Post-growth: the science of wellbeing within planetary boundaries

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There are increasing concerns that continued economic growth in high-income countries might not be environmentally sustainable, socially beneficial, or economically achievable. In this Review, we explore the rapidly advancing field of post-growth research, which has evolved in response to these concerns. The central idea of post-growth is to replace the goal of increasing GDP with the goal of improving human wellbeing within planetary boundaries. Key advances discussed in this Review include: the development of ecological macroeconomic models that test policies for managing without growth; understanding and reducing the growth dependencies that tie social welfare to increasing GDP in the current economy; and characterising the policies and provisioning systems that would allow resource use to be reduced while improving human wellbeing. Despite recent advances in post-growth research, important questions remain, such as the politics of transition, and transformations in the relationship between the Global North and the Global South.

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Introduction

How can contemporary societies enhance human wellbeing in the absence of economic growth? This question is the foundational scientific issue for the emerging research agenda on post-growth,[1] motivated by the tight coupling of growth in gross domestic product (GDP) and environmental damage,[2] the declining marginal benefits of income for human wellbeing,[3] and the social and political risks of economic slowdowns.[4] Post-growth refers to societies that do not pursue GDP growth as an objective, and which are able to meet human needs in an equitable way without growth while staying within their fair share of planetary boundaries.

Post-growth research can be seen as part of sustainability science that is influenced by—but not constrained within—ecological economics, drawing from different traditions and contributing to the construction of a new economics that brings interdisciplinary (eg, ecological, anthropological, historical, sociological, and political) insights into our understandings of how human provisioning works. Post-growth emphasises independence from—or prosperity without[5]—growth, and serves as an umbrella term encompassing research in Doughnut and wellbeing economics, steady-state economics, and degrowth. Doughnut and wellbeing economics call for the satisfaction of basic human needs and high wellbeing within planetary boundaries, whereas steady-state economics emphasises the need to stabilise societies' resource use at a relatively low, sustainable level. Doughnut, wellbeing, and steady-state economics generally position their proposals within the current capitalist system, whereas degrowth is critical of the possibilities of an egalitarian slowdown within capitalism given that capitalist competition is structurally geared towards growth. Degrowth therefore emphasises the need for a planned, democratic transformation of the economic system to drastically reduce ecological impact and inequality and improve wellbeing. Degrowth, similarly to steady-state economics, regards a lower GDP as a probable outcome of efforts to substantially reduce resource use.[6] Reducing GDP is not a goal of these approaches, however,[5] but, it is seen as something that economies need to be made resilient to. The Doughnut and wellbeing approaches are more agnostic about GDP growth, but still view it as a poor measure of progress. Post-growth is plural and open to all these perspectives. All approaches converge on the need for qualitative improvement without relying on quantitative growth, and on selectively decreasing the production of less necessary and more damaging goods and services, while increasing beneficial ones.

There is a large literature on post-growth and increasing interest in the concept as indicated by articles in prominent scientific journals,[7–9] reports in international media,[10] and substantial new funding for post-growth research.[11–14] To our knowledge, this is the first comprehensive review of the field. Unlike recent systematic reviews of degrowth, for example,[15–17] which quantify emerging themes and gaps in the literature, our Review is an expert overview, written by leaders in the post-growth field, each specialised in one of its various branches. We have identified what we deem to be the most important recent contributions, without being constrained by the conventions of a narrower systematic review (ie, looking only at articles where the term post-growth appears in the title or body of the article), to include the theoretical and empirical evidence that is relevant to post-growth claims. First, we explain how post-growth research has evolved within planetary sustainability science, engaging with ongoing debates about ecological, social, and economic limits to growth. Second, we provide an overview of controversies, advances, and breakthroughs in the field in the past 5 years and identify remaining knowledge gaps.

Ecological, social, and economic limits to growth

Resource limits

The year 2022 marked the 50th anniversary of Limits to Growth, a report that first posed the question of whether there are limits related to the Earth system that could put

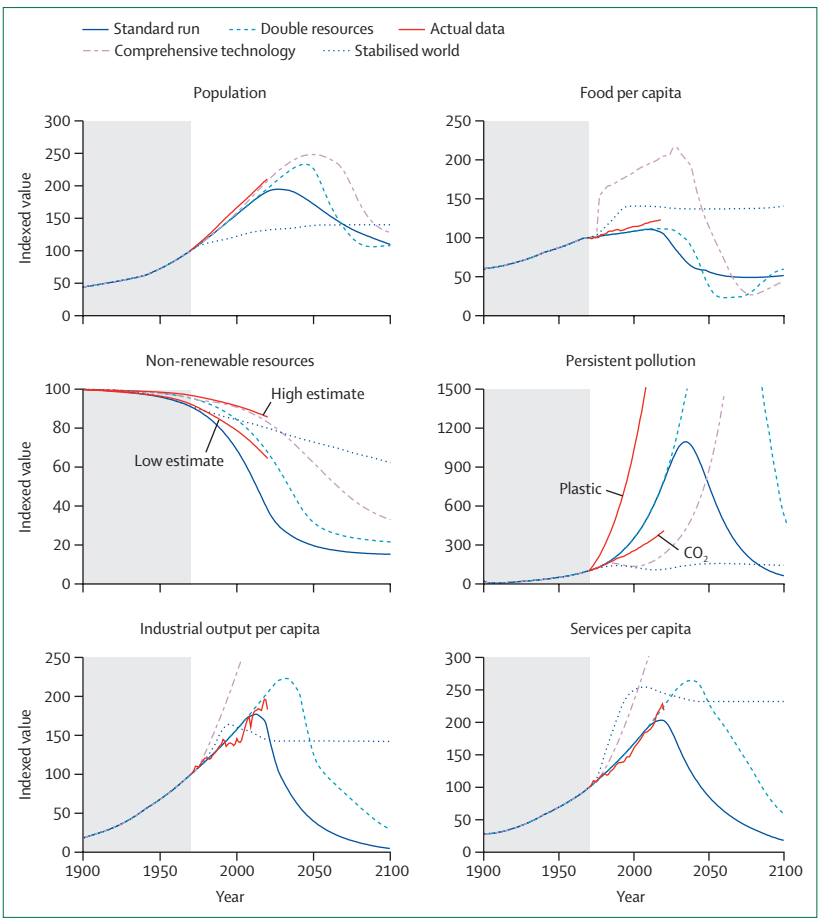

Figure 1: **Four different scenarios of the original Limits to Growth model in comparison to actual data**
Data are presented for six modelled variables, with blue lines showing four scenarios of the Limits to Growth model, and red lines showing actual data. Each data series is indexed to its value in the year 1970, with the exception of the data for non-renewable resources, which are indexed to 1900. The grey shaded region shows the historical time period for the model (1900–70). This figure was created using the authors' own calculations, using publicly available data. Data for global population were obtained from the World Bank.[19] Industrial output per capita and services per capita were obtained by multiplying global real GDP per capita (constant 2015 US$) by the respective shares of industry and services, also obtained from the World Bank.[19] Food per capita is the daily calorific supply in kcal. A low and high estimate are provided for non-renewable resources, following the method of Turner,[20] whereas two different indicators are provided for persistent pollution (ie, atmospheric CO_2 concentration and cumulative plastic waste), following the method of Herrington.[21] The model runs were obtained from the detailed description of World3 published following the original report.[22]

constraints on industrial development. The report was based on a system dynamics model (World3) that was parameterised with data from 1900 to 1970, and simulated scenarios for population, food, non-renewable resources, pollution, industrial output, and services to the year 2100.[18] In the Standard Run of the model, which assumed the continuation of historical decision-making, the result is overshoot and collapse (figure 1). In this scenario, as industrial capital grows, it consumes a larger and larger share of the resource flow, until resource depletion leads to the collapse of the industrial base, followed by the collapse of everything that is dependent on it—services, the food supply, and ultimately, the human population.[17]

Limits to Growth triggered a long and heated debate,[23] which remains unsettled.[24] Many economists suggested that high prices for scarce resources could result in technological innovation and resource substitution. The assumption that technology grows exponentially, and at a rate sufficient to offset the drag from resource depletion, allows growth to continue without limit.[25] The decline of commodity prices in the 20th century, and especially in the 1980s, when the debate about Limits to Growth took place (figure 2), was seen as a repudiation of the Limits to Growth hypothesis and a confirmation of the power of technology to offset resource scarcity.[25]

The Standard Run of the Limits to Growth model, however, did not suggest scarcities before the 2010s. Given the cumulative nature of compound growth, the hypothesis was that seeming abundance would at some point turn quickly into scarcity.[18] Increasing resource prices since the 2000s (figure 2), coupled with economic shocks, have brought back concerns that resource scarcities might indeed limit growth.[27] Other system dynamics models built on World3 suggest peaks and scarcities for various critical metals in the second half of the 21st century.[28,29] However, these models, similarly to the original World3 and all future-oriented models, run the risk of underestimating unpredictable technological breakthroughs that might be incentivised by higher resource prices.

