**A Critique of Techno-Optimism**

***Efficiency without sufficiency is lost***

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**1. Introduction**

Across human history technology has played a significant role in the development of civilisation – a role that has accelerated dramatically over the last few centuries due to the interrelated emergence of capitalism and the scientific and industrial revolutions. Through technological advancement humans have been able to produce electricity, cure diseases, split the atom, travel into space, invent computers and the internet, and map the human genome, among an unending list of things that often seem like miracles. Notably, these technological advancements have also assisted in the unprecedented expansion of our productive capacities through harnessing the energy in fossil fuels and developing machines to augment human labour. This has allowed many people, primarily in the developed nations, to achieve lifestyles of material comfort that would have been unimaginable even a few generations ago. Increasingly it seems that all 7.6 billion people on the planet are set on achieving these high consumption lifestyles for themselves, and at first consideration the universalisation of affluence indeed seems a coherent and plausible path of progress.

But all that glitters is not gold. No matter how awesome the advancement of technology has been as a means of raising material living standards, there are also well known social and environmental dark sides that flow from this mode of development. Economic activity depends on nature for resources, and as economies and populations have expanded, especially since the industrial revolution, more pressure has been placed on those natural and finite resources, ecosystems, and waste sinks. Today we face a series of overlapping crises owing to the heavy burden our economies are placing on the planet (Ehrlich and Ehrlich, 2013; Ripple et al, 2017). It is estimated that the global economy now exceeds the sustainable carrying capacity of the planet by 70% (Global Footprint Network, 2017), with deforestation, ocean depletion, soil erosion, biodiversity loss, nitrogen and phosphorous pollution, water shortages, and climate change being just a sample of these acute, unfolding problems (Rockstrom, et al., 2009). Recent publications from the IPCC (2014) reiterate the immense challenge of climate change in particular, with the necessity of rapid emissions reductions becoming ever more pressing as carbon budgets continue to shrink through lack of committed action. At the same time, great multitudes of people around the planet still live in material destitution, and the global population continues to grow (UN, 2017), suggesting the environmental burden is only going to be exacerbated as the global development agenda – the goal of promoting growth in global economic output – is pursued into the future (Turner, 2012).

Technological optimists believe, however, that just as the application of technology has been a primary cause of environmental problems, so too does it provide the primary solution (Lovins, 1998; Lovins, 2011; Lomborg, 2001). Techno-optimism, in this sense, can be broadly defined as the belief that science and technology will be able to solve the major social and environmental problems of our times, without fundamentally rethinking the structure or goals of our growth-based economies or the nature of Western-style, affluent lifestyles. In other words, techno-optimism is the belief that the problems caused by economic growth can be solved by more growth (as measured by GDP), provided we learn how to produce and consume more efficiently through the application of science and technology.

There is debate, it should be stressed, among techno-optimists regarding environmental policy solutions. While some believe that problems can be solved by ‘free-markets’ (see, e.g., Simon and Kahn, 1984; Beckerman, 2002), most recognise a strong role for government in regulating markets, commonly through either tax or cap-and-trade market mechanisms (see, e.g. Hatfield-Dodds et al, 2015) designed to incentivise the uptake of innovative technologies. Common to all techno-optimists, however, is an assumption that environmental problems can be solved via the applications of technology within the framework of the growth economy (Purdey, 2010).

This chapter presents an evidence-based critique of such techno-optimism, arguing that the vision of progress it promotes is unrealisable due to the limits of technology and the inherent structure of growth economics. The focus of this critique, however, is not on specific technological solutions (see Huesemann and Huesemann, 2011; Hamilton, 2013) but rather the more subtle faith techno-optimists place in ‘efficiency’ as the environmental saviour. The critical analysis begins in Section 2 by placing techno-optimism in theoretical context. It is important to understand the structure of techno-optimism and see why it forms a central part of the ideology of growth. In Section 3 and 4 the poor historical record on ‘decoupling’ GDP from environmental impacts is examined, and this analysis is used to explain why efficiency improvements have not produced sustainable economies despite extraordinary technological advance in recent decades. It turns out efficiency improvements have not often been able to keep up with continued economic and population growth, meaning that overall environmental impact continues to grow, despite efficiency improvements. Section 5 unpacks the arithmetic of growth to expose how deeply implausible techno-optimism really is, in ways the optimists themselves seem scarcely aware. The central conclusion of this critique is that technology cannot and will not solve environmental problems so long as it is applied within a growth-based economic model. The degree of decoupling required is too great.

