

A third option for climate policy within potential limits to growth

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Climate change has revived debates around the concept of limits to growth, 45 years after it was first proposed. Many citizens, scientists and politicians fear that stringent climate policy will harm economic growth. Some are anti-growth, whereas others believe green growth is compatible with a transition to a low-carbon economy. As the window to curb warming at 2 °C closes, this debate will intensify. This Review critically reflects on both positions, providing an overview of existing literature on the growth versus climate debate. Both positions are argued here to jeopardize environmental or social goals. A third position, labelled an 'agrowth' strategy, is proposed to depolarize the debate and reduce resistance to climate policies.

Forty-five years ago the renowned study *The Limits to Growth* was published for the Club of Rome¹. It suggested that a combination of pollution accumulation and depletion of non-renewable resources—driven by income and population growth—would result in global overshoot, immediately followed by economic and demographic collapse. The impact of *The Limits to Growth* cannot be overstated, in terms of inspiring later integrated modelling as well as creating broader support for environmental policy.

Even though climate change was not a settled issue at the time, *The Limits to Growth*¹ included a graph (ref. 1; Fig. 15) to show that the atmospheric concentration of CO₂ was rising exponentially at a rate of 0.2% per year. It noted that “It is not known how much CO₂ or thermal pollution can be released without causing irreversible changes in the Earth's climate ... before the vital processes are severely interrupted”. Despite a widespread belief that the predictions of *The Limits to Growth* have not materialized, suggested collapse under business as usual (the ‘standard run’) occurs somewhere after 2025. Moreover, there is evidence that we may be on track regarding the predicted patterns^{2,3}.

Many regard climate change as the most significant environmental challenge to future economic growth, either because it will create considerable damage along with associated economic costs, or because stringent climate policy will curtail growth. Both economists and others express pessimism^{4–9}. The fear that stringent climate policies will frustrate future economic growth is arguably an important reason for many voters and politicians to be hesitant about giving genuine support to such policies. It partly explains why the Copenhagen climate summit largely failed¹⁰ and the recent Paris Agreement was designed around climate targets rather than policies.

One may expect the new debate on climate versus growth to endure and even intensify in the coming years as the time window to limit global warming to 2 °C closes. This Review argues that in order to make progress on climate policy worldwide, we have to understand its intricate relationship with economic growth.

Green growth under climate change and policy

First we briefly review conceptual and theoretical arguments around climate policies boosting or curtailing economic growth. To avoid any confusion, ‘growth’ and ‘economic growth’ here consistently

mean growth of GDP (gross domestic product) or GDP per capita—the difference between their rates being negligible in the absence of quick population growth or decline, as currently characterizes most rich countries.

Many economists are optimistic about combining growth and a stable climate^{11,12}. Some suggest it is just a matter of revising growth policies, such as assuring that investments in education, infrastructure and entrepreneurship are oriented toward recognizing climate risks and opportunities¹³. Others argue that it requires an optimal balance between investments in traditional productive capital, vulnerable to climate change, and adaptive capital, unproductive in the absence of climate change¹⁴. A very common belief is that climate policies can generate a “Schumpeterian burst of growth”¹⁵ or “unbounded growth in the intellectual economy”¹⁶. There are two reasons to doubt this. Firstly, energy and low-carbon innovations go along with various systemic effects, like energy rebound¹⁷. Secondly, historical Schumpeterian growth has depended on innovations that improved product quality or introduced new functions attractive to consumers. But low-carbon innovations tend to be factor-saving in the sense of reducing the use of a production factor like energy, or its carbon content, in the production of goods and services¹⁸. This arouses little interest from consumers, translating into limited potential to boost market demand. To illustrate, green electricity has no productive, functional or aesthetic advantage to consumers over fossil fuel based electricity.