From resource limits to planetary boundaries

Scientists have also sought to assess the validity of the Limits to Growth model by looking at how well it fits historical trends since its publication.[20,21] Previous studies[21,30] have explored how the various runs of the Limits to Growth model compare with actual trends and suggest that the world is most closely tracking the Double Resources scenario,[18] which differs from the Standard Run in its assumption that the initial stock of non-renewable resources is twice as large as the Standard Run resource stock (figure 1). In this scenario, collapse occurs later and is driven not by scarcity of non-renewable resources (ie, a source limit), as in the Standard Run, but by persistent pollution and its impact on ecosystem stability (ie, a sink limit, otherwise known as a regenerative capacity limit). The Double Resources scenario arguably aligns more closely with the current understanding of the most pressing environmental limits facing humanity. For example, climate change is a much greater concern now than running out of fossil fuels[31] (interestingly, the original Limits to Growth report did refer to the possibility of climate change as a form of persistent pollution). The replication of trends in the relatively stable 1970–2020 period, nonetheless, does not imply by any means that collapse will occur by a specific date.[32] The Limits to Growth model was never intended to make exact predictions, but to explore the system's overall behavioural tendencies. Moreover, as the Limits to Growth modellers suggested, less attention should be given to the model's behaviour past the peak as the

process of approaching limits will instigate a change in the system's structure.

The past decade has seen a shift in sustainability science from questions of resource scarcity to those of global change and limits, through the study of planetary boundaries that provide a "safe operating space for humanity".[33] Anthropogenic pressures now exceed six of the nine identified planetary boundaries—those related to carbon emissions, biodiversity loss, land-system change, freshwater change, biogeochemical flows, and novel pollutants.[34–36] Natural scientists have linked Earth system trends to socioeconomic trends, including economic growth, illustrating the "Great Acceleration" of ecological impacts and population and economic growth.[37] Some economists, by contrast, have argued that as economies get richer, after a specific point in development, their impact on the environment is likely to decrease (ie, the environmental Kuznets curve hypothesis).[38] The new consensus in the empirical literature, however, is that although some local pollutants, such as sulphur dioxide, have fallen in high-income countries, typically due to better policy, this does not hold for greenhouse gas emissions, material use, or other global ecological impacts.[38]

A separate discussion concerns whether crossing planetary boundaries will limit growth. There are two contending perspectives on this question. In William Nordhaus's DICE model, for example, the reference scenario projected that a 4·3°C increase in global temperature by 2100 would lead to only a 4·3% loss in output compared with baseline projections, in a global economy that is 7·8 times larger than in 2015.[39] However, such projections excluded uncertain, abrupt, and non-linear changes in the Earth system, and underestimated climate damages by relying on current correlations between regional temperature and regional GDP as a proxy for the economic impact of global warming.[40] Newer studies suggest much higher economic costs of climate change than previously estimated—with existing warming already locking in a 19% income per capita loss within the next 26 years,[41] whereas each additional 1°C rise in temperature costs the world 12% in GDP losses.[42] Given the uncertainties involved in such estimations, and the problems with reducing all ecosystem and wellbeing losses due to climate change to a GDP figure, an alternative approach, which many sustainability scientists have adopted, is to take planetary boundaries as a precautionary objective, and then ask whether it is possible to return to or stay inside planetary boundaries with continued economic growth.[43]

The decoupling controversy

Much of the research on reconciling economic growth with planetary boundaries has been framed as a question of whether it is possible to achieve green growth—ie, to decouple GDP from carbon emissions and material use (the latter because it is strongly linked to environmental