**2. Techno-Optimism and the Ideology of Growth**

In 1971, Paul Ehrlich and John Holdren published an article that greatly advanced the understanding and communication of environmental problems and their potential solutions (Ehrlich and Holdren, 1971). In this article they developed what has become known as the IPAT equation. This equation holds that environmental impact (I) equals, or is a function of, Population (P), Affluence (A), and Technology (T). While this equation is not without its limitations and drawbacks, it nevertheless made it easy for environmentalists to talk about the nature of the unfolding environmental crisis (Meadows *et al.*, 2004). With the IPAT equation, it could be shown in clear terms that environmental impact could be mitigated by the various means of reducing population, reducing per capita income, and reducing the energy or resource intensity of production and consumption through technological development and better design. Put otherwise, the equation showed that continuous population and consumption growth would exacerbate environmental problems, unless technological advancement could outweigh those impacts through efficiency gains.

One of the attractions of the IPAT equation was the way in which it highlighted how individuals and policy-makers had various options available to them for tackling environmental problems. People who cared about the environment could try to lessen impact either by trying to reduce population, by trying to reduce consumption, or by trying to produce and consume as efficiently as possible.

Nevertheless, the fact that there were options turned out to be a mixed blessing. After all there was (and still is) extreme social, economic, and political resistance – by governments, business, and across much of civil society – to taking concerted action on two of the three IPAT variables: population growth and per capita income. With respect to population growth, while we know it is the multiplier of everything (Alcott, 2010), population control is obviously a thorny issue, in that procreation seems like a very private and intimate issue that governments should not try to regulate. For this reason, population has been, and to a large part remains, one of the great taboo subjects of the environmental debate. A similar dynamic could explain the marginalisation of consumption. Since a higher income is almost universally considered better than a lower income, governments, and indeed the voting public, have looked for other ways to lessen environmental impact. To borrow a phrase from George Monbiot (2006), people do not ‘riot for austerity’.

The IPAT equation, however, had within it the win-win solution that people seemed to be seeking: efficiency improvements. Even if a nation was unable to reduce population, and even if it was unwilling to reduce its income, the equation provided a theoretical framework that showed that it was nevertheless possible to reduce environmental impact through technological advancement (Simon and Kahn, 1984). At the core of this claim was the idea of ‘decoupling,’ according to which economic growth could be divorced from growing environmental impacts, thereby enabling continued increase in production, consumption, economic turnover and ‘living standards,’ while resolving serious resource and environmental problems.

This ‘techno-fix’ approach was a much more politically, economically, and socially palatable way to address environmental problems. It provided governments, businesses and individuals with a means of responding to environmental problems (or being seen to respond to environmental problems), without confronting population growth or questioning affluent lifestyles. It is such a convenient idea that governments and businesses tend to believe in it, irrespective of whether it has much empirical support. As the next sections show, however, the empirical support for decoupling is lacking, which is a most inconvenient truth for those consciously or unconsciously committed to the ideology of growth (Hamilton, 2003).

**4. Are Economies Decoupling Growth from Impact?**

As noted, ‘decoupling’ is the idea that GDP growth can be, over time, progressively divorced from environmental impacts. In assessing the recent decoupling record, it is imperative to distinguish between ‘relative’ and ‘absolute’ decoupling (Jackson, 2016). Relative decoupling refers to a decline in the ecological impact *per unit* of economic output. Absolute decoupling refers to a decline in the *overall* ecological impact of total economic output. While relative decoupling may occur, making each commodity less materially intensive, if the total consumption of commodities increases then there may be no absolute decoupling; indeed, the absolute ecological impact of total economic activity may increase.

Given that the global economy already exceeds the planet’s sustainable carrying capacity by 70% (Global Footprint Network, 2017), large scale absolute decoupling is what is needed. The problem is, the record to date suggests very little *absolute* decoupling is occurring, let alone at the rates that would be needed for long-term sustainability – an issue we will return to below.

