an excessive use of fossil fuels (coal, oil and gas) and industrial processes. Companies have been among the main culprits in environmental degradation as they overexploit natural spaces and destroy biodiversity with their pollution (Gray and Bebbington, 2001; Otero et al., 2020; Parrique, 2022; Bigoni and Mohammed, 2023).

Recent literature highlights the tension between corporate economic growth and ecological sustainability objectives (Engelmann et al., 2019). The literature identifies three responses to this tension (Svenfelt et al., 2019): (1) seek a balance between ecological sustainability and economic growth (Daly, 2014), i.e., by targeting economic growth while trying to reduce its negative impacts on the environment (Victor, 2010),

for example by moving towards international agreements and national legislation on a voluntary basis (Randers, 2012); (2) make ecological sustainability a fundamental requirement in economic development (Alfredsson and Wijkman, 2014), whereby there can be no economic growth without achieving ecological sustainability; and (3) embrace degrowth, i.e., reduce consumption and production in order to reduce energy and raw material consumption (Svenfelt et al., 2019), whilst maintaining (or improving) the carbon efficiency of economic activity.

As Engelmann et al. (2019) have pointed out, the first two options are part of so-called “green growth.” Recently, there has been much discussion of this concept of green growth (Mensah and al., 2019) motivated by the observation that “global pursuit for economic success often leads to environmental degradation” (op. cit., 2019, p. 1). Green growth suggests that companies are required to use clean inventions, processes, technologies and energy that can generate environmental benefits throughout the value chain (Engelmann et al., 2019) while improving the sustainability of their operations (Bhupendra and Sangle, 2015). This means investing in green technologies that reduce the potential risk of climate change (Lin and Zhu, 2019).

From the critical perspective of so-called green growth, the third

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option (degrowth) emphasizes the concept of sufficiency (Hickel, 2019) and more frugal consumption (Kallis, 2011). This approach has recently received support due to the ecological consequences of economic expansion (Engelmann et al., 2019). Recent research in environmental science (Matthews and Wynes, 2022) has shown that the climate has already warmed by 1.25 °C, whereas the maximum temperature increase target for achieving (and maintaining) zero net carbon dioxide emissions globally within the century is 1.5 °C (IPCC et al., 2022). According to the authors, meeting this target would require reducing CO₂ emissions by 43% from 2022 to 2030 (Matthews and Wynes, 2022), which could require degrowth (Hubacek et al., 2021).

Beyond these two paradigms of growth and degrowth, serious questions are now being raised about the concept and measurement of so-called green growth. "Green growth" has been the subject of much criticism (Dale et al., 2016), not only because it may be "greenwashing" (Stoknes and Rockström, 2018, p. 42), but also because it lacks "measurable criteria ... and clear and simple indicators" (Stoknes and Rockström, 2018, p. 42). In addition, Stoknes and Rockström (2018) and, more recently, Tilsted et al. (2021), have drawn a distinction between "green growth" and "genuine green growth." The authors point out that it is difficult to determine whether these types of growth are actually "green" or whether they are "light green" or an example of "greenwashing." While several authors argue that, in many cases, green growth refers to slightly more sustainable production, this is not sufficient if we consider the limits of the Earth's ecosystem (Ferguson, 2015). In this respect, Stoknes and Rockström (2018, p.43) suggest that genuine green growth may be defined as follows: "to earn the label of 'genuine green growth' the carbon productivity of an economic entity must achieve a trajectory over time sufficient to meet science-based targets derived from planetary boundaries".

While these definitions have their merits, they currently have several limitations. First, they have only been posed at the macro (state) level and have not been used at the micro (company) level. Yet companies play a key role in environmental degradation (Gray and Bebbington, 2001; Otero et al., 2020; Bigoni and Mohammed, 2023; Lux, 2023).

Second, while recent articles have examined companies' carbon productivity (Wu and Yao, 2022; Bagchi et al., 2022), these studies have not linked this productivity to practical environmental targets, such as those of the UNPCCC target-setting methods or Science-Based Targets initiative when this is now considered essential for the future of our ecosystem (Bjørn et al., 2017; Bjørn et al., 2021; Bebbington and Rubin, 2022; Bai et al., 2022). They therefore rely on an "ungrounded" environmental efficiency rationale that can lead to companies being classified as "green" when, in fact, they are not. This is particularly true of the work of Randers (2012), who proposes a "GEVA" tool to guide companies based on their GHG emissions per unit of value added, but which, as underlined by Bjørn et al. (2021), does not make a specific reference to the IPCC.

Third, in these articles, the authors are not interested in changes in carbon productivity vis-a-vis the growth rate, so they do not allow for an assessment of the absolute impact on the Earth's ecosystem. For example, the GEVA tool proposed by Randers (2012) is based on a single target for corporate GHG emissions per unit of value-added. Beyond the fact, as the author points out, that GEVA may show spurious variations from year to year, as value added can be seen as a fraction of revenue and may fluctuate over time, it is based on assumptions that reduce its operational scope. According to the SBTi report (2019), the GEVA Target is estimated by assuming that all companies are growing at the same rate that is equal to the global growth rate, which is arbitrarily set at 3.5% per year. This conceptual limitation tends to reduce the usefulness of the indicator for controlling global emissions when global GDP growth is different from this rate.

Lastly, these studies (Wu and Yao, 2022; Bagchi et al., 2022) do not consider the issue of degrowth, due to a logic that is based exclusively on growth. For example, Wu and Yao (2022) underscore how a low-carbon activity without economic growth would be meaningless under the

principle that "economic growth is critical for enhancing social welfare and increasing the population's standard of living" (Wu and Yao, 2022, p. 1). The authors therefore effectively exclude any discussion of degrowth for meeting environmental targets. By focusing solely on increasing the intensity and efficiency of R&D to improve carbon productivity, Bagchi et al. (2022) also help do away with the idea of potential business degrowth, even though this could be part of the solution (Hickel, 2019).

These ideas lead us to raise the following related questions: How can we assess whether a company is truly helping preserve the Earth's ecosystem? Can the measurement of a change in carbon productivity associated with IPCC targets constitute a relevant way to assess companies? And what does this measure tell us about the growth or degrowth prospects of companies with regard to the need to preserve our environment?

This paper therefore has two objectives: (1) to question and propose the use of a carbon productivity indicator for companies in relation to the IPCC's targets; and (2) to question and discuss the growth or degrowth capacity of businesses with a view to preserving the Earth's ecosystem.