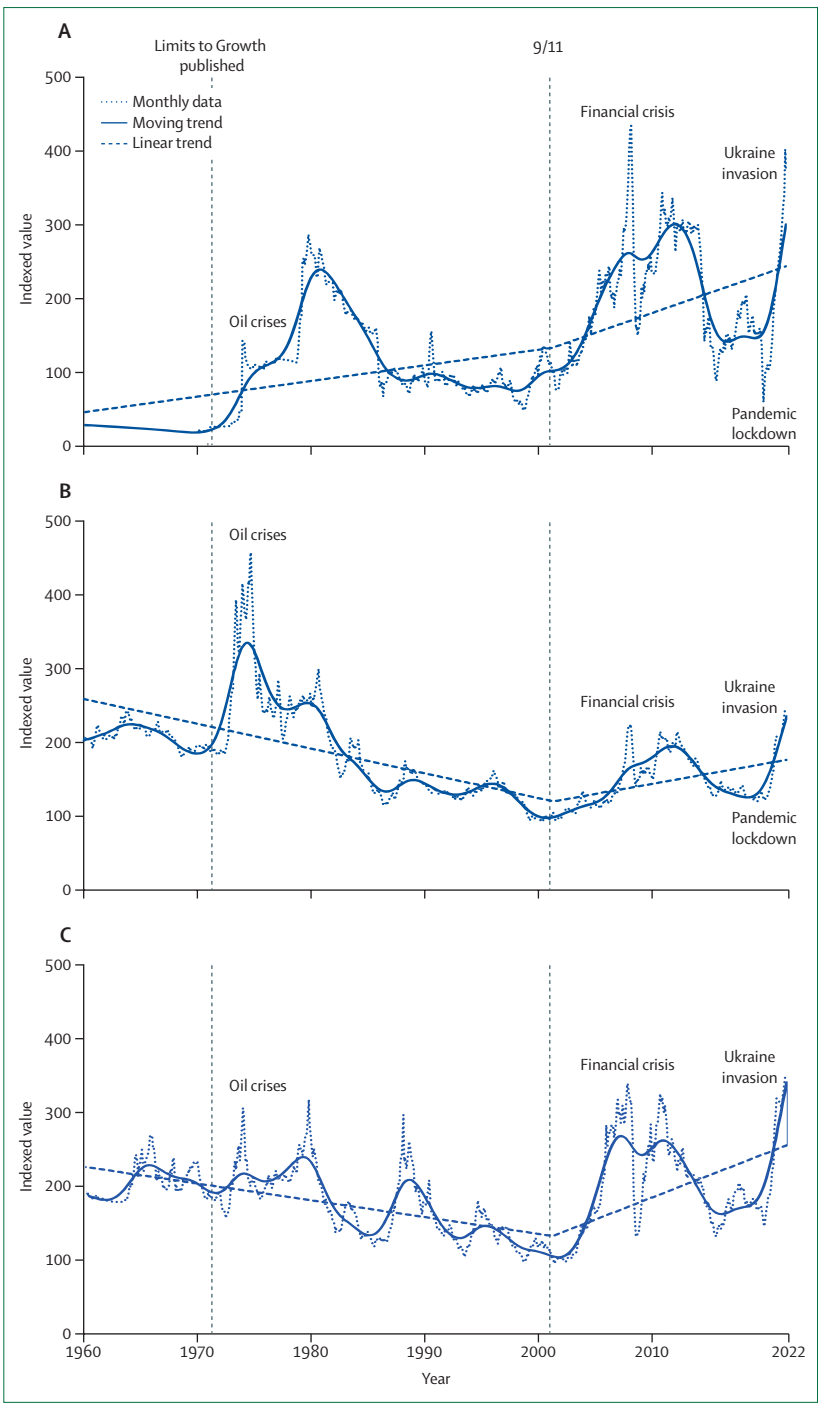

Figure 2: **Commodity price indices, 1960–2022**
(A) Commodity price index for energy; the rate of growth in real prices was initiated by the 1970s oil crises and increased after 9/11. (B) Commodity price index for food; a declining trend in real prices during the last four decades of the 20th century was reversed after 9/11. (C) Commodity price index for metals and minerals; a declining trend was reversed after 9/11, leading to what are now the highest real prices in 62 years. Commodity price indices are taken from the World Bank's Commodity Price Pink Sheet.[26] Nominal price indices from historical Pink Sheet data have been deflated to real prices using the Federal Reserve's Implicit GDP Deflator and indexed to September, 2001. Linear trends are calculated before and after this point. Moving trends are calculated using the Hodrick–Prescott filter (with λ=14 400).

pressures and biodiversity loss).[44,45] This literature distinguishes between relative decoupling, which is a decline in the material or carbon intensity of GDP, where GDP grows faster than material use and emissions; absolute decoupling, which is when GDP grows while material use and emissions decline; and sufficient absolute decoupling or genuine green growth, which is when GDP grows while material use and emissions decline enough to keep the economy within planetary boundaries.[46]

Cross-national evidence indicates that GDP remains coupled to resource use as measured by material footprint (ie, accounting for the biomass, minerals, metals, and fossil fuels required to support the final consumption of goods and services).[47] This finding holds across material categories and most regions, with some exceptions, such as decreasing fossil fuel use in some European countries.[47] The consensus from recent reviews and meta-analyses is that while relative decoupling of GDP from material use is common, there is no evidence of sustained absolute decoupling.[2,48] Moreover, modelled projections indicate that at the global scale, absolute decoupling is unlikely to occur even with optimistic assumptions about technology.[49]

Why are resources and GDP so tightly coupled? A first explanation focuses on the so-called rebound effect—the hypothesis that technological improvements in resource efficiency do not necessarily yield reduced resource use because declining costs lead to increased demand.[50] A study of 57 cases of materials and modern artefacts, for example, found no evidence of dematerialisation,[51] and economy-wide energy rebounds of 78–101% have been observed in the USA, the UK, and some European countries.[52] Another explanation focuses on the material intensity of services, structural change, and international trade. A global empirical analysis found that all sectors of the economy are roughly equivalent in terms of their climate, land, and water impacts due to the embedded resource requirements of services and the fact that incomes earned in the service sector are partly spent on material goods.[53] Cross-border research indicates that as high-income economies grow and shift towards services, they increasingly offshore agricultural and industrial production and rely on imports[47] (eg, for agriculture, the Global North net-imports embodied land and biomass from the Global South[54]). Domestic material extraction might therefore decline, but total material footprint—which accounts for materials embodied in trade—continues to increase.[47] These explanations are in line with the ecological economics view of the engine of the economy being energy, materials, and human labour.[55]

With carbon emissions, the picture is more complex, since substitution with cleaner energy is possible. In the period 2005–15, absolute decoupling of GDP from emissions occurred in several high-income countries, even accounting for trade (ie, consumption-based emissions).[56] However, this time period was one of historically low growth for many of these nations (figure 3), suggesting that while decoupling is possible, the rate of growth still matters, and the lower it is, the more feasible absolute decoupling becomes. In the USA, for instance, the 2008 recession was an important cause of emissions reduction,[57] complicating arguments about green growth. A 2018 study found that Sweden, Denmark, and Finland have achieved sufficient decoupling,[46] but critics have noted that this assessment uses the 2°C carbon budget instead of a 1·5°C budget and ignores consumption-based emissions.[58] The speed of reduction is also not sufficient from a fairness perspective if one accounts for the higher mitigation responsibilities of countries that historically have been high emitters of greenhouse gases.[58,59] Even the best performing nations, such as the UK and Sweden, are not on track to meet Paris Agreement objectives, as a fair distribution of the global carbon budget would require them to reduce emissions by 10% and 12% each year, respectively, which is double their existing policy commitments.[60]

Despite this uncertainty about the prospects of sufficient decoupling, green growth remains a standard feature of the climate mitigation scenarios for 1·5°C and 2°C that are modelled using conventional integrated assessment models and reviewed by the Intergovernmental Panel on Climate Change (IPCC).[61,62] These scenarios reconcile economic growth with climate goals by relying on hypothetical large-scale negative emissions technologies with CO_2 removal schemes developed in the future, unprecedented energy efficiency improvements, or both.[63] These scenarios also ignore climate impacts on the economy and society.[64] Several studies raise questions about the risks of relying on untested negative emissions technologies[65] and about the historically unprecedented rates of GDP–energy decoupling in low-energy scenarios.[52] Five new studies show how reductions in aggregate output make achieving climate objectives easier, without having to rely on possibly unrealistic assumptions about technological change.[66–70]

If the standard green growth argument is that growth can continue while ecological pressures are reduced to sustainable levels, a stronger claim is that greening the economy can itself be an engine of growth. Several economic models show that investments in green infrastructure and climate mitigation might have a multiplier effect that increases growth in countries with economic slack.[71–73] The short-run stimulus effects of a clean energy transition, however, should be distinguished from possible second-order, or longer-run effects.[74] There are open questions concerning whether green investments crowd out other, more productive (in terms of GDP) investments,[75] or whether stranded fossil fuel assets might cause financial shocks that impact GDP negatively.[72] Models show that if clean energies depend on dirty inputs for their production, technological innovation does not suffice to both sustain growth and