Consider the example of carbon emissions. There is no doubt that significant *relative* decoupling – i.e. emissions per unit of GDP – has taken place. Tim Jackson (2016: 88) reports that the amount of carbon released per unit of world’s economic output has declined continuously over several decades, from 760 grams of carbon dioxide per dollar in 1965 to just under 500 grams of carbon dioxide per dollar in 2015. That is an average decline in carbon intensity of a little under 1 per cent per year. Nevertheless, despite these efficiency gains, global carbon emissions have continued to rise in absolute terms, more than *trebling* over the same period. It is true carbon emissions from fossil fuels and industry (excluding land-use change) were flat from 2014-2016 at about 36 billion tonnes, suggesting that emissions might have peaked and could soon start to decline. Unfortunately, however, global emissions have since recommenced their upward trajectory, with indications that record levels were reached in 2017 (Global Carbon Budget, 2017). This shows that – even thirty years after the IPCC was established – the significant relative decoupling of carbon (and energy) intensities has so far failed to translate into actual absolute declines. To date, technological advance is not fulfilling its promise to reduce overall impact.

A similar story holds with respect to global resource consumption, a measure which includes aggregate consumption of biomass, fossil fuels, metal ores and minerals. A review of the evidence found that resource efficiency improvement for the global economy between 1980 and 2009 averaged 0.9% p.a. (Giljum et al., 2014). This, however, represented a per annum efficiency improvement that was less than one third of the rate that would have been needed for ‘absolute’ decoupling (Giljum et al: 328), i.e., growth of GDP without any increase in materials use. As such, over the same period global materials use more than doubled. Furthermore, as a UNEP (2016) report found, this efficiency improvement rate masks a more recent efficiency *decline* since the turn of the century, from 1.2 kg per one US$ of GDP in 2000 to almost 1.4kg per US$ by 2010 (UNEP, 2016: 40). In other words, far from decoupling – even in relative terms – this report showed that, from the turn of the century, the global economy has undergone a process of material ‘recoupling’. Given the fact that increasing material consumption use ‘is one of the key drivers for environmental problems and is directly or indirectly responsible for problems such as climate change, water scarcity or biodiversity loss’ (Giljum, 2009: 332-3), it should be no surprise that these problems, far from improving at the global level, continue to get worse (Ripple et al, 2017).

It is true that some limited absolute decoupling is underway in certain sectors of some nations, specifically as some developed economies move towards ‘service’, ‘information’, or ‘post-industrial’ modes of production and consumption (see i.e. Steinberger et al, 2013). This is especially the case for localisedpollutants, such as wastewater discharge, sulphur dioxide emissions, and carbon monoxide emissions (Dinda, 2004; Bo, 2011). Some of these nations have reduced domestic carbon emissions (i.e. emissions released within the national territory) in absolute terms (Carbon Tracker, 2016).

However, while these reductions are positive steps in the right direction, the achievement is often less impressive on deeper interrogation. Often a large fraction of the decoupling taking place in rich nations is a result of environmental ‘leakage’ – that is, the process whereby wealthy nations have, throughout the globalisation era, increasingly externalised environmental damage via mechanisms such as pollution trading and the outsourcing of environmentally intensive production to developing countries, especially China. While it may be possible to ‘externalise’ impacts from a given nation, the planet, of course, is a closed system in this regard. Accordingly, when ‘externalised’ manufacturing or agricultural commodities – and their associated environmental harms – are ‘internalised’ from an accounting perspective, much of the apparent environmental progress of high consuming countries disappears. For example, it is no good claiming a reduction in national deforestation, say, if a nation is simply importing more wood from abroad rather than cutting down its own trees (Asici, 2013). Similarly, it has hardly environmental progress if the rate of species loss is reduced within a nation if, at the same time, the net import of luxury agricultural crops is driving accelerated species extinction across the globe (Lenzen et al, 2012). The OECDs aggregated carbon reductions between 2000 to 2013 reduce by about half when a consumption based methodology is used and the emissions embedded in imports from ‘pollution havens’ in China and other industrialising nations are fully accounted for (Carbon Tracker, 2016). To the extent that some nations have achieved absolute decoupling in carbon emissions, the problem remains that this process has been too slow and too minor to provide much solace, and as noted above, from the global perspective that ultimately matters, carbon emissions remain on the rise.

