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Reconnecting technological development with human welfare

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ABSTRACT

Many observers see advances in technology as the key means for ensuring continued economic growth, and with it human progress as well. In particular, three modern technologies—biotechnology, information technology (sometimes including robotics and cognitive technologies) and nanotechnology—are seen by some researchers as converging and thus bringing about unprecedented benefits for humanity in the coming decades. The aim of this paper is to answer the question: can the on-going rapid advances in these new technologies lead to a better future for all? By examining three important sectors—transport, health/medicine, and agriculture/food—we show that application of these technologies are either largely irrelevant, too expensive, or too risky to meet the future needs of all humans in these sectors.

1. Introduction: high technology views of the future

Nothing epitomises the remarkable progress of technology better than Moore's Law. A simplified version of the law is that ever since the 1960s, the number of transistors per computer chip has doubled on average every two years. Nevertheless, two questions need to be raised here. First, for how long can this growth continue? Most experts think this growth can continue indefinitely, although perhaps not with silicon chips. Others—including, it seems, Moore himself—believe progress will stop, perhaps soon, because of technical or even economic limits [1–3]. And an even more important question must be asked: What relevance does this undoubted technical progress have to do with making life better for all humanity?

Kurzweil, Molitor, Drexler, Ausubel and others all see a new era being brought about by technology advances, without any need for social change [4–7]. The question of how the global inequalities present in the world today will be reduced is never addressed. Kurzweil [4] has argued that technological change is not linear but exponential, that the time between successive major innovations has been decreasing exponentially for at least the past 10 millennia. We will thus soon encounter what he terms *The Singularity*: 'This is a time when the pace of technological change will be so rapid and its impact so deep that human life will be irreversibly transformed. We will be able to reprogram our biology, and ultimately transcend it. The result will be an intimate merger between ourselves and the technology we are creating.'

The Singularity has not been without its critics, and has been unkindly labelled 'rapture for nerds' [8]. Kurzweil's key graph, showing decreasing time between major inventions, may be an artefact. For example, telephone, electricity and radio are lumped together as a single major innovation, whereas the computer and the personal computer are regarded as two separate ones. If the first trio were similarly regarded as separate innovations occurring over a century ago, the very short

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time between their appearance would disrupt Kuzweil's smooth curve towards the Singularity. Nevertheless, it is still true that the present generation is experiencing an extraordinary rate of technical change. Unlike changes to, say, methods of generating grid electricity, the rapid changes in information technology (IT) are experienced personally by billions of people.

Other futurists are similarly optimistic about future prospects, at least in terms of material well-being. Writing in *The Futurist*, Aguilar-Millan et al. [9] foresaw a post-scarcity world developing by around the year 2050, one in which 'technological advances will facilitate decreasing costs until conceivably almost everything is free to the consumer (...)'. They add: 'Scarcity will no longer exist in this world, and, without scarcity, the concept of charging a price to consumers as a means of generating revenue will be unworkable.' In this highly optimistic view, it seems that the success of market economy will be its undoing. Another recent article in *The Futurist* argued that by 2020, carbon nanotubes will enable us to solve 'our energy, raw materials, and environmental problems' [10].

Neither these views nor the Singularity represent the mainstream academic, corporate or government views of the future. Nevertheless, the mainstream views are not so very different in that they all foresee continued exponential growth in the world economy for at least the rest of this century, driven by technology advances. They would agree with the argument of Rivers [11] that human progress is driven by, and is inseparable from, technological improvements. In fact for many researchers, technological forecasts are *all* that is needed: once we know what technology will be widely deployed, we also know what the future will be for humanity.

Table 1 shows the conventional, or what could be called the 'modified business-as-usual (b-a-u) view' of our planet in 2050. Compared with the values in 1900, or even 1950, the projected values for GDP or energy use are astounding. The forecast ranges for 2050 are also in line with the year 2030 or 2035 projections of organisations like the Energy Information Administration (EIA) [12], the International Energy Agency (IEA) [13], and BP [14].

Official forecasts and the vast majority of academic forecasts assume global economic growth will continue at around 2–3% per year real growth out to 2050 (see for example [12–14]). And continued economic growth is, after all, a central policy of all the world's governments, as well as international organisations such as the OECD and the World Bank. In contrast to the lip service given to climate mitigation, governments are firm in their commitment to economic growth. The experience of the past two decades has shown that if any conflict is perceived between CO_2 emissions reduction and economic growth, it is CO_2 reductions which lose out.

However, not all commentators think the new technology will usher in a Utopia. Most of these critics are from the social sciences, but an 'insider' critic is Bill Joy, a prominent computer researcher. He worried in his eponymous article in *Wired* magazine that '*The Future Doesn't Need Us*' [24]. He wrote: 'The 21st-century technologies—genetics, nanotechnology, and robotics (GNR)—are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the reach of individuals or small groups. They will not require large facilities or rare raw materials.' His conclusion was that limits on technology were necessary: 'And if our own extinction is a likely, or even possible, outcome of our technological development, shouldn't we proceed with great caution?' We will return to these concerns in the Discussion section.

The new technologies, IT, biotechnologies and nanotechnology (along with robotics and cognitive technologies) are often referred to as '*convergence technologies*' [25], and it is assumed that their convergence will bring about unprecedented transformations in our lives. Not only will these technologies have synergistic effects when applied to sectors like medicine or industry, but they will also mutually reinforce each other's potential. Markovic and colleagues [26] have argued, for example, that nanotechnology can help overcome the physical limits that IT hardware could soon face. Similarly, advances in biotechnology, such as the sequencing of the human genome, would not have been possible without the earlier advances in IT.

In an article published in *Futures* around two decades ago, Ernest Braun [27] in his eponymously titled article asked *Can technological innovation lead us to utopia?* and concluded that it could not. This paper similarly asks whether or not the more recent technological advances will benefit humankind. Answering this question requires a values judgement. The preferred future explicitly assumed in this paper is one in which the human needs of all the world's people are met in a manner that does not compromise the ability of future generations to do so. Or, more generally, to meet these needs without compromising ecosystem service provision. (The health of the various Earth ecosystems is usually considered vital for our own survival, and to the minor extent that it is not, we may need to consider their health as a value in itself.) The UN Millennium Development Goals [28], which include items such as eradicating extreme poverty and hunger, and ensuring

Table 1
Various global parameters: historical 1900–2010, forecasts for 2050.

Parameter	1850	1900	1950	2010	2050	References
Population (billion)	1.18	1.65	2.53	6.90	8.11–10.61	[15]
Urban population share (%)	10.0	13.6	29.4	51.6	67.2	[15]
GDP ($US 1990 trillion PPP)[a]	0.94	1.97	5.34	53.10	88.70	[16,17]
Light duty vehicles (millions)	0.0	0.03	51	870	1700–2800	[18,19]
Passenger travel (trillion p-k)	0.0	0.2	3.0	43.4	103.0	[20,21]
Electricity consumption (PWh)	0.0	0.0	0.85	21.33	46.2–49.0	[22,23]
Primary energy use (EJ)	28.1	43.6	100.7	544.5	770–1175	[21–23]

[a] Purchase parity pricing.