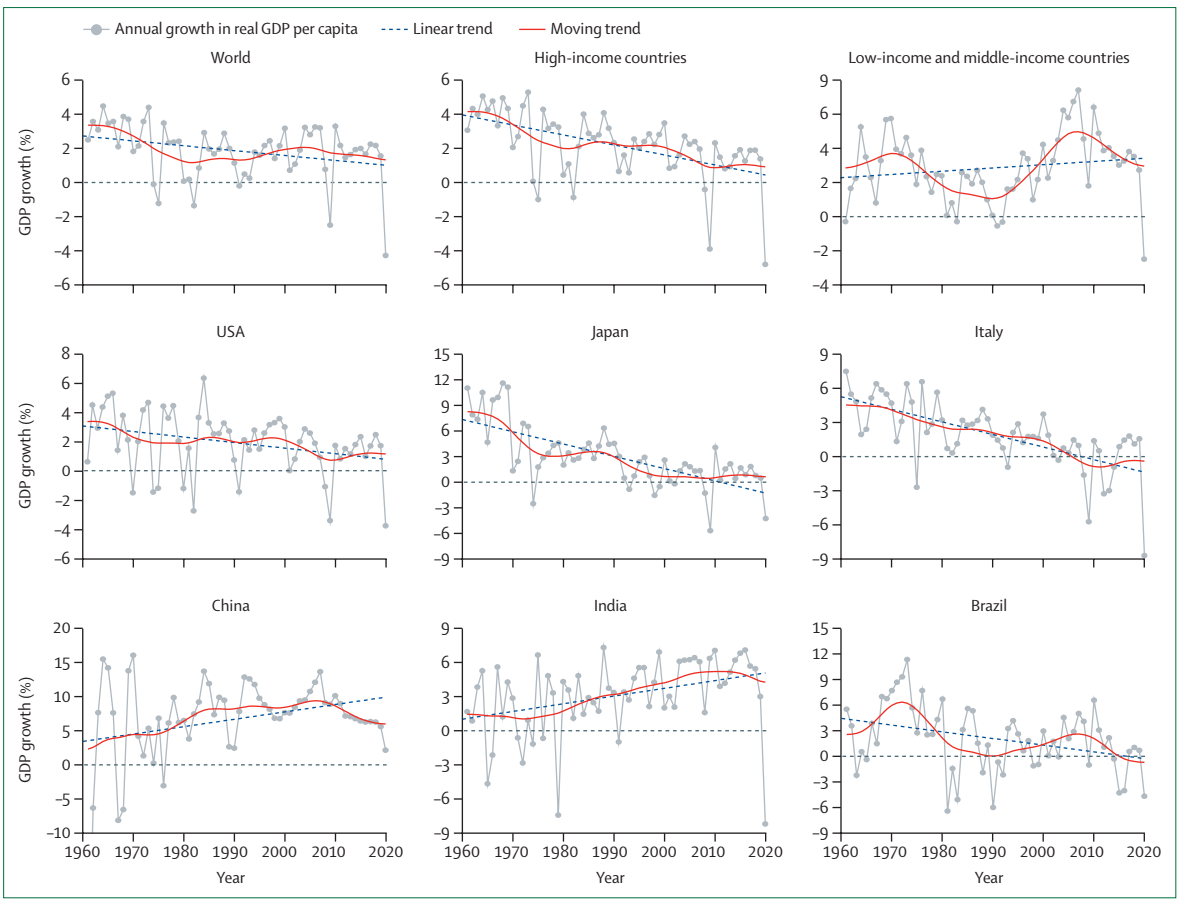

Figure 3: **Growth rate in real GDP per capita, 1960–2020, for different regions and countries**
Since 1960, the rate of GDP growth has declined in high-income countries, and also for the world as a whole. The rate of GDP growth increased in many middle-income countries over this period (eg, China and India), fell in others (eg, Brazil), and might now be declining overall as well. This figure was created using the authors' own calculations based on data from the World Bank.[19] Country classifications follow those of the World Bank (ie, high-income countries are those with a 2020 gross national income per capita of US$12 696 or more, whereas low-income and middle-income countries are those that fall below this threshold). Annual percentage growth in real GDP per capita is provided in constant 2015 $US. The moving trend was calculated using the Hodrick–Prescott filter (with λ=100). GDP=gross domestic product.

reduce emissions.[76] There are ongoing debates regarding the social and environmental impacts of a clean energy transition,[77–79] its implications in terms of the net energy left for other societal uses,[79,80] and the emissions that this transition will involve.[79] A related argument is that a decline in energy return on energy investment—ie, the ratio between the amount of energy produced and the amount of energy used to produce that energy, therefore a proxy of a net energy surplus—will negatively impact growth[81] and that if it falls below a certain minimum ratio, growth might altogether become impossible.[82] However, concerns that a shift to renewables could precipitate such a scenario are probably misplaced, as renewables have comparable, if not higher, energy return on energy investment than fossil fuels, when energy returns are measured at the point of use.[83,84]

In summary, there is little agreement as to whether sufficient absolute decoupling is feasible. One can note a schism on this question between mainstream and ecological economics, and green growth versus post-growth approaches in sustainability science. Although green growth is theoretically possible, and inadequate progress in the past is no proof of future impossibility, the post-growth field suggests taking a precautionary approach, given the historical record and the rapid narrowing of the window to prevent ecological breakdown.[85] Post-growth, it should be emphasised, does not state that decoupling economic activity from emissions and getting to net zero emissions is impossible, just that it is made harder by economic growth. For energy and material use, which can only be reduced and never brought to zero, the necessary reductions are easier to achieve with post-growth.

Human wellbeing and social limits to growth

A second motivation behind post-growth research, dating back to the same era as Limits to Growth, is the observation that above a certain level of income, GDP

growth does not improve human wellbeing.[86] The social limits hypothesis holds that there is a limit to the extent that growth improves subjective wellbeing, because humans adapt to higher levels of income,[87] and compare themselves to others who are also getting richer,[88] or because additional production goes towards zero-sum status goods.[89] The social cost hypothesis is that above a certain level of GDP, the costs of growth (eg, congestion, pollution, mental health, social upheaval) might offset its wellbeing benefits.[90] Growth is said to become uneconomic.[91]

One line of evidence supporting the social limits hypothesis is the much-debated Easterlin paradox, in which self-reported happiness is found to vary directly with income, both between and within nations, but over time the growth of income is not significantly related to the growth of happiness.[92] This finding has been challenged[93] and it seems that the empirical relationship between growth and happiness depends on the set of countries, the length of period, and the type of wellbeing that is measured.[94] Moreover, although income and happiness appear to be related during decreases in GDP, this relationship does not apply during GDP increases.[95] New studies that have inspired post-growth research have shown that countries with full employment policies, strong social safety nets, and decommodified public services exhibit increased life satisfaction[88,96] and that human relations have a much stronger effect on personal wellbeing than income.[97]

Research on wellbeing has shown that a wide range of indicators of social outcomes show diminishing returns as GDP per person increases.[95] These indicators include the first seven Sustainable Development Goals (no poverty, zero hunger, good health, quality education, gender equity, safe water, and sufficient energy), which, under existing arrangements, are achieved at a GDP of around $15 000 per person (measured in 2011 US purchasing power parity dollars).[98] Improvements in social outcomes have been found to be driven primarily by factors other than income, such as public health programmes and other public services.[99–101]

Tentative support for the social cost thesis comes from research on alternative indicators to GDP.[102] The Genuine Progress Indicator (GPI), for example, is a more comprehensive metric of progress that, in contrast to GDP, distinguishes between damaging and beneficial activity.[3] A meta-analysis of 17 countries finds a general pattern of levelling-off of GPI, and a decoupling of GPI from GDP.[3] Globally, GPI per capita peaked in 1978 and has since not increased beyond about $7000 per capita (measured in 2005 US$).

Even if growth above a certain level of income does not improve wellbeing, this does not imply that negative growth benefits wellbeing. The negative effects of recessions on happiness are well established;[88] however, positive trends in social outcomes have been observed during some recessions,[103] and they have been linked to social bonds[104] and public health systems.[105] Given concerns with growth linked to overshooting planetary boundaries and fatally undermining human long-term wellbeing, post-growth research asks under which social conditions and with what types of policies could high levels of wellbeing be sustained at low levels of output and resource use.[106] In contrast to the utility maximisation approach that underpins GDP, post-growth conceptualises human wellbeing in terms of a wide range of subjective and objective measures of wellbeing, with a focus on satisfying basic needs.[106,107]

Stagnation and economic limits to growth

Another question is whether growth will continue in economies that have already reached high levels of GDP. High-income countries, such as the USA, Japan, and Italy, are showing signs of declining growth rates or even stagnation.[108,109] Per capita GDP growth rates have decreased in these countries over the past 60 years, with a more modest slowdown in the global economy (figure 3).