The effect of environmental leakage is most pronounced with respect to overall material usage. Wiedmann et al (2015) has shown that absolute decoupling within OECD nations is only evident when using the ‘domestic material consumption’ (DMC) accounting measure, which fails to factor in upstream raw materials embedded in imports that originate outside the focal country. If instead one uses the recently developed material footprint (MF) – a measure which includes all the raw materials associated with final demand of a given economy – the picture looks very different. The study found that between 1990-2008 the material footprint of the OECD (as well as the EU), ‘kept pace with increases in GDP and no improvements in resource productivity at all are observed when measured as the GDP/MF’ (Wiedmann et al, 2015: 6273). In other words, when a proper accounting is applied, many OECD nations have not even achieved relative decoupling in material footprint over the last two decades, let alone absolute reductions. Accordingly, the idea that wealthy nations have reached ‘peak stuff’ seems to be no more than a widely promoted myth that only serves to entrench the economics of growth.

In the final analysis, any rich world decoupling to date remain far from adequate to put humanity on a sustainable pathway – a point we will elaborate on below. As a rule, the richest nations remain, on a per capita basis, by far the most environmentally impactful (Global Footprint Network, 2017). Certainly, the environmental impacts of the rich nations are not showing an ‘inverted U’ shape claimed by advocates of the so-called Environmental Kuznets’ Curve, which holds that getting rich is the best way to live lightly on the planet (Beckerman, 2002). At the global level, decades of extraordinary technological development have failed to decouple GDP from environmental impact. Despite isolated examples of success, every year more carbon emissions are sent into the atmosphere and more renewable and non-renewable resources are extracted from our finite Earth. It seems, therefore, that the ‘optimism’ in ‘techno-optimism’ lacks evidential foundation

**5. Efficiency and the Rebound Effect**

The poor historical record of decoupling reviewed above is counter-intuitive, perhaps, because one might ordinarily think that efficiency gains would lead to substantial reductions in energy and resource demands. In other words, it is plausible to think that as the world gets better at producing commodities more efficiently, the absolute impacts of our economic activity would naturally decline. But we have seen that this assumption has not played out in reality. In part this is due to sheer growth in economic throughput and energy services, which has overwhelmed the efficiency gains that have been made. But another critical part of the explanation is due to what are known as ‘rebound effects’ (Alcott, 2005; Polimeniet al*,* 2009; Saunders, 2013). A rebound effect is said to have occurred when the benefits of efficiency improvements are partially or wholly negated by consumption growth – either by consumers or by industry – that was made possible by the efficiency improvements (Herring and Sorrell, 2009; Alcott and Madlener, 2009). For example, a 5% increase in energy efficiency may only reduce energy consumption by 2% if the efficiency improvements incentivise consumers or industry to increase demand for energy (meaning 60% of anticipated savings are lost or ‘taken back’). In other words, efficiency improvements can provoke behavioural or economic responses (‘rebounds’) that end up reducing some of the anticipated benefits of the efficiency improvements. When those rebounds are significant enough they can even lead to *increased* resource or energy consumption, which is sometimes called ‘back-fire’ or the ‘Jevons paradox,’ in reference to the classical economist William Stanley Jevons who first observed the phenomena. There are two main categories of rebound effects – direct rebounds and indirect rebound.

A direct rebound occurs when an efficiency gain in production results in increased consumption of the same resource (Khazzoom, 1980; Frondel *et al.*, 2012). For example, a more fuel-efficient car can lead people to drive more often, or drive further, since the costs of fuel per kilometre have gone down; a more efficient heater can lead people to warm their houses for longer periods or to hotter temperatures, since the relative costs of heating have gone down; energy efficient lighting can lead people to leave the lights on for longer, etc. (Sorrell, 2009). Similar dynamics operate in industry whereby the introduction of more energy efficiency methods either reduces the price of a commodity (since it makes production less resource-intensive or time-intensive), or else enables the development of new product lines, thus acting to incentivise higher consumption, meaning that some or all the efficiency gains are lost.

An indirect rebound occurs when efficiency gains lead to increased consumption of some other resource. For example, insulating one’s home might reduce the annual consumption of energy for electricity, but the money saved from reduced energy costs is often spent on other commodities that require energy (e.g., a plane flight or a new computer). This can mean that some, or all the energy saved from insulating one’s house is consumed elsewhere, meaning overall energy dependence can stay the same or even increase.

