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I have always found engineers to be refreshingly practical, empirical people. So I'd thought I'd use my time today to encourage you to keep the debate about sustainable development thoroughly practical and empirical! I said this to a friend who replied: but the ones you're talking to are very much at the idealistic edge of the profession! Let's hope I don't puncture that.

The quest for 'sustainability' seems to have become absolutely mainstream. Countries, cities, businesses, trade and professional associations and a huge array of non-governmental organisations have been falling over themselves to frame their strategies and missions in terms of 'sustainability'. Indeed, you have to work hard to find organisations that don't find room for some language about sustainability in their mission statements.

But dig below the generalities and you will discover a series of parallel universes governed by some very different belief systems. The problem to my mind can be traced back to the genius of the Brundtland formula: "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Those simple words provide a definition wide enough to accommodate just about any tailor-made definition you care to think about

Which should immediately make us cautious: do we have a consensus or is this in fact intensely contested terrain over which contestants have for the time being sought to declare a verbal truce? Supporters of sustainable development, while conceding the 'elusive' nature of the concept assert some core shared principles. Sceptics label it a 'fudge'

To my mind, much that is trumpeted the name of sustainable development is often over-blown, confused and lacking in any sense of priority. That's in large part because there is a pretence of consensus where in fact there is significant disagreement. Any honest assessment of whether, in the 15 years since Rio, the world economy has embarked on the sort of sustainable global development path many hoped for, would have to be that it has not. While all sorts of things have been done – and marketed – in the name of sustainability, some of the big trends continue to go the wrong way.

One popular explanation for this is what is claimed to be a 'lack of political will'. But this seems to me facile. Better explanations might be that leaders either didn't know what they were signing up to or, more cynically, that they never intended to deliver.

I prefer the first explanation. I think the world embraced a concept that it only poorly understood and then allowed it to be elaborated in ways that assumed agreement where there wasn't any. Over and over again we have witnessed verbal consensus where there were real differences or, more importantly, insufficient hard information to operationalise concepts that were often nebulous.

This grew, in part, out of a tendency to extend the reach of sustainable development to social and ethical considerations which are rather different in character from the more basic equity concerns of the Brundtland formula, namely: how to promote development that will lift billions of people out of abject poverty while at the same time reversing the tide of environmental degradation.

As an example of this sort of 'paradigm creep' we might turn to the *'Principles for a Sustainable Society'* developed by IUCN, UNEP and WWF. The first principle asserts that we should

"share fairly the benefits and costs of resource use and environmental conservation among different communities and interest groups, among people who are poor and those who are affluent, and between our generation and those who will come after us."

While another states that

"A national programme for achieving sustainability should involve all interests, and seek to identify and prevent problems before they arise."

My purpose here is not to take issue with the values of those who have promoted these formulations but draw attention to the problems they create for those who would seek to embody them in policies or codes of conduct. The question of what constitute 'fair shares' in modern societies is one of the most contested and value laden debates we can approach even when focussed solely on the redistributive impact of taxation and welfare systems. Scaling this debate up to cover everything and extend it temporally across generations invites an order of magnitude more complexity which, far from 'identifying and preventing problems before they arise' would be likely to end in the exhaustion of those consulted and the dilution of any conclusions.

I would advocate returning to a more modest version of the original Rio compromise – avoiding irreversible environmental degradation that would be to our long-run cost while allowing for a path out of poverty in the developing countries of the world. (The 'modesty' of that agenda was, by the way, strictly relative!) To operationalise it requires an approach that is compatible with the sort of human and institutional limitations that afflict politicians, businesses and citizens at large, namely: limited resources, limited attention spans and

competing priorities. We need to deal with three factors: **ignorance**, **time,** and how we go about making difficult **trade-offs**. Let me deal briefly with each in turn.

Ignorance is in some ways the easiest problem to describe. We know the extent of the changes we have made to the concentration of atmospheric gases responsible for trapping incoming solar radiation and the likely impact on tropospheric temperatures; we know that human activity is now controlling or interfering with 25-40% of the planet's photosynthetic output; we know that we have doubled the global terrestrial fixation of nitrogen from the atmosphere and tripled the rate at which phosphorus is lost from soils to watercourses (and ultimately finding its way into the oceans).