Economists have sought to explain this trend in several ways. One interpretation is that marginal returns decline as an economy grows and becomes more complex.[110] Endogenous growth models, however, claim that knowledge and new ideas can provide increasing returns to capital investment in infrastructure or education that offset diminishing returns.[111] New empirical evidence suggests that productivity in research and innovation might be declining, with implications for economic growth.[112] Many economists now think that there is a stagnation trend in high-income countries, with explanations focusing either on demand-side and investment-related factors,[113,114] or supply-side factors (eg, demographics, education, distribution, energy, and debt).[109,115] For the latter, energy is found to account for only a small share of the drag on growth, but this argument assumes that the effect of energy on GDP is small given the small share of energy-related expenditures in total GDP. If energy were to become scarce, which is possible, albeit far from certain, this relationship could change, given that when energy is scarce, it can impose strong constraints on growth.[116] During large oil shocks, for example, output growth can substantially fall.[117]

Whereas an economic slowdown has traditionally been seen as a problem,[118] a few recent contributions approach it as the outcome of economic success: high-income countries have reached historically unprecedented levels of output and wealth, and stagnation is the effect of desired developments, such as lower voluntary fertility rates or a shift from manufacturing to services.[108] Other studies, however, show that the shift of high-income countries to services has been based on an unequal exchange of labour with low-income and middle-income countries, such that high living standards in the former are subsidised by underpaid agricultural and industrial labour in the latter.[54,119]

Whatever the underlying reason or one's attitude toward it, an economic slowdown could prove to be environmentally beneficial.[120] Economic research has shown that the desired (or optimal) rate of consumption growth might decline to close to zero if (environmental) risks associated with new technologies and people's preferences for safety are taken into account.[121] From a post-growth perspective, the problem then is not that growth might be coming to an end, but rather that, given that economic and political systems are dependent on growth for their stability,[5] stagnation under capitalism poses substantial risks to institutional stability.[4] How to prosper without growth therefore becomes a crucial question.[5]

Post-growth research

Over the past 5 years, research under the labels of post-growth,[1] degrowth,[122] Doughnut economics,[43] wellbeing economics,[123] and steady-state economics[91] has started sharpening the questions that need to be answered if the goal of prosperity without growth is to be achieved.

Post-growth models and policies

An absence of growth in existing economies can trigger unemployment, inequality, and debt accumulation, as factors that are linked to social instability and diminished wellbeing.[4,5] Recent research has explored the conditions under which such outcomes could be averted. An important methodological advance has been the development of several new ecological macroeconomic models.[124] These models differ from the original Limits to Growth model by integrating economic and financial variables. Unlike conventional macroeconomic models, which apply an optimisation framework with a single goal (eg, utility, and hence GDP growth), ecological macroeconomic models typically have multiple non-substitutable goals (eg, sustainability, equity, and human wellbeing).[125] Models simplify and quantify a complex reality, allowing a range of possibilities to be explored, based on what-if scenarios. However, quantification might miss more qualitative, ambiguous, and context-specific elements that are better captured by mixed, or qualitative approaches, such as case-studies or ethnographies, which are also part of the interdisciplinary toolkit of post-growth research.

Two particularly important ecological macroeconomic models developed to test the possibility of post-growth interventions and trajectories are LowGrow SFC (calibrated with data for Canada[126]) and Eurogreen (calibrated with data for France[127]). Different policy measures and assumptions produce different outcomes, but it is notable that scenarios from these two models and countries share some core tendencies (figure 4). In both models, lower growth paths lead to much better climate outcomes. Moreover, good social outcomes are possible when the right policies are implemented. Working-time reduction and a shift from capital-intensive to labour-intensive sectors maintain employment without growth, while a job guarantee (Eurogreen) and additional transfer payments (LowGrow SFC) reduce inequality. Sustainable scenarios combine technology, policy-driven investment strategies, and redistribution in ways that slow growth and environmental impact without compromising wellbeing. Public debt increases, although not to unsustainable levels, whereas household debt declines (figure 4).

Reducing working time is crucial in these scenarios because it reduces unemployment, which is the effect of increasing labour productivity in the context of lower or declining growth.[5,128] In addition, studies at different scales (national, state, and household) and over time (from the 1990s to the present) show that working time is positively correlated with carbon emissions,[129,130] although to date, robust causal models have not been estimated and there is continued debate about the efficacy of working-time reduction as a strategy for climate mitigation.[131] Ongoing global trials involving a four-day workweek might provide further insights on such questions.

Carbon and resource taxes are also used in these models. Previous studies provide additional evidence on the utility of these interventions. For example, fuel taxes lead firms to innovate more in clean (and less in dirty) technologies,[132] although the transition can be slow unless taxes are combined with heavy research subsidies.[133] Questions remain regarding the distributive consequences of carbon taxes[134] and their political acceptability.[135] Some researchers suggest that redistributive tax designs, such as carbon dividends,[136] and inclusive decision-making processes might improve acceptance.[137] However, as concluded by a notable economist,[138] given political obstacles, "carbon pricing alone at politically plausible levels is unlikely to be particularly effective in reducing emissions from the oil and gas used in the transportation, commercial, and residential sectors [and] economists need to look elsewhere for efficient climate policies".

Several other policies for a post-growth transition have been proposed, and recent efforts have attempted to synthesise these into coherent packages (table).[139] Some of these policies might be compatible with growth, but in the post-growth literature, the objective is to secure good social outcomes (eg, employment and decent living standards) in the absence of growth, and to restructure the economy to be greener, healthier, and more equitable.[139] Core proposals include universal basic services (including health care), an unconditional income, a job guarantee, and working-time reductions. Although more research is needed, many of these policies have already been applied in practice, including within controlled experiments. For example, there is growing evidence on the positive social effects of basic income-like cash transfers to economically vulnerable groups.[140] There is evidence also that productivity-led working-time reductions can improve

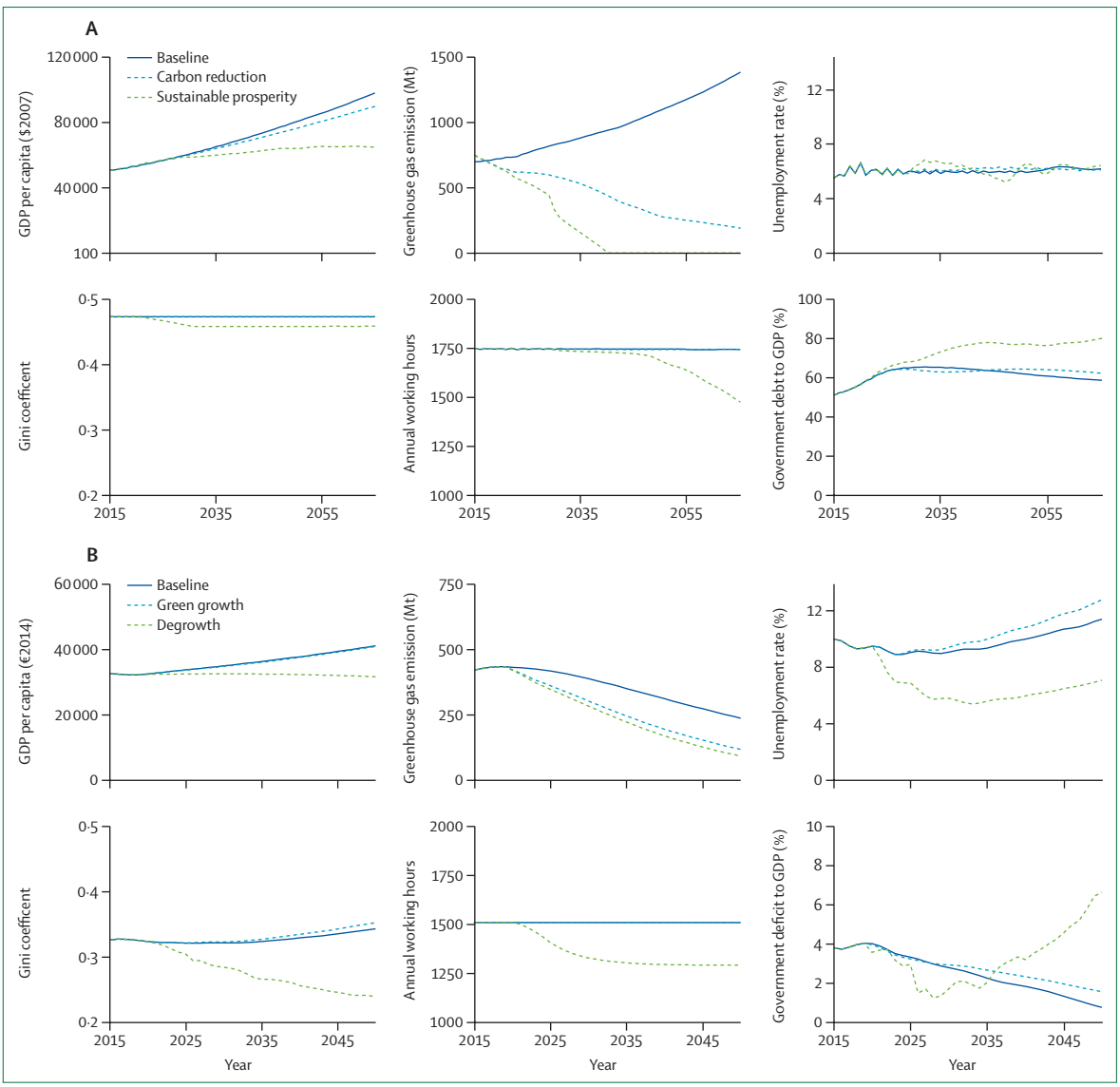

Figure 4: **Simulating the post-growth transition: case studies from Canada and France**