In order to achieve our objectives, we first study the relevance of corporate economic growth or degrowth and the changes in corporate emissions achieved through modified carbon productivity. This allows us to propose an indicator for assessing green growth based on the change in carbon productivity expressed in terms of IPCC targets. We also study and illustrate our proposal using data on GHG emission volumes (in tCO₂e) published between 2015 and 2019 by the largest French companies in the SBF 120 index. Our study therefore contributes to the existing literature through its originality and innovative approach. This is the first study to examine green business growth by investigating the link between the change in carbon productivity and IPCC targets. We also highlight the essential role played by companies in the fight against global warming by controlling changes in their level of activity. Lastly, our proposed indicator (IPCC CAPRO Change Target) can help businesses and stakeholders become more aware of the climate consequences of their operations, thereby enabling them to find trade-offs between economic development and environmental preservation.

The paper is organized as follows. Section 2 presents the concept of carbon productivity and its relationship with green growth. This is followed in Section 3 by a demonstration of the usefulness of analyzing the change in carbon productivity in relation to the IPCC's targets for companies.

In Section 4, we explain the methodology applied to SBF 120 companies and present our results. Section 5 discusses the growth/degrowth characteristics of companies and our proposal for the IPCC CAPRO Change Target. Section 6 concludes with a discussion of the study's main results and contributions.

2. Carbon productivity and green business growth

Recent research suggests using carbon productivity to assess the green (or non-green) growth status of economic entities (Stoknes and Rockström, 2018). According to Shen et al. (2021), carbon productivity can serve as a key indicator in assessments of economic growth that is low in carbon emissions. Carbon productivity (or annual resource productivity) has historically been measured as an economic activity level divided by a physical unit representing resource consumption that is expressed, for example, in tonnes, kWh or even hectares (Stoknes and Rockström, 2018). This measure is used to determine the genuineness of entities' green growth by comparing variations in carbon productivity and economic growth rates (historically from a macro perspective, GDP or GNE (gross national expenditure)). The change in carbon productivity from one period to the next represents the percentage change in the ratio of the entity's economic activity level over its use of environmental resources. This can be represented by carbon emissions considered to be the main contributors to environmental problems such as climate change (Usman and Makhdam, 2021).

Some studies point to the value of linking carbon productivity with policy objectives, particularly at the level of economic sectors (Li et al., 2018). The ostensible objective is to achieve an optimal trade-off between carbon emissions and the outcome of economic transactions in order to promote growth and employment while still striving to balance the cost-efficiency ratio. However, the outcome depends on several factors, such as the data and methodology used (Bagchi et al., 2022). An industry-based approach to carbon productivity would therefore be necessary to take into account the fact that certain industries have a greater potential for reducing carbon emissions, as shown by Wu et al. (2020) for electric power generation and the steel industry.

Industries in general and companies in particular thus have a major role to play in the ecological transition (Stamm, 2015) by locating their operations close to the citizens and consumers who are the source of their growth. The idea would therefore be to be able to specify, operationalize and translate what green growth means for businesses into concrete targets. In the vast majority of studies, so-called “green” growth must respect the following inequality: change in carbon productivity > change in economic growth. In this specific case, growth is green because there is a decoupling of the entity’s growth from its use of resources: the economy grows while emissions fall.

In order to study this decoupling, particularly with regard to emission reductions, it is essential to understand the origin of GHG emissions and the systems used to measure them (Harris and al. 2020). In this respect, Tilsted et al. (2021) distinguish between two perspectives: (1) a production-based accounting (PBA) approach, which places the responsibility for pollution on political authorities, whereby nation states are “the agents of global warming” (Lohmann, 2009, p. 501 cited by Tilsted et al., 2021); and (2) a consumption-based accounting (CBA) approach, which questions the consumer behaviour and lifestyles that drive the economic growth of the companies producing goods and services. According to the European Environment Agency (EEA, 2013),¹ the PBA approach can include emissions related to the economic activities of households and companies in a country where production and consumption may not be near each other. Conversely, the CBA approach includes emissions occurring upstream of the production of all products and services consumed by citizens, regardless of where the production takes place. It is therefore based on the emissions attributed to the final consumers of goods and services, rather than to the emitting producers. There is a growing body of research focused on the second approach, as carbon emissions from activities and consumption span across borders (Sudmant et al., 2018). In this respect, turnover appears to be a good proxy for valuing consumption.

On this basis, green growth for a company (without using any IPCC targets) can therefore be defined as follows (Stoknes and Rockström, 2018):

$$\Delta \text{ Carbon Prod.} > \Delta \text{ Turnover} \quad (1)$$

where Δ Turnover is the annual change in a company’s turnover, expressed as a percentage, and Δ Carbon Prod. is the annual change in carbon productivity, corresponding to the change in the ratio of turnover to environmental resources used (in this case, tonnes of CO₂).

However, while it is important to assess green growth, proposing a decontextualized assessment of the environmental objectives as identified by researchers in the natural sciences (Matthews and Wynes, 2022) may raise certain problems. It would therefore appear important to be able to link the study of companies’ carbon productivity to the IPCC targets and, more specifically, to carbon emissions constraints, in order to preserve the Earth’s ecosystem.

¹ EEA, 2013. European Union CO₂ Emissions: Different Accounting Perspectives. European Environment Agency: Publications Office of the European Union, Luxembourg.

3. Changes in carbon productivity and IPCC targets for companies

Companies currently report on their environmental commitment by calculating their GHG emissions and how they have changed over time (Fromont et al., 2022). Thus, the Scope² is used by various stakeholders (consumers, employees, investors, and regulatory bodies) to assess the results of the environmental policy implemented to reduce carbon impact (Trinks et al., 2020; Fromont et al., 2023). Companies with a negative change in their Scope 1 and 2 emissions are believed to help reduce global emissions. To achieve this goal, growing companies must strive to improve their carbon productivity at a pace that exceeds their growth rate (Δ Carbon Productivity > Δ Turnover). This is the definition of green growth as discussed above. However, adopting the definition of corporate green growth as “change in carbon productivity > change in economic growth” does not tie this growth to the constraints of the Earth’s ecosystem. Indeed, this definition could just as easily be described as relative green growth or relatively decoupled green growth. However, it is completely impossible for the IPCC et al. (2022) objectives (base on UNFCCC work) to be reached if companies simply reduce their emissions in relation to the growth rate of their overall activity. They must proceed to an absolute decoupling consistent with the IPCC objectives. With this in mind, some authors (Stoknes and Rockström, 2018; Tilsted et al., 2021) have sought to identify a minimum threshold for annual carbon productivity growth in order to meet IPCC targets. In their 2018 article, Stoknes and Rockström set an optimistic minimum value of 5% to limit the rise in temperature to 2 °C. More recently, Tilsted et al. (2021) updated this value based on a stricter target of limiting the temperature increase to 1.5 °C. They identify three more or less precautionary values in terms of the carbon productivity target (which they call Δ CAPRO): 6% (least precautionary value), 10% (average value) and 14% (most precautionary value). However, these minimum thresholds were the product of reflections with macro entities (nation states), while considering the growth of these entities as linear at a fixed value of 3% per year. Defined as the minimum threshold of change in the annual carbon productivity that would allow for preservation of the Earth’s ecosystem, these Δ CAPRO objectives can be approximated with the following equation:

Δ CAPRO Target = required annual global emission reductions + annual growth assumption of the entity (Stoknes and Rockström, 2018; Tilsted et al., 2021).