These are significant interferences in the bio-geochemical cycles that have over time created the sort of biosphere we are familiar with. What we don't know is the likely consequence of this scale of interference or (as seems inevitable) the consequences of even larger interferences. The sheer complexity of these cycles – and the paucity of available data in some respects – means that we cannot say with any confidence what sort of feedbacks might cause sudden, unexpected changes in the sort of world we expect to be living in. These feedbacks might not necessarily all be negative. We just don't know.

Remaining resolutely focussed on improving our scientific understanding is essential. The biosphere is – and always has been – in a state of constant change. Human pressures are adding to those changes. We need to understand better the changing, dynamic nature of the biosphere and, given its complexity, be cautious about rash verdicts either of impending doom or Pollyanna-ish complacency. As Professor Vaclav Smil reminds us:

"What we need is not more clever arguing, and what we cannot get, given the inherent complexities of biospheric transformations and major uncertainties concerning their outcomes, is a confident, albeit probabilistic, appraisal of our prospects."

Take loss of biodiversity as an illustration of flying blind. While there is huge debate over the number of species and the natural or 'background' rate of species extinction, there seems little doubt that we have increased that rate by as much as an order of magnitude. In the process we are getting rid of species we haven't described and whose importance for eco-system functioning and/or potential human value are unknown. The implicit choice that is being made is between the conservation of potential 'knowledge' embodied in living things versus the creation of new 'knowledge' through the on-going substitution of natural for human capital. What we don't know is whether we're losing something of much greater long-term value than what we're gaining.

What about **time**? It's something all of us are short of and much attention has been lavished on trying to forecast the timescales within which actions must be taken to avert this or that crisis. There are two problems here.

One is that our forecasting abilities are woefully inadequate for the complex human responses we are trying to guess. Even something as apparently quantifiable as the dynamics of population growth remains shrouded in conjecture. As a distinguished demographer, Joel Cohen, has remarked, "the demographic future has none of the inevitability that population projections convey [because] no one knows what people will choose to want." If we can't predict choices about fertility, it should come as even less of a surprise that attempts to forecast future energy demand (a key determinant of the time we may or may not have to head off serious climatic risks) are almost doomed at the outset. A recent survey of forecasting attempts over the last 100 years described the whole enterprise as "a manifest record of failure".

Yet we need to have some working hypotheses about what it is we are trying to sustain over what time-frame and then be in a position to monitor what actually happens because, as has been observed, sustainability can only be assessed after the fact. Hence the importance of constantly monitoring trends over time and being prepared to adapt to those trends. This is what the universal take up of the economic *and* environmental accounts by governments would enable us to do. The tools exist – they're just not being applied universally or in a way that allows us to make proper inter-country comparisons.

But there is a second sense in which time is not 'on our side' and that is the time it takes for both institutions and attitudes to change. Look at the time it takes to try to stabilise dysfunctional states. Look at the time it takes to mobilise even functional societies to confront a challenge such as AIDS. I don't intend to dwell on this point but it does seem to me the single biggest challenge to those who argue for urgent change, with little more than exhortations for information and education.

Even democratic societies (which one assumes tend to be the most information rich and open to new ideas) have difficulty sustaining radical policy changes without the stimulus of a crisis. Is this so surprising? At the level of individual agents, we know how difficult it is to persuade people to modify their behaviour even when lifestyle risks they run are well described and the risks of harm strongly predictable.

I don't expect you to draw comfort from this assessment, but I hope it underscores the importance of taking very seriously the time it takes for people to change their behaviour in the face of risks that, in terms of human timescales, are relatively long term.

Finally there is the question of **trade-offs** – both in a physical sense and in a policy sense. One of the unfortunate trends in much writing about sustainability has been a flirtation with the notion that there is some lost equilibrium that must be re-captured. It is certainly valid to point to the greatly-increased rate of change that human activity is causing to the biosphere thereby possibly placing at us at risk of feedbacks that occur on timescales to which our civilisation cannot adapt. But it is misleading to suggest that there is some way we can live that removes the need for constant adaptation.