Panel A shows results for Canada, generated using the LowGrow SFC model; panel B shows results for France, generated using the Eurogreen model. Each model was used to simulate three different scenarios, ranging from a baseline scenario through to a post-growth scenario. The policies included in each scenario are additive, in the sense that they build on the policies included in the preceding scenario. (A) Modelled scenarios for Canada are for the period 2015–65. The baseline scenario assumes the continuation of historical trends and relationships. The carbon reduction scenario adds a price on carbon emissions from electricity generation, an increase in labour productivity and energy efficiency, carbon abatement by non-electricity industry, and electrification of road and rail transportation. The sustainable prosperity scenario adds reduced working hours, net-zero carbon emissions by switching from brown to green investment, increased transfer payments to reduce inequality and poverty, and a lower rate of of population growth. (B) Modelled scenarios for France are for 2015–50. The baseline scenario assumes the continuation of historical trends and relationships. The green growth scenario adds a price on carbon and an equivalent tax on imports, incentives for increasing labour productivity and energy efficiency, innovation policies and incentives, and an increased share of electricity in final energy demand. The degrowth scenario adds reduced working hours, a job guarantee, a reduction in consumption and exports, and a wealth tax. Data for LowGrow SFC are from Jackson and Victor;[126] data for Eurogreen are from D'Alessandro et al.[127] GDP=gross domestic product.

environmental outcomes[141] and that intensified labour productivity, with no reduction in working time, negatively affects workers' wellbeing and damages long-term productivity.[142] Finally, there is sufficient evidence that universal basic services are directly linked to strong social outcomes. Data from 153 countries show that an increase in public health expenditure is associated with a decrease in both child and adult mortality.[143] Data from 193 countries show that universal health coverage is associated with increased life expectancy at birth and increased healthy life expectancy.[144] Concerns abound about how to pay for such social policies in a post-growth scenario, and how to do this while also controlling inflation. These are currently being addressed by proponents of these policies through

	Description	Advocates' case for	Concerns or points of debate
Universal basic income	A monthly income guaranteed to all residents for life, without any requirement	Compensates for unpaid care work; reduces inequalities; enables people to engage in non-wage creative activities; decouples survival from employment; removes stigma and bureaucracy associated with conventional benefit systems	If funded by tax on income or resources, universal basic income might create a dependency on growth to fund it; it might suppress wages or increase rents, as business owners pay less and property owners charge more in the knowledge that workers receive the basic income; environmental pressure might rebound if income is spent on material consumption
Working-time reduction	Reduction of statutory hours of work per week or year	Ensures high employment in the absence of growth; confers wellbeing and health benefits; reduces environmental pressures; redistributes productivity gains to labour	Might reduce purchasing power for workers if hourly pay remains constant (this is not the case, however, for proposals for working time reduction with constant monthly wage); might result in rebounding environmental impacts if free time is used in resource-intensive ways; might increase unemployment if rising labour costs encourage firms to adopt labour-saving strategies
Universal basic services	Guaranteed access to health care, education, housing, transit, food, and care services for all, without (or with only partly) having to pay for them	Secures minimum conditions for decent living regardless of fluctuations in aggregate output; reduces poverty; redistributes access to services; reduces inequalities	Access to some services (eg, food and housing) might need means-testing, which can create stigma and could create incentives for people to remain insecure to retain access to these services
Job guarantee	All residents are guaranteed access to training and employment in essential public works	Eliminates involuntary unemployment; reduces poverty and exclusion; can be used to direct labour toward socially and environmentally beneficial activities; can be used to set good labour standards and wages across the whole economy	Limited public ownership of means of production constrains the possibility of redirecting the economy through public works; in some countries, the state might have insufficient legitimacy to restructure the economy and it might be unpopular to work for the state; higher wages could prompt labour-saving strategies by capital; higher wages could stimulate more growth
Maximum income	A maximum permissible total income or a maximum wage differential within an organisation, or society as a whole	Limits inequalities; reduces the excess purchasing power of the rich; reduces unnecessary production and consumption; reduces ecological impacts	Tax evasion; outmigration of high-paid professionals
Wealth tax	Progressive annual tax on asset holdings above a certain threshold	Reduces inequalities; distributes wealth more equitably; can be used to fund social and ecological policies	Tax evasion; wealth and capital flight
Public money	Creation of money by the state to spend on social and environmental initiatives; credit policy and taxation are used to reduce excess demand to control inflation	Increases fiscal possibilities; facilitates debt-free money that does not require growth to be repaid	Power can be misused to pay for socially and environmentally detrimental projects; might be politically difficult to tax money out of circulation to reduce inflation
Replacing GDP	Replace GDP with wellbeing and sustainability indicators	Removes distorting role of GDP, which is a poor measure of wellbeing; directs policy to wellbeing and sustainability goals	Absence of powerful epistemic community to support alternative indicators; GDP accounting entrenched in institutional structures
Cap and adapt	Cap and phase out fossil fuels, rationing fossil fuel use per country	Direct reduction of emissions; equitable sharing of mitigation	Monitoring and enforcement; unlikely to reach more binding international agreement
Green New Deal	Public investment programme on the order of 5% of GDP to achieve a just climate transition, coupled with social policies	Fast mobilisation of resources for climate mitigation; social justice and reduction of inequalities	Cost, and pressure for growth to pay back investments; environmental injustice against regions where raw materials are extracted from
Carbon taxes or dividends	Tax carbon (including on imported goods) and return revenue as a universal dividend	Incentivises a shift away from carbon-intensive activities; avoids distributional consequences and conflict	Needs to be very high to have a real effect; few substitution possibilities for many carbon-intensive activities; has lost political momentum

A summary of the main arguments made by advocates of these policies, alongside their most pertinent critiques. Advocates have defended proposals against such critiques; we see these debates as open and marking frontiers for new research.

Table: **Post-growth-oriented policies**

Modern Monetary Theory and public money finance (table).

A core social and economic question concerns the dynamics of inequality in the absence of growth. This question is motivated by Thomas Piketty's thesis that when GDP growth is lower than the real rate of return to capital (which has historically been around 5%), a greater share of national income can accumulate in the hands of wealth holders.[145,146] Data from the USA, China, France, and the UK show rising top income and wealth shares since the 1980s, but with substantial variations due to different country-specific policies and institutions.[147] Notably, in Piketty's dataset, inequalities historically increased after the 1980s in a period when economies did grow, and the great reduction in inequalities in the 20th century was the side-effect of the two wars and the destruction of wealth, as well as the redistributive policies that were brought about by the wars. In low-growth or zero-growth environments, policies that reduce returns to capital (eg, by taxing wealth or by promoting worker ownership) and policies that support a shift to labour-intensive industries (eg, education or health care) can prevent inequality from increasing.[145,146] Independently of growth rates, the role of strong trade unions is also crucial in reducing inequalities.[148]

Beyond economic policy-oriented research, researchers have also sought to conceptualise what post-growth would look like in various domains of life: from innovation[149] and urban planning[150] to fashion[151] or leisure.[152] These studies follow a more qualitative approach, often based on case-studies, offering rich hypotheses about cultural, social, and political arrangements that could allow societies to prosper without growth in different contexts.