Table 1 presents the values obtained by Stoknes and Rockström (2018) and Tilsted and al. (2021) as a function of the probability of meeting the IPCC targets.

Relating these numbers to the concept of green growth and the idea of making ecological sustainability a fundamental requirement for corporate economic development (Alfredsson and Wijkman, 2014), we can redefine a company’s green growth with the following conditions:

$$\Delta \text{ Carbon Prod.}_i > \Delta \text{ CAPRO Target} \quad (2)$$

or in expanded form (see methodology for justification and parameter details):

$$(1 + \Delta \text{ Carbon Prod.}_i) > \frac{1 + \Delta \text{ Growth}_i}{1 + \Delta \text{ IPCC Target}} \quad (3)$$

² The GHG Protocol, created in 1998 to help companies calculate their carbon footprint, groups the various sources of greenhouse gas emissions into three main categories: Scopes 1, 2 and 3 (Wbcsd, 2004). Scope 1 covers all direct GHG emissions from sources that are owned or controlled by the company, such as emissions resulting from combustion in facilities or equipment. Scope 2 covers indirect emissions from consumed electricity, heat and steam. Scope 3 (optional) includes all other indirect emissions (such as transportation, purchasing, subcontracting, etc.) resulting from the activities of various stakeholders in the company’s value chain.

Table 1
 Δ CAPRO targets for different probabilities of meeting IPCC targets.

Probability of meeting IPCC targets	IPCC trajectories of max 2 °C (2015–2050 period) <i>Stoknes and Rockström, 2018</i>		IPCC trajectories of max 1.5 °C (2018–2050 period) <i>Tilsted and al., 2021</i>	
	Required annual reduction in GHG emissions (Δ IPCC Target)	Δ CAPRO Target (with 3% growth rate)	Required annual reduction in GHG emissions (Δ IPCC Target)	Δ CAPRO Target (with 3% growth rate)
> 66%	2%	5%	11%	14%
>50%	N/A	N/A	7%	10%
>33%	N/A	N/A	3%	6%

Δ CAPRO Target correspond to the minimum threshold for annual carbon productivity growth in order to meet IPCC targets given an assumption of economic growth.

where “ Δ Carbon Prod._{*i*}” is the percentage change in the carbon productivity of the firm *i* corresponding to the variation in the ratio of its economic activity level to environmental resources used, “ Δ Growth _{*i*}” is the growth rate in economic activity of the company *i* and “ Δ IPCC Target” is the annual decrease in GHG emissions required to meet the IPCC targets (based on UNFCCC work) in each of the tiers (3%, 7% and 11%).

This conceptualization of green growth suggests that companies need to increase their carb productivity above a certain rate to meet the IPCC targets (11% and 7%) despite increasing their activity levels.

This proposal raises the question of whether the current economic (de)growth of companies is consistent with IPCC emission reduction targets, given the evolution of their carbon productivity. To this end, we will study and illustrate the use of this indicator for SBF 120 companies.

4. Use of carbon productivity in relation to IPCC targets in the SBF 120

We want to estimate the extent to which assessing green growth based on carbon productivity in relation to IPCC targets is a better indicator for ranking organizations than indicators that are based solely on changes in emission indicators, such as the Scopes. In addition, we want to be able to exercise judgment about desirable prospects for corporate growth or degrowth in terms of preserving the Earth’s ecosystem. To this end, we will study data from SBF 120 companies.

4.1. Sampling and methodology

The sample consists of the GHG emission volumes (in tCO₂e) published for the 2015–2019 period by the largest French companies in the SBF 120 index. France’s “Grenelle 2” legislative framework requires listed companies to publish their carbon footprint (Decree, 2012-557). This data is useful for forming a representative sample of large French companies, thereby limiting the influence of bias (self-reporting) on our results. The GHG data is certified by an independent third-party organization (Decree, 2012-557), which tends to homogenize the quality of published GHG data for better comparisons of the emissions of different companies.

In order to estimate the annual change in GHG emissions, we only selected companies that had published a minimum of two consecutive years of emission volumes (tCO₂ e). The GHG data were collected from the Thomson Reuters Refinitiv database and includes all direct emissions produced by the company’s operations using fossil fuels (Scope 1) as well as indirect emissions by the generators of the electrical energy consumed by the companies on their production sites (Scope 2). A total of 419 data publications were found to comply with the selected criteria during the study period. The sample is composed of polluting sectors (Transport, Waste Treatment, Energy, Chemicals, Materials and Heavy Industries - N = 169) and less sensitive, so-called low-polluting sectors

(N = 250).³

In order to determine the carbon efficiency of economic activity, the carbon productivity of each company was first estimated by calculating the ratio of its turnover (as recommended by *Net-Zero Asset Owner Alliance, 2020*⁴), used as a proxy for the economic growth of the entity (as discussed above), to its emission volume (tonnes of GHG) for the same year *t* (*Bagchi et al., 2022*). Second, the variable “ Δ Carbon Prod._{*i,t,t+1*}” was calculated by estimating the rate of change (%) in carbon productivity from one year to the next for each company *i*. The dependency between the rate of change in carbon productivity of a firm *i* (Δ Carbon Prod._{*i,t,t+1*}), the rate of annual variation in its GHG emissions (Δ GHG _{*i,t,t+1*}) and the rate of change in its turnover (Δ Turnover _{*i,t,t+1*}) can be expressed as follows⁵:

$$(1 + \Delta \text{Carbon Prod.}_{i,t,t+1}) = \frac{(1 + \Delta \text{Turnover}_{i,t,t+1})}{(1 + \Delta \text{GHG}_{i,t,t+1})} \quad (4)$$

Three tiers of carbon productivity growth were then defined for the companies, based on the GHG emissions reduction scenarios (Δ IPCC targets: 3%, 7% and 11%) proposed by *Tilsted et al. (2021)*:

$$\text{Optimistic tier : } (1 + \Delta \text{Carbon Prod.}_{i,t,t+1}) > \frac{(1 + \Delta \text{Turnover}_{i,t,t+1})}{(1 - 3\%)} \quad (5)$$

$$\text{Median tier : } (1 + \Delta \text{Carbon Prod.}_{i,t,t+1}) > \frac{(1 + \Delta \text{Turnover}_{i,t,t+1})}{(1 - 7\%)} \quad (6)$$

$$\text{Pessimistic tier : } (1 + \Delta \text{Carbon Prod.}_{i,t,t+1}) > \frac{(1 + \Delta \text{Turnover}_{i,t,t+1})}{(1 - 11\%)} \quad (7)$$

Furthermore, taking into account the latest estimates published in the journal *Science* (*Matthews and Wynes, 2022*), which recommend a minimum 43% reduction in GHG emissions over the period 2022–2030 – i.e. around 7% per year – to keep the rise in temperature at below 1.5 °C, we believe that only those companies that meet the two most stringent tiers (median –7% and pessimistic –11%) can be qualified as “green.” The companies that manage to reach the first tier (optimistic –3%) are considered “light-green,” while those below this tier are “grey or black.”

