BOOK REVIEW

Technology and Sustainable Development: The Promise and Pitfalls of Techno-Solutionism
Henrik Skaug Sætra (ed.) (2023) 286pp., £43 paperback, Routledge, Milton Park UK, ISBN 9781032350561

How a problem is framed determines the tools and mentality of a solution. If one has a hammer, then all problems are to be nails. In society, we have adopted a propensity to reach for technology to solve our problems, even if it is to our detriment. There is a framing of techno-optimism, that there should be an openness to accept technology to better the world (Danaher, 2022). The source of this optimism is easy to understand in the light of the rise of progress narratives (Rotman, 2021). This faith in technology encourages the adoption of a techno-solutionist paradigm: as Sætra puts it, that we 'can and should use technology to solve the challenges we happen to face' (p.2). The appeal of this is that it leans on our own sense of agency to solve our own problems. This sense of empowerment may be hollow as efforts may lack coordination or may be undermined by institutional forces.

There are also wide-arching externalities generated by committing to a techno-central approach. The impact of technology is not simply solving the problem for which it is designed; it resonates throughout society. Supply chains are needed to support the use and the creation of technology. Labor and institutions are required for the extraction of raw minerals. Techno-solutionism must be considered in the entirety of the consequences. There are three core dimensions of sustainable development outlined throughout this work that may be observed to better understand the depth of this influence. There are environmental, social and economic dimensions that may be leveraged to elucidate the benefits and costs of techno-solutionism (Brundtland *et al*., 1987). Given the large scope of this endeavor, an established framework is needed to guide the discussion.

The United Nations' Sustainable Development Goals (SDGs) are 17 goals meant to encourage and define sustainable development. SDGs encompass both social and environmental inequities and support multifaceted evaluation of technology through their breadth. The evolution of SDGs also promotes discussions on the trade-offs within the different dimensions. For instance, a technology may encourage economic growth at the cost of environmental sustainability. Navigating these contradictions and prioritizing SDGs is at the core of the discussion. The SDGS are used to encapsulate the cascading effects of techno-solutionism. To comprehend their significance, the three dimensions of sustainability are considered thematically to guide discussion using a case study approach. By emphasizing a singular technology and applying the framing of SDGs and sustainability, the aggregated costs and effectiveness of technology as a solution to our problems become clear.

Environmental

Artificial intelligence is a collection of technologies that combines data, algorithms and computing power (p.26). They are characterized by emergent properties that mimic cognitive processes using associations. The promise of AI is that it provides the means for greater efficacy and optimization. AI could play a role in resource management as a means to mitigate environmental stress from agriculture and to assist in decision-making (Mann, 2021). However, considerable environmental stress underlies the technology. AI applications consume vast amounts of energy for computation, analysis and classification. There are several general processes that consume most of the energy to support the creation and use of AI. The first process is training the AI, while the second is running inference with the trained model. When training a large language model, a single processing unit

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might use more than 400 watts. Training models similar to ChatGPT demand as much as 10 gigawatt-hours (GWh) of electricity. This is comparable to the annual electrical usage of more than 1,000 US homes. When running inference through queries, 1 GWh may be consumed daily, which is about equal to the daily consumption of 33,000 US homes (McQuate, 2023). Thus, a great amount of energy is consumed in both facets of deploying AI. The cost associated with running inference is largely related to the infrastructure. For instance, cloud computing eats up energy at a rate somewhere between the national consumption of Japan and that of India (Murdock and Brevini, 2019; Brevini, 2021). The solution to this problem is determined by one's adherence to techno-optimism. The authors of this book prescribe a legislative solution using a framework, while technological institutions continue to promote technological solutions.

The appeal of technological solutions is that they are unilateral in nature and incremental. There are numerous techniques that lower the demands of AI for power. There is transfer learning in which the weights trained by a larger model are fine-tuned with a specialized dataset for a particular purpose. There are also optimizations on trained models to lessen the resources required to run. There are pruning techniques, quantization and encoding techniques. These techniques have been developed largely for AI to be deployed through the Internet of Things, but they offer a means to mitigate resource demands for resource-iconscious developers. By deploying these techniques, the carbon footprint associated with running inference may be reduced by a factor of four (Krishnan and Faust, 2022). There are also legislative solutions that follow similar trajectories.