Growth dependencies

Under existing economic arrangements, growth is regarded as necessary to increase employment, reduce inequalities, and raise tax revenue to pay for public services. How can these growth dependencies be reduced? For instance, how can welfare systems (eg, pensions, education, and health care) be sustained without growth? Researchers have proposed that specific policies can achieve these objectives (table). The difficulty associated with modelling such changes lies in the inability to calibrate them using historical experience. Two approaches have been taken to address this problem. One is to analyse case studies in which individual nations (eg, Japan) have had to manage long-term stagnation.[153] The other is to deconstruct the mechanics of growth dependency for particular sectors of the welfare state and generate different institutional possibilities for welfare without growth.[154,155]

The relationship between social spending and GDP is arguably an important source of growth dependencies. As research on the UK social care sector shows, population ageing and increasing productivity in other sectors that raise the cost of care services, coupled with a privatisation and financialisation of the sector that makes short profits necessary, renders constant growth an imperative for social care providers. But this growth crucially depends on power relations, since there are alternative options for financing care services other than through growth in revenue, yet these are limited by vested interests linked to the privatised organisation of the care sector.[155] How to pay for social services without growth is an important question, and a research agenda is now opening on the possibilities of public finance and credit regulation to redirect labour and resources where they are most needed without relying on growth.[156]

Debates persist about whether capitalist economies have inherent growth imperatives—ie, mechanisms that require growth to keep the economy functioning and that are difficult for individuals, firms, or nation states to circumvent.[157] Studies have argued that under conditions of technological innovation, firms are under pressure to accumulate capital to avoid being driven out of business by competitors.[157] Debt with interest might also compel growth, at least in the case of private or external debts, although models find that positive interest rates are compatible with non-growing economies if all profits from interest are distributed to households.[158] A study of ten historical cases concluded that interest-bearing loans have been problematic in past non-growing and slow-growing economies, and have occasionally been dealt with by cancelling debts or banning compound interest.[159]

Although post-growth policy frameworks are fairly well developed, there has been less focus on the politics that can make such radical policies possible. One line of research looks at the factors that lock in growth-oriented policies and thus leave little room for alternatives. Historians and social scientists have sought to explain the origins of the political hegemony of growth:[160] the dominance of the pursuit of GDP growth as a political objective. Growth might not be an economic imperative in the abstract, this literature suggests, but rather a political imperative, locked in by power relations, institutions, and accounting systems geared towards its pursuit.[161] The contemporary preoccupation with GDP first emerged as a response to the need of governments to manage economic production during the Great Depression and the Second World War, whereas growth-targeting became entrenched during the Cold War, linked to the arms race between the two blocs.[161] An iterative process between accounting and targeting, and the institutions geared towards the measurement and pursuit of GDP, gradually made growth appear as a natural and unquestionable objective.[162] But the success of growth, as a political objective, stems from its function, which was to appease and deflect distributional conflict, becoming a core factor of state legitimacy and political stability.[163] Political theorists now debate the effects that an end of growth might have on the legitimacy and stability of liberal democracies.[4,164] However, some scholars argue that while a shift to authoritarianism is a strong possibility, social conflict might also, under conditions that remain to be studied, open up paths to deeper and more direct forms of democracy.[122]

Whereas these accounts suggest that a post-growth transition might be politically difficult for structural reasons, other studies point to promising political possibilities. Survey research shows that most Europeans are in favour of post-growth,[165] most scientists (especially climate scientists) are either agnostic towards growth or favourably inclined towards degrowth,[166] and interviews with elected members of the European Parliament find a strong current of post-growth ideas among left and green politicians.[167] Research on the German Parliament, however, finds that political discourse and practice around growth remains unresponsive to politicians' individual convictions, because of growth's entrenched role as a political option to mitigate distributional conflict.[168] Promising avenues open when the problem is framed as one of limited resilience due to growth-dependence, and with specific solutions that respond to immediate challenges of stability[169] or when prioritising wellbeing rather than averting environmental loss.[170]

Although there is a vibrant literature on the ways social movements could act as political agents of post-growth,[171–173] less attention has been paid to the geopolitical implications of post-growth scenarios, and the risks first movers might face, such as capital flight or a decline in geopolitical power. As with the climate clubs proposed by economists,[174] there might be possibilities for post-growth clubs, where nations collaborate around a shared set of post-growth policies and impose penalties on non-participants. The Wellbeing Economy Governments partnership (including Scotland, Iceland, New Zealand, Wales, Finland, and Canada) and the Fossil Fuel Non-Proliferation Treaty (a sort of international agreement on an equitable downscaling of a damaging industry, now signed by many countries), can be seen as steps in this direction.[123,175]

Living well within limits

Post-growth research on resource use and human wellbeing grapples with two big questions: can wellbeing be achieved at lower levels of resource use than what characterises high-income countries today? And if so, would this allow humanity as a whole to stay within planetary boundaries?

Post-growth research explores both subjective and objective measures of wellbeing, and recent empirical studies agree on two important points. First, there is substantial variation in the levels of resource use and carbon emissions at which good social outcomes are currently secured,[176,177] with several middle-income countries achieving social outcomes that match or exceed those of high-income countries.[178] Second, there are currently no countries that achieve good social outcomes while staying within their fair share of planetary boundaries (figure 5)—although some, such as Costa Rica, come close.[180]

Empirical research points therefore to an important conundrum. On the one hand, high-income countries achieve high levels of human wellbeing but significantly overshoot their fair share of planetary boundaries.[181,182] The level of resource use of these high-income countries cannot be universalised.[177] On the other hand, despite a decline in the amount of energy required to achieve human development goals,[183] modelling decent living standards for all within planetary boundaries shows that, under existing conditions, there is very little room for excess or for inequality.[184]

This research has led to a shift of attention towards alternative provisioning systems and the types of distributional dynamics that could radically change current relationships between resource use and human wellbeing.[185] Provisioning systems refer to both physical systems (eg, infrastructure and technology) and social systems (eg, markets, government institutions, and culture). Research shows that by increasing beneficial provisioning factors (eg, public services, income equality, and democratic quality) and reducing other detrimental factors (eg, economic growth beyond moderate levels of affluence), human needs can be met at much lower levels of energy use.[186] There is also well established, but in need of updating, empirical evidence that many low-income countries that implement public provisioning systems achieve better health outcomes than much wealthier economies that do not.[187] Moreover, the first global decent living energy modelling effort calculates that human needs can be met at a good standard for 10 billion people with levels of energy use that are compatible with 1·5°C.[188] A recent review of industrial transformation models and scenarios found that combined supply-side and demand-side measures could reduce current economy-wide material use by 56%, energy use by 40–60%, and greenhouse gas emissions by 70% to net zero.[189]