In this way, our perspective is comparable to the Absolute Contraction Approach endorsed by the Science Based Targets initiative (SBTi). Indeed, this method sets emissions reduction targets for companies that are aligned with the global annual emissions reduction rate that is required to limit global warming to 1.5 °C (currently estimated at 4.2% - *SBTi, 2019*). Thus, all companies must reduce their absolute emissions or their carbon intensity at the same rate, regardless of their initial emission performance.

4.2. Results

An analysis of the changes in carbon productivity, economic growth and changes in GHG emissions of the SBF 120 companies in our sample (*Tables 2 and 3*) sheds some light on the profile of companies characterized by green growth, but also on the conditions of growth and

³ These two subsamples were formed based on the results of a 2019 report by the *Centre Interprofessionnel Technique d’Études de la Pollution Atmosphérique* (CITEPA), which is the authority charged with assessing GHG emissions in France.

⁴ As Bolay and al (*2022, p.2*) point out “The most commonly used financial measures are market capitalization, revenue, and enterprise value (*Thoma et al, 2018*). Revenue and enterprise value are recommended by *Net-Zero Asset Owner Alliance (2020)*”.

⁵ Detailed process:
$$\Delta \text{Carbon Prod.}_{i,t,t+1} = \frac{\frac{\text{Turnover}_{i,t} \times (1 + \Delta \text{Turnover}_{i,t,t+1})}{\text{GHG}_{i,t} \times (1 + \Delta \text{GHG}_{i,t,t+1})} - \frac{\text{Turnover}_{i,t}}{\text{GHG}_{i,t}}}{\frac{\text{Turnover}_{i,t}}{\text{GHG}_{i,t}}} = \frac{(1 + \Delta \text{Turnover}_{i,t,t+1})}{(1 + \Delta \text{GHG}_{i,t,t+1})} - 1.$$

Table 2

Percentage Changes in Carbon Productivity, Turnover and GHG of the largest French companies in the low-polluting sectors listed on the SBF 120 over the period 2015–2019. In parentheses, the relative position of the change in activity level and the change in carbon productivity at the origin of the variation in GHG emissions.

	Low-Polluting (LP)												
	N _{LP} = 250	% Δ Turnover (T)				% Δ GHG				% Δ Carbon Productivity			
		Mean	Q25	Q50	Q75	Mean	Q25	Q50	Q75	Mean	Q25	Q50	Q75
<i>Growth and decrease in GHG (% Δ⁺ T < % Δ⁺ Carbon Prod.)</i>													
Growth with high drop in GHG > -11%	16.40%	6.76	1.65	4.55	9.43	-23.30	-30.84	-18.52	-14.34	42.82	24.04	33.79	55.85
Growth with moderate drop in GHG ε]-7%; -11%]	9.20%	7.52	2.68	6.91	10.71	-8.94	-10.55	-8.49	-7.81	18.08	12.91	17.34	22.34
Green Growth (2022)	25.60%	7.03	2.11	6.22	9.67	-18.14	-23.70	-13.50	-9.75	33.93	17.15	25.00	37.10
Growth with low drop in GHG ε]-0%; -7%]	18.00%	8.34	2.18	5.24	10.50	-4.05	-5.75	-4.25	-2.48	12.98	6.62	9.71	14.40
<i>Light Green Growth (2022)</i>													
<i>Growth and increase in GHG</i>													
High growth and moderate rise in GHG. (% Δ ⁺ T > % Δ ⁺ Carbon Prod.)	16.40%	16.76	5.85	10.86	19.05	6.32	3.14	4.99	7.77	9.80	1.48	3.77	11.61
Growth with high rise in GHG (% Δ ⁺ T > % Δ ⁺ Carbon Prod.)	18.80%	8.51	2.14	5.91	11.10	26.38	8.83	19.70	34.51	-12.56	-19.30	-8.76	-3.03
Grey or Black Growth	35.20%	12.35	3.71	8.05	15.62	17.03	4.21	8.60	20.26	-2.15	-10.55	-0.92	3.33
Total with Δ⁺ Turnover	78.80%												
<i>Degrowth and decrease in GHG</i>													
Degrowth with high drop in GHG (% Δ ⁻ T < % Δ ⁺ Carbon Prod.)	8.80%	-3.67	-3.94	-1.72	-0.47	-17.29	-28.49	-13.52	-5.32	21.10	4.37	13.40	24.58
Degrowth with low drop in GHG (% Δ ⁻ T > % Δ ⁻ Carbon Prod.)	4.80%	-7.54	-11.72	-6.25	-4.40	-3.08	-5.37	-1.60	-0.31	-4.60	-6.52	-4.60	-1.85
<i>Degrowth and increase in GHG</i>													
Degrowth with high rise in GHG (% Δ ⁻ T < % Δ ⁻ Carbon Prod.)	7.60%	-9.12	-11.95	-1.98	-0.71	12.21	2.45	8.98	13.41	-18.10	-26.65	-11.73	-8.22
Total with Δ⁻ Turnover	21.20%												
TOTAL	100.00%												

degrowth that enable companies to meet the IPCC targets.

4.2.1. Companies that are growing

In our results, growing companies are defined here as companies whose production and therefore sales (our economic variable here) are growing (Parrique, 2022), i.e. companies whose turnover variation between t and t+1 is positive. A growing company sells, produces and consumes more and more. Within growth companies, we distinguish four categories according to the direction and intensity of their GHG variation.

4.2.1.1. Growing companies with a sharp decrease in GHG emissions: "green" companies. In this study, in line with our results, green growth occurs when there is an absolute decoupling between economic growth (production/sales) and the ecological burden (in this case GHG), and when this absolute decoupling is in line with an IPCC trajectory with at least a 50% chance (required annual reduction in GHG emissions of at least 7%) of achieving net-zero emissions targets by 2050.

The results are quite similar for the so-called polluting and low-polluting companies. On average, these companies report moderate to sustained economic growth (6.76%–7.52% for low-polluting companies and 9.71%–10.21% for polluting companies) combined with a very significant decrease in GHG emissions (on average, 18.14% for low-polluting companies and 14.34% for polluting companies). Moreover, the most environmentally efficient companies in this category had emissions reductions that went far beyond the most stringent IPCC targets (Q25 of 23.70% for low polluters and 19.03% for polluters), while 75% of the companies in this category had reductions greater than the

median tier of 7% (Q75 of 9.75% for low polluters and 8.66% for polluters).