A recent overview of the theoretical literature on green growth concludes that there is no guarantee for substantial positive effects of environmental policies on income growth¹⁹. One general model study finds that if dirty and clean goods are complementary to some extent, long-run growth has to come to a halt to avoid dangerous climate change. Indeed, the reality is that cleaner services add to dirtier goods in consumption rather than provide a substitute for them. Moreover, cleaner activities often depend through a web of intermediate goods and services on many other, dirtier activities. The authors find that technological innovation will in this case be insufficient to undo the increase in emissions associated with income growth²⁰. The viability of a smooth transition to green growth is further cast in doubt as it requires substantial investment, research and development in reducing carbon intensity, which means taking resources away from improving labour productivity, known

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as crowding-out²¹. Likewise, shifting taxes from labour to carbon could weaken the incentives for cost-saving firms to increase labour productivity²². However, this would undermine the fundamental basis of economic growth²³.

According to some authors, public policy should therefore shift its attention from the productivity trap—that is, compensating potential unemployment due to labour productivity rises with higher incomes and derived aggregate demand—to employment with slow, low growth²⁴. A related idea is that combining employment and climate goals is so ambitious that it requires not only decoupling of GDP and CO₂ emissions but also of GDP and employment. However, since GDP growth and employment tend to be positively correlated, a likely implication of this second type of decoupling is lower growth rates²⁵.

Simply calling for green growth^{26,27}, or ‘sustainable growth’ as was the customary term in earlier decades²⁸, is not convincing when it ultimately equates to paying lip service to the climate and giving priority to growth. This might be motivated by a sceptical position that regards growth and associated environmental damage as inevitable—driven by a consumers’ rat race, firms’ focus on market share increase, and governments’ concern for the public budget²⁹.

From the fact that after over two decades since the signing of the United Nations Framework Convention on Climate Change, countries have been unable to implement effective climate policies, one might deduce that the majority of politicians, and by default their voters, do not really believe in green growth under such policies. Arguably, economists optimistic about green growth have been unable to convince politicians that it represents a low-risk strategy. In addition, the recent global economic crisis—and various indications that average growth as historically observed in rich countries is unlikely to be recovered^{30,31}—do not facilitate a strong belief in green growth. Even the International Monetary Fund (IMF) recently published a paper arguing that the costs of growth policies may have exceeded their benefits³².

All these considerations do not mean that green growth is definitely impossible. The economy has a tremendous flexibility to change. It just needs to be triggered by the right combination of policies, notably strict regulation—ideally through a global carbon price—and public subsidies for innovation and deployment. However, being categorically pro-growth represents a risk-seeking strategy with respect to climate change. A more precautionary strategy would involve preparing society for the possible scenario that serious climate policy will reduce the rate of economic growth.

One should also recognize that decarbonization is an insufficient condition for green growth as various other environmental and resource problems—as reflected by the planetary boundaries³³ and UN Sustainable Development Goals³⁴—need a definite solution as well. Such problems may even get worse due to so-called environmental problem shifting³⁵ triggered by climate strategies and population growth³⁶. All these considerations illustrate the huge ambition of a green growth strategy.

Zero or negative GDP growth to stop climate change

Many of those concerned about climate change fear that economic growth globally will outpace any reductions in carbon intensity of economic goods and services. Even if all countries were to improve their energy efficiency, given that many emerging economies have high energy intensities and tend to grow quickly, global energy efficiency may deteriorate—a case of Simpson’s paradox. In response, some argue in favour of explicit anti-growth or ‘degrowth’ strategies, the latter aimed at reducing the size of the market economy, that is, GDP. Terms like “downscaling of production and consumption” are used in this respect³⁷. The effectiveness and feasibility of these strategies can be questioned, however, on various grounds.

The 2008 global economic crisis, which negatively affected well-being around the world, did reduce carbon emissions. But it was

a tiny blip on the overall increasing trend, and was in fact smaller than expected³⁸. In view of this, the scale of any GDP decline strategy would have to be huge to reach a significant reduction of emissions. Moreover, factors other than growth co-determine emissions, notably the composition of consumption and production, and the nature of all energy generating and energy using technologies in the economy. Since nobody knows the dynamic balance between these factors, the required magnitude of GDP degrowth is unknown. This means we cannot plan for it: any concrete degrowth rate would be arbitrary.