While the basic mechanism of rebound effects is widely acknowledged, and, indeed, beyond dispute, there is an ongoing debate over the magnitude of the various rebound phenomena (Chakravarty *et al.*, 2013). There is, however, a strong body of literature arguing that the rebound effect is larger than has been previously assumed (Sorrell, 2015; Sanders, 2013). Saunders (2013), for example, finds that there was an average *direct* energy rebound (thus excluding potential indirect rebound) of 62% across 30 sectors of U.S industry from 1980 to 2000. Without entering further into the intricacies of the complex empirical and theoretical debates, it is fair to say that despite the uncertainties, there is broad agreement that rebound effects exist and that they are significant. The benefits of technology are almost always less than presumed, and, in fact, at times efficiency improvements can lead to more, not fewer, resources being consumed overall.

**6. The ‘Growth Model’ Has No Techno-Fix**

The forgoing lines of argument should be enough to cast doubt on the faith of the techno-optimists. But faith dies hard, even in the face of compelling evidence. Thus, the techno-optimist is likely to double down and proclaim that past behaviour is not a reliable guide to future success. As Nordhaus and Shellenberger (2011) argue: ‘The solution to the unintended consequences of modernity is, and has always been, more modernity – just as the solution to the unintended consequences of our technologies has always been more technology.’ While this can be accepted as a theoretical possibility, there are dynamics at play – including the laws of physics – that suggest that decoupling through efficiency gains will not reduce the overall ecological impacts of economic activity if global growth remains the primary economic goal (Ward et al, 2016).

This uncomfortable reality was highlighted by a recent study (Ward et al, 2016), which extrapolated out the implication of Australia pursuing economic growth at the modest rate (by historical standards) of 2.41% per annum each year until the end of the 21st century. The study assumed rapid technological development and proactive policy settings (i.e. a steeply rising global carbon price), resulting in historically unprecedented energy and resource efficiency gains. Nevertheless, given that by 2100 the Australian economy would have undergone an eightfold expansion, the study found that by 2100 Australian material and energy use, instead of declining, would have risen by 29 per cent and 256 per cent respectively on current levels (Ward et al; 9). The authors conclude that this demonstrates ‘categorically that GDP growth cannot be sustained indefinitely’ (Ward et al 2016; 10).

Even this scenario, however, understates the true magnitude of the challenge for those advocating techno-optimism. First, these scenarios assume that efficiency gains will be just as easy to achieve in coming decades as they have in the past. But this assumption is highly questionable, given the reality of diminishing returns from investment, which we are already witnessing today, and which are likely to accelerate as ecological conditions deteriorate. This is most obvious with respect to the resource sector, which includes, of course, fossil fuels accounting for over 80 per cent of the global economy’s primary energy (IEA, 2017). For basic economic reasons, humans tend to extract the cheapest and easiest resources first while leaving the more difficult, dangerous and expensive resources for later. What this means is that, over coming decades, the energy and financial costs of resource extraction will tend to rise. Indeed, this trend is already apparent; several decades ago, for example, the energy in one barrel of oil could be used to extract 30 barrels of oil, but the ratio is now estimated to be around 18 and the ratio will only decrease in coming decades (Hall et al, 2014). The impact of depletion is also evident in the mining sector with declining mineral ore grades and increasing mining waste rock and tailings resulting in higher energy, water and emission costs for mining and ore separation (Mudd, 2009). The upshot is that, even if there are rapid efficiency gains in, say, manufacturing processes, in coming decades they are likely to be increasingly counteracted by efficiency *declines* in resource extraction. This situation evokes the challenge faced by the Red Queen in Lewis Carroll’s *Through the Looking Glass*, who must run faster and faster simply to stay in the same place (Likvern, 2012).

Secondly, the Ward et al (2016) scenario only looks at the implication for decoupling in one economy (Australia); but the challenge for techno-optimism is far more daunting if we look at the wider global context. This is especially true if we take seriously the long-term goal of the global development agenda (UNEP, 2016) which aims to bring the poorest parts of the world up to the living standards enjoyed by the developed world –a goal that many techno-optimist scenario’s neglect to take on board (see e.g. Hatfield-Dodds et al, 2015). After all, from a moral perspective, it is difficult to argue that one section of the global population is entitled to a certain income per capita while denying a similar level to others. If the global development agenda of universalised affluence were to be achieved over the next 80 years, how big would the global economy be relative to the existing economy?

The figures are confronting, to say the least. Let’s assume, as with the Ward et al (2016) scenario, that continuous economic growth at a modest 2.41% growth rate leads today’s developed nations (i.e. OECD) to expand their economies eight-fold by 2100. Let us also assume that by this time the world population will have reached 11 billion, in line with median U.N projections (UNDSEA, 2017). Let us finally assume that this population has by the end of the century, caught up to the per capita incomes of the OECD. If this scenario were ever to be achieved, the global economy would end up approximately 28 times larger than it is today!