The good results of these companies in terms of reducing GHG emissions are due to the strong growth in their carbon productivity, which allows them to meet the IPCC targets (11% and 7%) despite an increase in their activity level (% Δ⁺ T < % Δ⁺ Carbon Prod.).

This group, which represents 25.6% of low-polluting companies and about 12.4% of polluting companies, would appear to illustrate that it is possible to decouple economic growth from compliance with IPCC constraints to preserve the Earth's ecosystem. This is, however, a relatively modest number of companies, especially in the group of polluting companies (1/8).

4.2.1.2. Growing companies with an insufficient reduction in GHG emissions: "light-green". This group of companies includes those showing economic growth and a decrease in GHG emissions that is small to moderate but nevertheless insufficient to meet the latest IPCC targets. For the low-polluting companies, the average GHG reduction was 4.05%, for relatively sustained average economic growth of 8.34%. For the polluting companies, the average emissions reduction was 2.76%, for an average economic growth of 7.85%. It should be noted that among the group of low-polluting companies, while more than 75% did not exceed a 5.75% reduction in their GHG emissions (Q25), 25% of them demonstrated an emissions reduction of less than 2.48% (Q75). As for the polluting companies, they tend to have slightly lower emission reductions: 75% of them had reductions below 4.61%, and 25% of them did not even manage to reduce emissions by more than 1%.

This lower reduction in GHG emissions compared to the previous

Table 3

Percentage Changes in Carbon Productivity, Turnover and GHG of the largest French companies in the polluting sectors listed on the SBF 120 over the period 2015–2019. In parentheses, the relative position of the change in activity level and the change in carbon productivity at the origin of the variation in GHG emissions.

	Polluting (P)												
	N _P = 169	% Δ Turnover (T)				% Δ GHG				% Δ Carbon Productivity			
		Mean	Q25	Q50	Q75	Mean	Q25	Q50	Q75	Mean	Q25	Q50	Q75
<i>Growth and decrease in GHG (% Δ⁺ T < % Δ⁺ Carbon Prod.)</i>													
Growth with high drop in GHG > -11%	7.10%	10.21	5.10	9.23	15.56	-18.49	-23.00	-17.62	-13.78	35.74	22.92	39.33	42.04
Growth with moderate drop in GHG ε [-7%; -11%]	5.33%	9.71	3.93	6.18	12.98	-8.80	-9.93	-8.44	-8.05	20.32	13.66	16.51	25.48
Green Growth (2022)	12.43%	9.99	5.16	8.40	15.56	-14.34	-19.03	-11.83	-8.66	29.13	17.67	27.50	40.34
Growth with low drop in GHG ε [-0%; -7%]	21.30%	7.85	3.79	5.86	10.77	-2.76	-4.61	-2.63	-0.97	10.92	5.83	10.12	14.46
Light Green Growth (2022)													
<i>Growth and increase in GHG</i>													
High growth and moderate rise in GHG (% Δ ⁺ T > % Δ ⁺ Carbon Prod.)	21.30%	12.86	6.26	10.48	20.74	5.84	2.06	3.17	8.22	6.57	2.70	4.36	8.36
Growth with high rise in GHG (% Δ ⁺ T > % Δ ⁺ Carbon Prod.)	13.61%	5.00	1.64	3.82	6.68	15.71	7.03	11.04	30.69	-14.96	-21.29	-5.14	-2.90
Grey or Black Growth	34.91%	9.79	3.13	6.92	12.29	9.43	2.39	5.56	11.50	-1.83	-4.64	2.40	5.37
Total with Δ⁺ Turnover	68.64%												
<i>Degrowth and decrease in GHG</i>													
Degrowth with high drop in GHG (% Δ ⁻ T < % Δ ⁻ Carbon Prod.)	11.24%	-3.39	-4.64	-2.30	-1.18	-12.18	-18.19	-8.09	-5.26	10.99	2.90	4.88	19.66
Degrowth with low drop in GHG (% Δ ⁻ T > % Δ ⁻ Carbon Prod.)	11.83%	-11.03	-12.47	-7.27	-3.23	-2.98	-4.72	-2.11	-0.91	-7.23	-9.26	-5.03	-1.15
<i>Degrowth and increase in GHG</i>													
Degrowth with high rise in GHG (% Δ ⁻ T < % Δ ⁻ Carbon Prod.)	8.28%	-7.86	-11.36	-6.43	-3.90	9.91	2.19	5.29	16.01	-15.42	-21.55	-14.07	-7.35
Total with Δ⁻ Turnover	31.36%												
TOTAL	100.00%												

group is explained by a carbon productivity growth that is more than 2.5 times lower (e.g. 10.92% on average for polluting Light Greens versus 29.13% for their Green counterparts), which is insufficient to meet the IPCC targets of 7% and 11%, given the growth in activity level.

These groups of companies represent 18% and 21.3% of the low polluters and polluters respectively.

4.2.1.3. Very high-growth companies with moderate rise in GHG: the “grey” companies. This group of companies is particularly interesting, for several reasons. First, it consists of the companies with the strongest economic growth (an average of 12.86% and 16.76% for low-polluting and polluting companies, respectively). Second, the increase in carbon productivity is much lower than their economic growth, which results in an average increase in GHG emissions of 6.32% for the low polluters and 5.84% for the polluters, both of which are far short of the minimum reduction targets of 7%. Third, this is a large group, accounting respectively for 16.4% and 21.30% of the sample. Their results are misleading, as they show increasing carbon productivity, which may seem good at first glance, but in fact their productivity falls far short of their economic growth.

4.2.1.4. Companies with moderate growth and high rise in GHG: “black” companies. This group stands out from the Grey Growth one in that it has a very high growth in GHG emissions (average rate of 26.38% for low polluters and 15.71% for polluters). This result is explained by the combination of a moderate growth rate on average (8.51% for low polluters and 5% for polluters) and a very pronounced decrease in carbon productivity (-12.56% on average for low polluters and -14.96%

for polluters).

This group is relatively large, representing 18.80% of the population of low polluting companies and 13.61% of the population of polluting companies. These companies constitute the economic group whose activities are most harmful to the Earth’s ecosystem.

According to the definition adopted earlier for “green” companies, growing “green” companies represent 25.60% of low-polluting companies and 12.4% of polluting companies. So fully 3/4 of low-polluting companies and 7/8 of polluting companies do not meet these targets.

4.2.2. Concerning companies in degrowth

In our results, degrowth companies are defined here as companies whose production and therefore sales (our economic variable) are decreasing (Parrique, 2022), i.e. companies whose turnover variation between t and t+1 is negative. A company that is in degrowth, sells, produces and consumes less and less. Within degrowth companies, we distinguish three categories according to the direction and intensity of their GHG variation.