In addition, thinking in terms of degrowth confuses cause and effect: perhaps serious climate policy will result in low, zero or even negative growth, temporarily or even permanently³⁹. But this does not imply the reverse causality that zero or negative growth will solve the problem of climate change, or is even a necessary ingredient of any solution.

Next, a deliberate degrowth strategy involves three severe risks. Through reducing consumer and investor confidence in the state of the economy, it might create an extended period of economic instability characterized by high unemployment. Moreover, as degrowth is not something that can be well controlled or planned, it could result in production becoming less efficient and even more polluting. Last but not least, a smaller size of the market economy would reduce tax revenue, implying less public funding for public goods.

I acknowledge that these critiques mainly apply to degrowth in a narrow sense of GDP decline. Indeed, degrowth is also interpreted as less consumption, work-time reduction, anti-capitalism, or simply physical degrowth⁴⁰. Nonetheless, the focus of this Review is on the interpretation of GDP decline, which is widespread and underlies much of the literature on degrowth.

Evidence for compatibility of growth and climate

Empirical evidence about whether or not growth and climate protection are compatible comes in various forms. The main climate-economy models provide support for growth being a realistic outcome under many climate policy scenarios^{41–44}. They have been criticized, though, for overestimating the rate of growth, notably as they omit many damage categories^{45–47} and underestimate the likelihood of extreme climate damages^{48–51}. Recent model approaches find strong negative effects on growth of poor countries^{52,53}, or even negative growth in most countries, due to climate change⁵⁴.

A large literature on the relationship between energy and growth is relevant to the debate on climate versus growth⁵⁵. One line of research argues that many theoretical and empirical studies assume production functions that imply optimistic assumptions regarding substitution away from energy⁵⁶. Improved energy quality, due to substitution between fuels within the production factor energy, has been more important to growth than the substitution away from energy⁵⁷. This raises worries about whether a future large-scale transition to renewable energy, substituting for high-quality fuels like gas and oil, will translate into worse average energy quality. If this is the case, economic growth might come under pressure. Hence, not only energy quantity but also its quality matters.

Some think that green growth is not just feasible but even that growth is required to push average income beyond a critical threshold in order to solve environmental problems. This idea has given rise to empirical research on the environmental Kuznets curve (EKC). The majority of EKC studies for CO₂ emissions, however, have not found strong evidence for the hypothesis that income and CO₂ emissions delink in absolute terms beyond a certain income threshold^{58–60}.

The economic crisis that started in 2008 was found to very briefly slow down and even reverse the rise in emissions: in 2009 they fell by 1.4%. But immediately afterwards, emissions increased rapidly by 5.9% in 2010⁶¹. This shows that changes in emissions per capita during growth and decline are asymmetric. In particular,

emissions tend to be sticky, meaning that their decline during recessions is lower than their increase during economic expansion, for similar rates of income change^{62–66}. However, one study finds no strong evidence for this asymmetry⁶⁷.

One study claims absolute decoupling for 21 countries since 2000 in terms of CO₂ emissions⁶⁸. However, the countries are not globally representative and the study does not account for carbon leakage. A recent input-output study for various countries finds that correlations between carbon intensity and growth indicators at the sector level do not reveal green growth to be happening⁶⁹, while another suggests that whereas production-based emissions may be decoupled, consumption-based emissions show a clearly positive relationship with income⁷⁰. To further explore the connection between growth and climate change, empirical studies of fast-growing large economies, such as China, are relevant. While some of these suggest that their projected growth is compatible with climate goals⁷¹, others are more pessimistic^{72,73}.

As carbon dioxide (or, more generally, greenhouse gas) emissions and carbon intensity of economic output can be relatively easily quantified, one can make clearer statements about the likelihood of green growth in the context of climate goals than for most other environmental problems. On the positive side, from 2013–2016 global CO₂ emissions have been virtually constant, despite global annual GDP growth of more than 3%. In the last 40 years there have been only three other periods in which emissions halted or decreased, so this is the first time that global growth goes along with constant emissions.