Indeed there are intriguing possibilities that natural climate change has actually been a driver for a succession of civilisational turning points that have in turn been rendered fragile by successive changes. Our civilisation is inextricably caught up in a dynamic process that has always required change. Entertaining romantic notions about the simplicity of pre-industrial societies is unhelpful unless we are prepared to embrace all the vulnerability to disease and natural disasters not to mention human aggression that went with it.

Civilisation as it has evolved since the last ice age has been based on the transformation of natural capital (to revert to the language of accounting I have already spoken of). We have chosen to transform natural capital into physical and intellectual resources which we have found more desirable. That is going to continue. Amidst all the various scenarios of which I am aware, none posits a world in which we achieve some equilibrium that leaves the remaining unaltered elements of the biosphere in their present state. Even the most optimistic scenarios envisage a widening human 'footprint'.

Take for example the most radical 'sustainability first' scenario sketched in UNEP's *GEO-3* report published in 2002. This scenario (one of four) is described as one in which

"a more visionary state of affairs prevails, where radical shifts in the way people interact with one another and with the world around them stimulate and support sustainable policy measures and accountable corporate behaviour."

In comparing the outcomes of the four scenarios the authors rightly point out that many of the benefits of their 'sustainability first 'scenario would accrue beyond the period for which they modelled results (to 2030). Notwithstanding that their results show large, ongoing substitutions of natural capital. Atmospheric concentrations of CO2 would still rise from 380 to 450 ppm, biodiversity is still under threat across 56% of the land area.

The numbers here are less important than the trends. Very simply, a future world even involving 'radical' changes in human interactions will involve massive on-going change. That means facing a future with, at the least, very significant continuing trade-offs. And since a prudent acquaintance with human nature suggests not using a 'visionary' or 'radical' state of affairs as the baseline, the trade-offs are likely to be even more significant. Last year's *World Energy*

Outlook forecast $16 trillion of new investment in energy services, the overwhelming bulk of which was in the fossil fuel sector.

Clearly there is no single sort of 'sustainability' or balance of trade-offs we might aim for. It all depends on the choices everyone from governments to individual consumers make. Different substitutions of resources will degrade or enhance different stocks in different ways. If you look at the consumption trends of rich societies – and even more so those of rapidly developing societies – it is tempting to conclude that we've taken a collective 'bet' that high and rising levels of resource use bring with them the technological capability to deal with any unforeseen problem. What if we're wrong?

On the other hand, to take – by means of stringent government controls – a different bet, namely that we should radically constrain resource use takes a different sort of a bet: that a radical change to political and social expectations in many countries is sustainable and that we have the institutional capabilities to deal with unforeseen human problems! This seems pretty heroic to me. Certainly, in this country a single major power outage is enough to cause political waves. A proposed congestion charge in Auckland is enough to get everyone into an uproar.

My own view of the trade-offs is irrelevant. All I want to emphasise is that there is no unique pathway to some ideal state. All we have are messy trade-offs, none of them costless and not much of a track record of making really big ones unless we're faced with a crisis. So improving the way in which we approach tradeoffs becomes critical. My short verdict is that we need to do so much more transparently and adopt mechanisms that are able to take account of new information and new trends flexibly and with minimum disruption.

Let me identify three priorities:

(1) Get the analytical framework right

One of the slogans of the post-Rio years was "think global, act local". As an ethic for personal responsibility there's nothing wrong with it. But local actions that ignore the global context can be next to useless. We live in an increasingly borderless economic space and solutions can't be implemented behind hermetically sealed borders. Similarly, how we judge the effectiveness of our actions can't take a narrowly nationalistic view.

Gathering data at the level of countries tells us nothing about the extent to which lifestyles in one country affect the global environment. A country can, for instance, look very good in terms of CO2 emissions. But it if it simply importing

goods which another country had to emit large amounts of CO2 to produce, the picture changes.

The debate about food miles which has recently received a good deal of coverage nicely illustrates some of the subtleties at stake here. Going on the front foot and developing measures of cross-border activity would enable us to develop a much more sensible view of our priorities in an increasingly globalised economy.

(2) Getting the information we need to manage risks over time as well as space

It as an even trickier calculation to understand the causality between generating waste today and its impact on the capacity of the environment to go on providing services in the future. This, from an environmental sustainability point of view, is the really critical issue. What feedback from a significantly altered biosphere would – at some future time - impose significant costs to human well-being and possibly irreversible effects which our descendants might bitterly regret? This is the worry that gnaws away in the back of many minds including some of those who remain confident that ecological crisis will be the mother of technological adaptation.