4.2.2.1. Companies in degrowth with a sharp decrease in GHG emissions: “green” companies. In this study, in line with our results, there is green degrowth when the absolute decrease in the ecological load (here GHG) is in line with an IPCC trajectory with at least a 50% chance (Required annual reduction in GHG emissions of at least 7%) of meeting the objective of net-zero emissions targets in 2050.

The results are quite similar for the so-called polluting and low-polluting companies. They demonstrate, on average, a moderate level of economic degrowth (-3.67% for low-polluting companies and

–3.39% for polluting companies). In tandem with this degrowth, they show a reduction in annual GHG emissions of 17.29% among the low-polluting companies and 12.18% among the polluting companies. Most of them meet the IPCC targets for preserving the Earth's ecosystem, although at least 25% of the companies in this group (Q75) have emissions reductions of less than 5.32% for the low polluters and 5.26% for the polluters.

To meet the IPCC targets, these companies combine a significant increase in carbon productivity (21.10% and 10.99% for low and high pollutants, respectively) with a reduction in activity levels.

This group of companies represents a relatively small 8.8% share of the sample's low polluters, but a larger 11.24% of the polluters, a rate that is almost equal to the share of "green" growth companies (12.43%).

4.2.2.2. Companies with strong degrowth and an insufficient reduction of GHG emissions: "light-green" companies. This group includes those companies experiencing economic degrowth and presenting a small decrease in their GHG emissions, one that is, however, insufficient to meet the latest IPCC targets (7% and 11%). For low-polluting companies, the average decrease in GHG emissions is 3.08%, for a relatively sustained average economic degrowth of 7.54%. For polluting companies, the average decrease in GHG emissions is 2.98%, for sustained average economic degrowth of –11.03%.

In this category, it is the reduction in activity level that is greater than the reduction in carbon productivity ($\% \Delta - T > \% \Delta - \text{Carbon Prod.}$) that allows these companies to slightly reduce their emissions.

4.2.2.3. Companies in moderate to sustained degrowth with high rise in GHG: "grey" companies. This group of companies illustrates how degrowth can also have a strongly negative impact on environment if the evolution of carbon productivity is not controlled. Such companies demonstrate moderate degrowth (–9.12% for low-polluting companies and –7.86% for polluting companies), but at the same time a high decrease in carbon productivity (–18.10% for low-polluting companies and –15.42% for polluting companies) that takes them far from the IPCC targets in terms of absolute emissions reduction (12.2% and 9.9% increases, compared to the expected 7% decrease). This is quite simply the second worst group of companies in terms of environmental impact, even though they represent a more modest share of the population, at approximately 8% of the companies in the sample.

This group demonstrates that even a high level of degrowth does not necessarily lead to a reduction in GHG emissions. Conversely, moderate degrowth would appear to be compatible with achieving IPCC targets when the company manages to significantly improve its carbon productivity.

5. Discussion

The above analyses have much to teach us about the use of carbon productivity indicators in relation to the IPCC targets, particularly with regard to the companies' growth/degrowth and environmental preservation.

5.1. Growth and degrowth green businesses

There is currently considerable debate about whether green growth is sustainable - i.e., whether the economic growth of companies is compatible with preserving the Earth's ecosystem. The positions taken on this issue are often radical and a source of some tension (Engelmann and al., 2019). For some authors (Alfredsson and Wijkman, 2014; Lin and Zhu, 2019), economic growth can be decoupled from environmental impact, while for others, the environment can be preserved only through degrowth (Svenfelt et al., 2019). In addition, proponents of a "green growth" approach go so far as to ignore any recourse to degrowth in their analysis as a way to support environmental objectives (Wu and

Yao, 2022). Conversely, there are authors who believe that growth should no longer be part of the debate (Abraham, 2019). A recent study in the natural sciences (Hubacek et al., 2021), which served as the basis for the conclusions of the latest IPCC report (2022), states that "*the evidence seems to be mounting that even widespread and rapid absolute decoupling alone might not suffice to achieve these goals [the 1.5 °C or 2 °C goals of the Paris Agreement] without some form of economic degrowth*" (p. 7).

Applying the change in carbon productivity in relation to IPCC targets on SBF 120 data provides us with some answers and lessons concerning the growth/degrowth characteristics of companies that currently meet GHG reduction targets (Table 3).

Firstly, green companies are not exclusively linked to a situation of growth or degrowth. An analysis of growth/degrowth companies shows that decoupled degrowth companies represent 7.6% of the sample, while decoupled growth companies represent 20.3% of the sample. In other words, approximately one third of "green" companies are experiencing degrowth, even though they represent only one quarter of the sample. It is therefore currently possible to be aligned with the IPCC targets in both positions, including among the so-called polluting companies. In fact, the degrowth position represents 40% of so-called "green" polluting companies. These results seem to suggest that level of growth plays a role in environmental preservation among French companies. Some of them, particularly those in the polluting sector, appear to be making an economic effort by reducing (or limiting) their growth, while others in degrowth continue to make significant efforts to reduce their emissions in order to meet the IPCC targets.

However, overall (for the SBF 120) these efforts are not sufficient, as it would appear that the vast majority of companies are not, as far as we know, following the trajectory required to meet the IPCC targets. Of course, this is the case for the so-called "grey" or "black" companies, but it is also the case for the so-called "light green" companies (Stoknes and Rockström, 2018, p. 42). In fact, the latter should simply be reclassified as grey, because they do not meet the 2030 emissions reduction pathway (43% decline in GHG emissions) necessary to meet the IPCC targets (Matthews and Wynes, 2022). These companies are both growth and degrowth companies, which appears to confirm the ideas advanced by Hubacek and al. (2021) about a solution that can only include a share of degrowth, which means, from the citizen's and consumer's point of view, "*a society with frugal consumption and downshifted, more localized economies*" (Kallis, 2011, p. 877). In addition, the position that involves seeking a balance between economic growth and controlling environmental impacts (Daly, 2014) is not desirable, as it actually results in less environmental degradation rather than environmental preservation.

Lastly, our results suggest the need for controlled and moderate growth and degrowth, echoing calls for sustainable production and consumption (Hickel et al., 2021). It is also notable that companies that are compatible with the IPCC targets demonstrate, on average, low to moderate growth or degrowth of their turnover, which would tend to decrease with greater reductions in GHG emissions. Companies experiencing strong growth in economic activity therefore have more difficulty meeting the carbon productivity requirement imposed by the IPCC criterion. Out of the 18 low-polluting companies and the 15 polluting companies, with business growth exceeding 20%, only two help protect the ecosystem with a GHG reduction target of 7%, compared to none if the more conservative 11% criterion is used.