Of course, such relative decoupling is far from sufficient. To limit global warming to 2 °C relative to pre-industrial levels, carbon intensity will have to fall considerably, by 4.4% annually for 1.5% growth, and by 2.9% for zero growth, far beyond historical reductions of less than 1%⁷⁴. Another way to frame this issue is by calculating the remaining years of current emissions given the carbon budget. To limit warming to 2 °C with greater than 66% probability, range estimates for the carbon budget translate into a time range of 15–30 years with CO₂ emissions at 2014 levels⁷⁵.

So green growth may not be feasible for two reasons: green policies may not allow for growth; or weak policies, out of fear of harming growth, will not deliver green outcomes. If we further recognize that concern about growth impedes public and political support for urgently needed climate policies, then we have enough motives to become less preoccupied with growth. This gives rise to a third strategy.

An ‘agrowth’ strategy

To clarify this third strategy and its performance in comparison with pro-growth and anti-growth strategies, Fig. 1 conceptualizes our search for human progress as choosing combinations of relative changes in GDP and (other) dimensions of social welfare *O*, such as unemployment benefits, good medical care, or protection against dangerous climate change. Ideally, *O* should increase over time or at least remain constant, implying a preference for areas *a*, *b*₁ and *b*₂ over *c*₁, *c*₂ and *d*.

First consider a pro-growth stance. It implies an *ex ante* constraint on our search for progress, visualized in the figure as the vertical curve associated with a desired minimum GDP growth rate *g*, such as the widely supported goal of 2% annual growth. This pro-growth constraint limits the search for developments and policies to area *b*₂. As a result, if certain desirable policies regarding environmental protection, public health or equity—captured by *O*—lead to a growth rate lower than *g*, they would not be adopted. Moreover, while a pro-growth strategy aims for a win-win outcome in *b*₂, it may in fact steer the economy to area *c*₂. The reason is that a win-win outcome may not always be feasible. For example, GDP growth may be accompanied by global warming (‘ungreen growth’) or rising inequity.

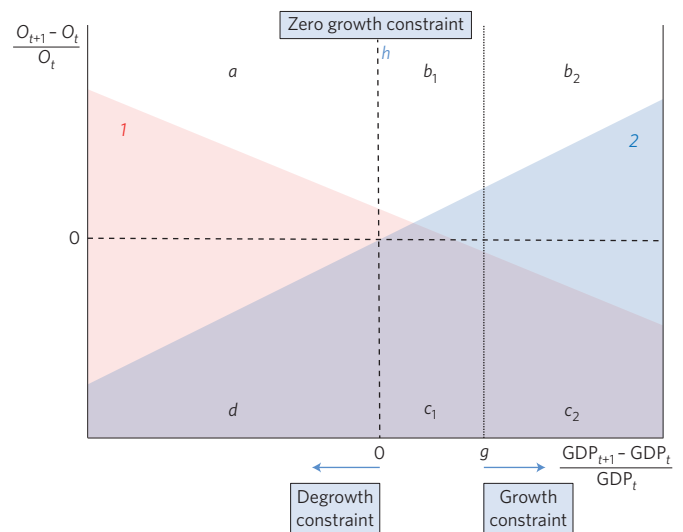


Figure 1 | Agrowth as search for human progress in the space spanned by relative changes in GDP and *O*. See section “An ‘agrowth’ strategy” for explanation. Rectangles separated by vertical/horizontal broken lines are labelled *a*, *b*, *c* and *d*. Coloured areas 1 and 2 (red and blue, respectively, with overlap in purple) represent uncertainty or distinct beliefs about feasible combinations of GDP and *O*. The symbol *t* denotes time.

Next, an anti-growth strategy searches in another restricted area, namely *a*. This runs the risk that one ends up with too low a level of GDP, insufficient to support a minimum level of certain *O* components, such as provision of essential public goods. This means one ends up in the lose-lose area *d*.