Take biodiversity. When fewer than 2 million species have been described and estimates of the total number 'out there' range from 5 million to 30 million or more, how do we sensibly seek to influence that rate of extinction caused by human activities? What components of the earth's biodiversity are needed for ecosystems to function in a way that will provide the 'environmental services' on which the continuation of life relies? Humanly-induced climate change is the other big global scale source of uncertainty: what level of green house gas accumulation in the atmosphere are we prepared to nominate as being potentially dangerous? We have to make trade-offs in the face of uncertainty. It is not about fine-tuning some equilibrium but trying to get agreement on key vulnerabilities and some provisional prudential limits that will avoid significant harm.

Any answer to these questions will involve trade-offs which will depend ultimately on the resilience and flexibility of human institutions. Deciding not to address them will not remove the need for trade-offs. It might simply mean we have fewer choices and less time to adapt than would otherwise be available.

(3) Choosing flexible policy instruments whose costs and effectiveness we can measure

Let me cut to the chase: we should use prices rather than exhortations wherever possible. The other day I received an e-mail from a friend who works for a major global consultancy and is rather splendidly titled “International Head of Corporate Responsibility and Sustainability”. Immediately below his central London co-ordinates came the slightly prim command: *Please consider the environment before printing this e-mail*. Knowing I was about to give this address and not wanting to lose track of it, I promptly printed it.

It’s a nice thought. But we have only so much time for thinking. If we started thinking about every transaction we make, we would soon be reduced to paralysis. We all need short cuts – ways of gathering and processing large amount of information simply. That’s what prices do. They convey information. The information encapsulated within them includes vital information on the costs of production including any demands – either from consumers at large or from regulatory interventions – to internalise environmental pressures.

We haven’t time to make endless discriminations. Eco-labels can play a role. But there is only so much time to pick through the proliferating greenwash to make really low-impact consumer choices. So if we want internalise some of the pressures that worry us, taxes and similar instruments make a lot sense. They are transparent, we can measure their impact, and we can adjust them in line with changing information.

This has to be the first-best answer for trying to tackle greenhouse gas emissions. We don’t know which technical solutions will be the best ones; we don’t know how quickly we need to move. We do know that we need to send some long term signals. Yet this is what politicians here – and everywhere – find so difficult. The very transparency – and political accountability – of mechanisms like taxes place them seemingly beyond reach. And so, faced with a risk which most people think worth managing, we have governments around the world coming up with ‘green’ solutions that simply muddy the waters.

Let me give you just one example that work I am involved with has recently uncovered. In the USA, as you know, it is believed to be politically impossible to using mechanisms like a carbon tax. It is, however, permissible to embark on much more costly - and distorting – fiscal adventures. Right now, biofuels are all the rage. Annual subsidies total around $7 billion a year and they’re rising fast. If (as their proponents are keen to argue) lower CO2 emissions are a reason to keep the subsidies flowing, then US taxpayers are spending around $500 per metric ton of CO2 avoided – and that’s on the most favourable estimate of the emissions reductions available from ethanol. It would have to be one of the more expensive imaginable ways of reducing emissions.

Even more bizarre, the US Government offers generous credits for flex fuel vehicles in the way it calculates its fleet efficiency standards. The result is that manufacturers have found it worthwhile to make their least efficient, gas guzzling

4-wheel drives flex-fuel capable even though virtually no-one who drives them uses biofuel. The result: energy inefficient vehicles have been made more attractive and as a result gasoline consumption has risen.

The world is full of such examples. If we are to become serious about sustainability, there will have to be a great deal more honesty and transparency about the costs of our consumption and the trade-offs we are prepared to make. Businesses need to be able to make long term investment decisions with a clear understanding of what the costs of becoming more sustainable are; consumers need to be able to make discriminating purchases based on prices that convey the best information we have about environmental costs.

Above all, we need to be able to scrutinise the effectiveness of such measures. Transparent policy tools like taxes or permits lend themselves to such scrutiny. Being practical and empirical people, I hope you would endorse this approach. If you're idealistic to boot then, like me, you'll keep hoping for first best solutions.