These results show that taking IPCC requirements into account, when assessing the environmental commitment of companies leads to encouraging controlled (limited) growth in their activities, thus making investment efforts aimed at achieving carbon productivity gains more sustainable and realistic. Another approach for limiting investment efforts would be to accept a slight degrowth in activities. Table 4 shows that degrowth companies are more likely to meet the IPCC targets than growth companies.

Beyond that, our results also suggest that we need to reconsider the tools used to assess the contributions made by companies to preserving

Table 4
Characteristics of companies in each growth/degrowth group.

Company characteristic	“Green” growth/degrowth	“light-green” growth/degrowth	“Grey or black” growth/degrowth
Change in activity	Moderate to sustained growth: 6%–10% Weak to moderate degrowth: –3% to –5%	Sustained growth: 8%–9% Sustained degrowth: –7.5% to –11%	“Grey”: Strong growth: 15% Sustained degrowth: –8% to –9% “Black”: Moderate to sustained growth: 5%–8.5% Strong increases: >13%
Change in GHG emissions	Decreases sufficient to meet IPCC targets (10%–30%)	Decrease insufficient to meet IPCC targets	
Representation of the companies	Low-polluting companies: 32.8% Polluting companies: 20.71% With: 28.4% ^a of “green” companies in degrowth (40% of green polluting companies in degrowth and 21.9% of green low-polluting companies in degrowth)	Low-polluting companies: 24.4% Polluting companies: 36.1% With: 33.6% of “light-green” companies according to the IPCC criteria in degrowth	Low-polluting companies: 42.8% Polluting companies: 43.2% With: 18.3% of “grey or black” companies according to the IPCC criteria in degrowth (19.2% polluting and 17.8% low-polluting)

^a In the total sample, 25.3% of the companies are in degrowth (21.20% of the low-polluting companies and 31.36% of the polluting companies).

the Earth’s ecosystem.

5.2. Proposal for an indicator that measures companies’ contributions to ecosystem preservation: the IPCC CAPRO change target

Until now, companies have reported on their environmental commitment by calculating their GHG emissions and changes in such emissions, using the Scope 1 and 2 (Trinks et al., 2020). To qualify as “green,” they need to have a negative Scope (1 and 2), achieved by increasing their carbon productivity faster than their growth rate: Δ Carbon Productivity > Δ Turnover (Stoknes and Rockström, 2018). Fig. 1 illustrates this dependent relationship between the direction of change in GHG emissions, on the one hand, and the relative change in turnover growth and carbon productivity. The threshold line that we call the Scope Threshold (Δ Carbon Productivity = Δ Turnover) allows us to

quickly identify which companies are managing to reduce their GHG emissions by maintaining the change in their carbon productivity above that of their turnover. The graphs also highlight how companies whose activities are growing at a fast pace must, at the same time, achieve significant gains in carbon productivity if they are to reduce their GHG emissions.

Although the Scope (1 and 2) emissions are widely used (Fromont et al., 2022), it does not assess companies’ contributions to IPCC targets, which are aimed at limiting rising temperatures. In order to identify organizations that are truly helping preserve the Earth’s ecosystem, we propose adjusting the Scope 1 and 2 emissions by incorporating the IPCC Target, which is considered necessary if the rise in global warming is to be limited to 1.5 °C (Tilsted et al., 2021).

To help protect the Earth’s ecosystem, companies must meet the following condition:

$$(1 + \Delta\text{Carbon Prod.}_{it}) > \frac{1 + \Delta\text{Growth}_{it}}{1 - \Delta\text{IPCC Targets}} \tag{8}$$

where the Δ IPCC target is the rate of GHG reduction required for preservation of Earth’s ecosystem.

Fig. 2 provides graphs for visually identifying which companies in the sample meet the annual GHG reduction targets of 7% and 11%, which are the rates currently considered necessary to meet the IPCC trajectories (based on UNFCCC work). Table 5 compares the companies that meet the GHG reduction target (scopes 1 and 2) with the companies that achieve the IPCC targets (7% and 11%).

As we can see, many companies that have succeeded in reducing their GHG emissions do not satisfy the conditions for meeting the IPCC targets (Table 5). In fact, out of the 96 polluting companies located above the Scope Threshold, 63% of them do not meet the IPCC target of 7%, which is considered the intermediate threshold. Based on this threshold, only 35 of the companies are helping preserve the ecosystem, or approximately 20% of the polluting companies. In comparison, the IPCC targets are met by a higher proportion of low-polluting companies. For example, 57% of low-polluting companies with reduced scopes manage to meet the 7% IPCC target.

Our results highlight the fact that distinguishing between growth and degrowth is relatively unhelpful if one does not at the same time question the reduction or not of GHG emissions. Towards that end, it should be noted that “growth” and “degrowth” are not symmetrical processes. Specifically, a company can grow rapidly, and transform its modes of energy consumption so that it can achieve zero GHG emissions. That would result through investing in energy efficiency and clean renewable energy resources to substitute for their existing reliance on GHG emitting fossil fuel energy resources. On the other hand, a firm that maintains its existing level of reliance on fossil fuel energy but nevertheless undertakes “degrowth” can only achieve very modest gains in reducing emissions. A company transforming its energy consumption modes while being in “degrowth” could for its part present excellent reduction gains. The indicator that we propose allows us to go beyond a

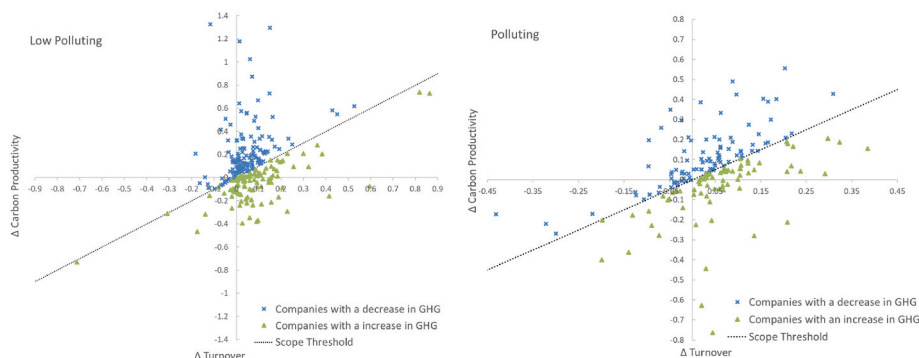


Fig. 1. Combination of Δ Carbon Productivity and Δ Turnover of Companies at the origin of Changes in GHG Emissions ($\Delta+$ GHG or $\Delta-$ GHG).