A very particular case is a zero-growth strategy. It would search in the smallest area, namely the line *h*. This is not just extremely restrictive, but virtually impossible to realize from a policy angle.

A third option, here termed an ‘agrowth’ strategy, has been overlooked. It reflects the insight that GDP growth may go along with both progress and regress, depending on the period, context and development stage. This suggests the logic of being *ex ante* agnostic about GDP growth. Since such a strategy does not give priority to growth or anti-growth it effectively ignores GDP as an overall measure of progress, and hence will be intentionally ignorant about any changes in GDP. In this way, it removes the possibility of imposing *ex ante* GDP growth or anti-growth constraints in pursuit of human progress. It thus allows for unconstrained search in the largest area, namely *a* + *b*₁ + *b*₂, which means maximum flexibility to reach a high level of *O*, and avoid ending up in the undesirable areas *c*₁, *c*₂ or *d*. Such an agrowth strategy does not beforehand exclude any option, whether it is negative growth (area *a*), zero-growth (line *h*), low growth (area *b*₁) or high growth (area *b*₂); it merely aims to realize acceptable values of all factors in *O* that contribute to human well-being, including employment, equity and a stable climate.

To illustrate the role of uncertainty and the need for a flexible, precautionary strategy like agrowth further, Fig. 1 also depicts two feasibility spaces, 1 (red) and 2 (blue)—with their overlap being purple. (These curves may seem similar to but are not to be confused with a production possibility frontier⁷⁶.) The two feasibility spaces can be interpreted in two ways: as reflecting uncertainty about future possible combinations of GDP and *O*; or as beliefs about such possibilities. For example, the blue space reflects optimism about combining increases in GDP and *O*, whereas the red space reflects pessimism. Considering such multiple feasibility spaces allows us to test the robustness of different growth strategies.

To see this, let us analyse what happens if we combine each feasibility space with a particular growth strategy. If the red space 1 applies, then the pro-growth strategy aimed at area b_2 fails and the economy ends up in area c_2 . But if the blue space 2 applies, then the anti-growth strategy will fail, reaching area d instead of the desired area a . Only if an agrowth strategy is followed can one realize an increase, and even a maximum increase, in O , regardless of which feasibility space is correct. Note that the two feasibility spaces plotted are merely illustrative and many others are conceivable. This reflects uncertainty about feasible combinations of GDP and O , which explains the persistent debate on growth versus the environment. As the figure shows, only an agrowth strategy is robust against, and constitutes the best response to, uncertainty about the correct feasibility space. The reason is that it searches in the largest area $a + b_1 + b_2$, unconstrained by any *ex ante* pro-growth or anti-growth aim. Anyone genuinely concerned about human welfare should feel convinced by this argument to replace pro-growth by agrowth. This is in line with the conclusion of a recent study that both pro-growth and degrowth strategies “constitute inadequate foundations for public policy as they fail to appropriately conceptualize social welfare”⁷⁷.

If one would adopt an agrowth strategy, one would in some periods be willing—as one would be indifferent about GDP movements—to give up potential GDP growth for a better environment, more leisure, more national or international equity, better health care, or a better balance between private and public sectors. For example, if more income equality meant a lower average income (GDP per capita) this would be judged negatively under a pro-growth strategy, as opposed to under an agrowth strategy. More generally, an agrowth strategy would enhance the sociopolitical acceptability of key policies directed at problems that harm social welfare, like inequity and climate change, by not requiring of such policies *ex ante* that they match some positive, negative or zero growth rate of the economy.

If climate policy turns out to have growth-reducing effects, reflected by the red feasibility area 1 in Fig. 1, those betting on a green growth strategy will end up being disappointed. In response, they may then withdraw support from or not give support to serious climate policies, so that the system ends up in area c_2 in the figure. In other words, a categorical pro-growth strategy is risky as it may obstruct implementation of good climate policies.