Needless to say, ecosystems are already trembling under the pressure of one ‘developed world’ at the existing size. Who, then, could seriously think our planet could withstand the equivalent of a 28-fold increase in the size of the global economy? The very suggestion is absurd, and yet this very absurdity defines the vision of the global development agenda. It is the elephant in the room. If we remember that humanity is already in ecological overshoot by 70 per cent, then to achieve long-term sustainability humanity would need to achieve a factor 48 reduction in overall environmental impact (i.e. resource use, carbon emissions) per unit of GDP. Compare this 48-factor reduction with the 5-factor reductions that some techno-optimists think might be achievable via an efficiency revolution which has historically failed to fulfil its promise (Von Weizsacker, 2009; Lovins, 1998). Accordingly, even if these figures are overstated by an order of magnitude, the point would remain that efficiency gains could not possibly be expected to make the projected amount of GDP growth sustainable. The levels of decoupling required would simply be too much (Huesemann and Huesemann, 2011; Trainer, 2012). To think otherwise is not being optimistic but delusional.

The question, therefore, must not be: ‘How can we make the growth model sustainable?’ The question should be: ‘What economic model is sustainable?’ And the answer, it seems, must be: ‘Something other than the growth model.’

**7. Efficiency Without Sufficiency is Lost**

The central message of this critical analysis is that efficiency gains that take place within a growth-orientated economy tend to be negated by further growth, resulting in an overall increase in resource and energy consumption, or at least no reduction. To take advantage of efficiency gains – that is, for efficiency gains to reduce resource and energy consumption to sustainable levels – what is needed is an economics of sufficiency; an economics that directs efficiency gains into reducing ecological impacts rather than increasing material growth (Alexander, 2012a; Goodman, 2010; Herring, 2009). Once the limits of technology (and thus the limits to growth) are recognised, however, it becomes clear that embracing an economics of sufficiency is necessary if we are to create an economic model that is ecologically sustainable.

Exploring what a sufficiency paradigm might entail, however, is beyond the scope of this paper. Let it simply be stressed that it would not mean rejecting the use of innovative technologies in relevant fields, nor more efficient ways of doing things. Rather, it would place such efforts in the context of a wider societal goal of achieving steady-state economies within the sustainable limits of a finite planet (Czech, 2013). For the most developed nations this will mean not just producing and consuming more *efficiently*, but also producing and consuming *less* and *differently*. This follows from the critique of techno-optimism detailed above. This can be achieved partly by cultural change, through which people practice ‘voluntary simplicity’ by exchanging superfluous consumption of resource-energy intensive products and services, for a variety of non-material pursuits that promise to bring greater life satisfaction (Burch, 2012; Alexander, 2012b). But lifestyle changes at the individual and household level will also need to be accompanied by profound changes in macro-economic policy, political systems, and settlement design (see, e.g., Alcott, 2008; Trainer, 2010; van den Bergh, 2011). Other chapters in this book explore some of these issues in more depth.

**8. Conclusion**

This chapter has reviewed the evidence in support of techno-optimism and found it to be wanting. This is significant because it debunks a widely-held view, even amongst many environmentalists, that ‘green growth’ is a coherent path to sustainability. Perhaps it would be nice if affluence could be globalised without damaging the planet. It would certainly be less confronting than rethinking cultural and economic fundamentals. But there are no credible grounds for thinking that technology is going to be able to protect the environment if economic growth is sustained and high consumption lifestyles continue to be globalised. The levels of decoupling required are simply too great. More efficient growth in GDP, therefore, is not so much ‘green’ as slightly ‘less brown’ (Czech, 2013: Ch. 8), which is a wholly inadequate response to the crises facing humanity.

Since there are no reasons to think that more efficient growth is going to reduce humanity’s ecological footprint within sustainable bounds, it follows that we must consider alternative models of economy – alternative models of progress – even if these challenges conventional economic wisdom. To draw on the dictum often attributed to Einstein: we cannot solve our problems using the same kinds of thinking that caused them. This may not be a popular message, and it may already be too late for there to be a smooth transition beyond the growth model. But on a finite planet, there is no alternative. The sooner the world realises this, the better it will be for both people and planet.

We must embrace life beyond growth before it embraces us.

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