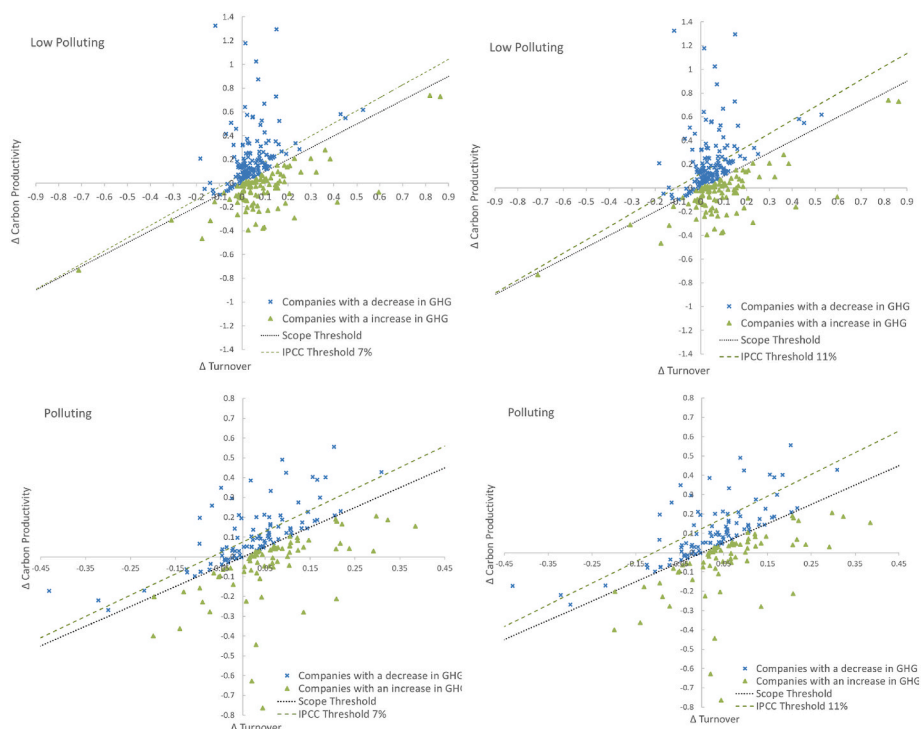


Fig. 2. Companies that meet the IPCC targets of 7% and 11% (observations located above the IPCC threshold lines).

Table 5

Δ GHG and Δ Turnover of Companies Compatible with the IPCC Trajectories for Different IPCC Thresholds (7% and 11%) in Comparison with the Scope Criteria (Scope 1 and 2 emissions reduction).

		Companies > Scope Threshold (Δ GHG)		Companies > IPCC Threshold of 7%	Companies > IPCC Threshold of 11%
Polluting	N		96	35	22
	Δ GHG	Mean	-7.48%	-15.61%	-19.73%
		Q25	-9.97%	-22.69%	-25.06%
		Q75	-1.84%	-8.87%	-14.14%
	Δ Turnover	Mean	2.17%	2.44%	0.54%
		Q25	-3.02%	-3.60%	-5.34%
Q75		8.29%	8.83%	10.32%	
Low Polluting	N		143	82	56
	Δ GHG	Mean	-12.30%	-18.77%	-23.64%
		Q25	-15.85%	-24.18%	-32.79%
		Q75	-4.40%	-10.24%	-13.64%
	Δ Turnover	Mean	4.57%	4.20%	2.65%
		Q25	0.16%	0.31%	-0.44%
Q75		8.54%	8.55%	7.58%	

comparison between growth and degrowth.

Indeed, this new indicator (the IPCC CAPRO Change Target) will therefore not only allow us to assess the extent to which major French companies have taken the IPCC targets into account, but it will also highlight the efforts that need to be made to meet these targets, particularly by polluting companies. Ultimately, this new measure helps guide companies as they develop economically while satisfying environmental requirements. Companies that know how to apply the measure will also have a significant competitive advantage.

6. Conclusion

This study has shown that taking IPCC requirements into account, when determining a company’s contribution to preserving the ecosystem, encourages controlled growth, or even slight degrowth, in their activities. We are witnessing accelerating global warming, but companies are seeking high growth to meet the expectations of various

stakeholders (shareholders, governments, employees, etc.). This does not appear to be compatible with the conditions required for ecological sustainability, even when efforts are made to improve carbon productivity. Furthermore, it would appear that the reduced GHG emissions reported by companies for their published Scope (1 and 2) are not sufficient to limit global warming to the IPCC trajectories (based on UNPCCC work).

This study contributes to the literature on sustainability by highlighting how a company’s level of economic growth plays an essential role in the fight against global warming. From a methodological point of view, our original contribution is to have proposed a new indicator that allows companies and their stakeholders to assess the real ecological impact of their activities by taking into account the GHG emission reduction target considered necessary to contain the rise in temperatures (the IPCC CAPRO Change Target). This indicator thus makes it possible to address some of the limitations of the indicators proposed to date (Bjørn et al., 2021). However, in line with the work of Bjørn et al. (2021)

and the SBTi studies (2020), we believe that, as things stand at present, companies could adopt several methods simultaneously (like the GEVA method-Randers, 2012) in order to estimate and reduce the risk of global emissions being exceeded.

The results of this study should be interpreted with due consideration for the fact that the indicator was applied to a specific sample of French companies (the SBF 120), since we preferred working with a sample that was homogeneous in terms of the nature and quality of the GHG emissions data in order to obtain rigorous results. The main reason for this decision was a lack of homogeneous data from various countries and over time. Using another homogeneous sample could provide additional insights. It should also be noted that strong legal constraints (notably under the “Grenelle 2” legislative framework) weigh on the French companies we studied, probably leading to an underestimation of the difference between the classification results produced by our proposed indicator (IPCC CAPRO Change Target) and those produced by another indicator (Scopes) that does not take the IPCC targets into account. Put another way, it is possible that the French regulatory framework, which is very strict in terms of communication (Fromont et al., 2022) and which is aligned with the Paris Agreements, may have led our (French) sample to environmental practices closer to the IPCC targets than a sample belonging to another, less strict regulatory context. Future research should apply the proposed indicator to companies in other countries. It should also take into account changes made to IPCC targets.

Finally, we feel that it is important to emphasize a point concerning the observed degrowth of companies. Our sample and analysis do not allow us to assert that a company has deliberately pursued a strategy of degrowth. We cannot know whether this degrowth is voluntary or involuntary. It is likely that, in most cases, the degrowth observed over this period is generally not voluntary, as we have not yet entered a world where the prospect of degrowth is an integral part of corporate strategy. Future studies could therefore focus on the link between the observed degrowth in activity and the declared strategy of companies, to study the effect of degrowth by design (Parrique, 2022) on compliance with IPCC targets. That said, the better results reported by companies in degrowth mode in this study suggest that degrowth by design could offer even better results.

Credit author statement

All three authors contributed significantly to all stages of this research (conceptualization, methodology, formal analysis, writing).

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Gulliver Lux reports financial support was provided by University of Quebec in Montreal.

Data availability

The authors do not have permission to share data.

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