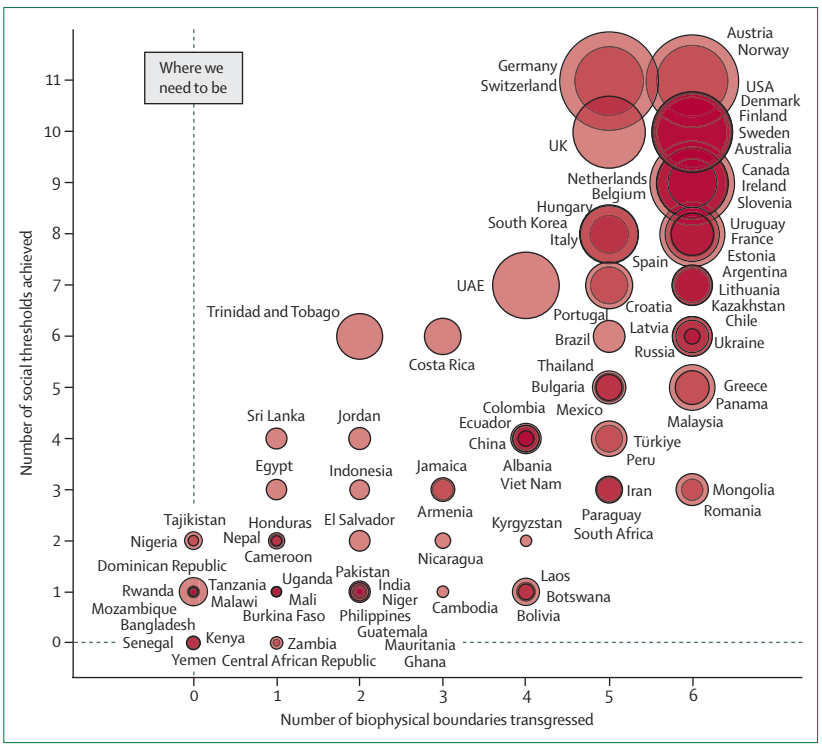

Figure 5: **Number of social thresholds achieved versus number of biophysical boundaries transgressed for 92 countries in 2015, scaled by per capita GDP**

Ideally, countries would be located in the top-left corner, where no country currently is. Currently, high-income countries achieve social goals, but at the expense of crossing planetary boundaries. Social and biophysical data are from Fanning et al[179] and per capita GDP data (measured in 2015 US$) are from the World Bank.[19] The 11 social thresholds are for life satisfaction, life expectancy, nutrition, sanitation, income poverty, access to energy, secondary education, social support, democratic quality, equality, and employment. The six biophysical boundaries are for CO_2 emissions, phosphorus, nitrogen, land-system change, ecological footprint, and material footprint. GDP=gross domestic product.

North–South dynamics in a post-growth context

In the post-growth literature, there is general agreement that low-income countries should achieve social outcomes similar to those that high-income countries presently enjoy, and should increase production as necessary to achieve these outcomes.[7,91] However, the

need for resource use contraction and convergence within the world economy raises questions about necessary changes to the structure of the world economy. A core question is how development and resource use in low-income countries links to development and resource use in high-income countries.

Ecological economists have approached this question using environmentally extended input–output data and have found that growth in high-income countries relies on a large net appropriation of materials, energy, land, and labour from the Global South, embodied in traded goods.[54,190] World-system scholars in turn have argued that this unequal exchange occurs because richer states are able to leverage their financial and geopolitical power to organise production in the Global South toward supplying global commodity chains, while depressing the prices of labour and resources in the Global South.[54,191] This process drains countries in the Global South of their productive capacities that could be used instead to provide for local human needs and achieve development objectives more directly.[54,191] This analysis runs counter to dominant narratives in development economics and mainstream policy discourses. However, if this literature is correct, post-growth in high-income countries might be beneficial for low-income countries, to the extent that it reduces or eliminates an unfair appropriation of resources.[171,172]

However, to the extent that low-income countries have come to depend on exports to high-income countries to maintain employment and service debts,[192] post-growth transitions and demand reduction in the latter could have damaging effects in the former, in the absence of policy interventions. The literature on monetary sovereignty[193] and industrial policy[194] could be helpful in offering insights into how governments in low-income countries can reduce reliance on foreign currency, and mobilise resources, labour, and production around human needs and national development objectives.

Another angle through which questions of human development and growth have been approached is through the literature on post-development and needs-oriented development, which have emerged from the Global South, and which argue that growth should not be pursued as an objective in itself; rather, the focus should be on social outcomes, following local models of human development and wellbeing, rather than a universal Global North growth model.[195,196] This literature builds on a long history of growth-critical ideas in some Global South countries, such as India and Bhutan,[197] or experiences in countries, such as Tanzania, Iran, and Haiti.[198]

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Lessons learned and knowledge gaps

Independent of what one thinks about the sustainability or desirability of economic growth, given that the world finds itself in a situation of slowing growth coupled with intensifying ecological breakdown, the emerging post-growth research described here asks important questions and offers tentative answers that can help prepare societies for an unstable future.

Post-growth research has established a new generation of national ecological macroeconomic models that make it possible to explore questions of stability and wellbeing without growth, while evaluating in a systemic way the effects of alternative social and economic policies. These models indicate that there are stable post-growth pathways that can allow high-income countries to achieve both social and environmental objectives. Yet these models could still be improved in four ways.

First, there is a need to expand the range of environmental and wellbeing indicators considered.[199] Recent extensions include material flows and the ecological footprint.[200] It would also be useful to explore whether post-growth scenarios would have positive or negative effects on other environmental variables, such as biodiversity, land-use, and water, or to model broader social measures, such as health and life satisfaction. Second, there is a need to adjust and calibrate the models for geographical and economic contexts other than those of Europe and North America, evaluating alternative development policies and stability questions relevant for Global South economies. Third, national-level models need to be improved to capture international relations and dynamics, accounting for trade, capital, and currency flows—factors that might complicate post-growth scenarios in a single country. And finally, there is a need to extend the national economy approach to global climate economy models that connect to and improve on existing Integrated Assessment Models, so that post-growth mitigation scenarios can be modelled for the IPCC.[63] One should expect important developments in all of these fronts in the next 5 years given substantial resources devoted by the EU to related research.[11–14]

As this Review has shown, there is accumulating evidence on policies that could secure wellbeing without growth in high-income countries (eg, universal access to essential goods and services, working-time reduction, and carbon and wealth taxes). Approaching the question of stability as a problem of growth dependency has helped to identify the institutional factors that link stability to growth, and the alternatives that might break such dependencies. Given that at present no countries are enacting post-growth agendas, small-scale experimentation, such as with basic incomes and working-time reduction, offers a controlled setting for reproducible knowledge, though experimentation must be scaled up and extended to other policies. One interesting direction is participatory action research, such as the Doughnut Economics Action Labs, where stakeholders and members of the public develop post-growth programmes for their cities.[201] Stakeholder approaches could also be used for diagnosing and addressing growth dependencies through policy labs. However, there is still a gap concerning policies suitable

for Global South contexts and the global institutional arrangements necessary to end unequal exchange between the Global North and the Global South.

There have also been important developments, as noted above, in understanding the factors that allow social outcomes to be decoupled from GDP, such as robust public services and safety nets, income equality, and democratic quality.[186] And beyond general contract and converge scenarios between high-income countries and low-income countries, there is a need for sector-by-sector and region-by-region analysis of human needs and resource transformations.

Finally, the question of politics emerges as an important research frontier. Whereas science is advancing on the questions of desired pathways, provisioning systems, and policies for a post-growth economy, we still know little about the politics that could make post-growth transitions possible in reality. A particular blind spot concerns geopolitical relations, and how changes in international governance and world orders open up, or close down, opportunities for post-growth and sovereign development.

Scientific interest in the questions addressed in this Review has increased over the past several years—the IPCC has extended discussions through its Sixth Assessment Report[85] and the European Research Council[13,14] and the European Commission have supported new research.[11,12] Whereas post-growth research has been developed primarily within sustainability science and ecological economics, there are important insights on questions of stability and wellbeing to be offered by many other disciplines. Bringing disciplines together, developing new trans-disciplinary concepts, and integrating empirical studies with theoretical frameworks and models could provide valuable insights into how societies can achieve high wellbeing without economic growth, and within planetary boundaries.

Contributors

GK led the conceptualisation and writing of this Review and compiled the table. JH contributed to conceptualisation and led the writing of the sections on planetary boundaries, wellbeing, and development. DWO, TJ, PAV, KR, JBS, JKS, and DÜ-V contributed to writing this Review. DWO carried out the analysis of the Limits to Growth scenarios and created figures 1, 3, and 5; TJ created figure 2; and PV created figure 4. The data used to prepare the visuals are available from the corresponding author upon reasonable request.

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