Instead, by ignoring GDP growth and thus being neutral about growth, an agrowth strategy facilitates the acceptance of serious climate policy. It will allow sacrificing some growth (area a or b_1 in Fig. 1) if required to meet climate goals, while not excluding a green growth outcome (area b_2) if consistent with these goals. So it means a flexible and precautionary approach, as it searches for combinations of GDP and O in a larger area, making it able to respond to uncertain futures as represented by the feasibility spaces 1 and 2 in the figure.

Precaution can thus be seen as reducing environmental, climate and social risks, as well as avoiding potential disappointment about realized growth compared to high promises or hopes common under a pro-growth strategy. One could regard these risks as the consequence of complexity of the economic-behavioural system of production, consumption and investment factors that jointly determine changes in GDP and climate over time. Ultimately, precaution as represented by an agrowth strategy is thus warranted because of economic complexity.

Practical steps

The debate on the limits to growth will not just continue but may well become fiercer, fuelled by increasing evidence on climate damages and our inability to reduce emissions sufficiently fast. The review of theoretical and empirical studies on growth versus the climate shows that green growth and anti-growth are both risky and not guaranteed to combine climate and social goals.

An important advantage of the neutral and precautionary agrowth strategy is that it can bridge pro-growth and anti-growth views and thus reduce polarization in the debate. It does not preclude GDP growth when it is feasible and goes along with improving human welfare, and neither eschews GDP decline if this is an inevitable outcome of policies solving urgent social or environmental problems. Hence, it could create more political space for better balancing of different components of social welfare and supporting serious, effective climate policies.

Admittedly, such a strategy may seem odd in the current political setting where low growth makes the large majority of politicians still very nervous. Pressure on politicians to focus on economic growth is high, though most economists accept GDP per capita to be far from a good measure of social welfare. Even so, preoccupation with GDP growth remains widespread in economics and politics. To solve this paradox⁷⁸, several actions are worth considering:

- Give more systematic attention to the shortcomings of GDP information in all education, and particularly in economics and business management studies at universities.
- Interrogate the preoccupation with growth in journalism, policy circles and politics so as to overcome the automatism with which many give priority to growth. This may require dealing with cognitive biases through debiasing techniques⁷⁹.
- Make political leaders of developing countries aware that an agrowth strategy facilitates a trade-off between less growth in rich countries and development with growth in poor countries, possibly needed to combine the goals of ending climate change and reducing global inequality⁸⁰.
- Put pressure on the IMF, the OECD, and the World Bank to accept a shift to a growth-neutral paradigm. They express a deep concern for climate and other environmental issues, but are caught in ambiguous notions such as ‘beyond GDP’ and ‘beyond growth’.
- Convince politicians to soothe excessive growth expectations that are often not met and then merely contribute to disappointment and economic instability.
- Stimulate debate in politics and wider society about the relevance and means of stepping outside the unproductive pro-growth versus anti-growth frame.

While an agrowth position does not require that we have an alternative aggregate welfare metric that can replace GDP, trying to implement such a metric worldwide, possibly under auspices of the United Nations, would be helpful⁸¹. Nevertheless, agrowth without a good aggregate welfare measure already means a considerable improvement over unconditional pro-growth, because sensible trade-offs between social (and/or environmental) goals, notably solving urgent problems, will no longer be frustrated by preoccupation with GDP rise. With a broadly accepted aggregate welfare measure—unfortunately still a distant ideal—agrowth would mean the best of all worlds.

The idea of a neutral and precautionary position is perhaps implicit in some previous writings on growth versus the environment. Nevertheless, it is often not immediately understood but needs to be contemplated before it can sink in. Arguably, it is easier to think in terms of pro-growth versus anti-growth or growth-optimism versus growth-pessimism. The green growth tale seems to have been unable to convince voters and politicians to strongly support effective climate policies. It is time to try out another strategy to raise support for serious climate policy. Green agrowth means one can be concerned about the connection between climate and growth without being anti-growth.

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Competing financial interests

The author declares no competing financial interests.