One 'technology' that has been developed by government is the nudge. Mills and Whittle explore the nudge as an ideological technology in their chapter of the book. A nudge should be understood as an incremental change in how an existing system operates through using different leverages to alter behavior. The goal of a nudge is to optimize behavior through encouragement rather than coercion (Thaler and Sunstein, 2008). When taken in aggregate, nudging may satisfy significant policy goals (Chater and Loewenstein, 2022). One of the most common examples of nudging is at the grocery store. People must pay a deposit to have access to a cart and must adhere to the policy set by the store by returning the cart to get the deposit back. While the amount of the deposit is usually trivial, it can create order and a better experience for all involved. In a sense, this technique is like the technological improvements in AI. Nudging is attempting to optimize an infrastructure through encouraging incremental changes. In very similar fashion, AI is stepping through gradients and attempting to minimize its own optimization functions. The success of this is dependent on the coordination of developers, just as nudging is dependent on the behavior of the masses acting in concert. The focus of nudging in terms of sustainability depends on whether nudging is effective or detractive. The concern is that people will become placated by an incremental change that is insufficient to meet the demands of the situation (Maki, 2019).

Carbon offsets operate within a similar framework to nudging and justify concern that aggregate individual action is insufficient. Carbon offset projects are often driven by social values and are orchestrated in a piecemeal fashion akin to nudging. Projects usually focus on protecting a plot of trees, the hope being that the aggregate effect of these projects is significant and will offset emissions. However, these projects are largely ineffective. Only 12% of them generate an offset (Probst *et al*., 2023). These projects lull the public into a false sense of action, supporting the arguments made by Mills and Whittle. The success of nudging is also uncertain, but it remains a technology that can be used when needed. It may very well be that nudging helps to build support for a cause by increasing engagement and visibility. It may be that secondary effects are more impactful. But the existence of the technology and the flexibility of its usage remain more significant than its effectiveness.

Social

Technology can create an environment for discourse. It may be used as a conduit to engage people with different perspectives to create more nuanced views, or it may become an echo chamber amplifying paranoia. These environments may also serve a different purpose. They may help to educate and empower. Two parallel chapters in the book deserve discussion. Sætra and Ese consider a browser add-on called ‘Shinigami Eyes’. It is open-source software meant to identify individuals with transphobic and trans-friendly profiles through labelling them with a color (Kiran, 2023). The other chapter, by Dechsling and Nordahl-Hansen, describes how virtual reality (VR) supplies support for those with autism. By providing an environment that is stable, VR enables an opportunity for greater independence. The goal of the Shinigami Eyes is to provide confidence and lower stress for trans individuals participating in social networks. There may be people who seem progressive, but are actually antagonistic towards trans people in this environment. The stress of identifying these individuals and knowing with whom to converse is the major motivation for the add-on. The concern with this categorization is that it could encourage echo chambers (bethylamine, 2023a). Not engaging with people with opposing views could deepen social cleavages and unintentionally disenfranchise end-users.

There are additional concerns with how this technology has been implemented. The initial concern is that it gives the creator disproportionate influence over the trans community. Since Shinigami Eyes is using machine learning, it can determine the parameters for classification. There is a trade-off between sensitivity and specificity that should be a community-wide discussion. Sensitivity is the ability to detect true positives (Trevethan, 2017). In this case, it is the ability of machine learning embedded in Shinigami Eyes to classify correctly transphobic people. Specificity is the ability to avoid false negatives and to discern between transphobic profiles and trans-friendly. While the labeling done by the community dilutes the influence of machine learning, the lack of discussion on this point remains a weakness. Additionally, the Shinigami Eyes add-on as an individual piece of software has essentially died out. The last commit to the project was several years ago. There are issues on the Shinigami Eyes Github page showing its dilapidated state, with the add-on not working with the latest versions of browsers (Kiran, 2023). However, there are progeny. Beth’s Anti-Transphobia Library is the spiritual successor to Shinigami Eyes (bethylamine, 2023b). The intention is to incorporate more sophisticated machine learning not available during the initial development of Shinigami Eyes (bethylamine, 2023b). This makes concern about how the trans community should navigate the sensitivity and specificity dichotomy more salient as the algorithm will have a direct effect on the community.

Autism spectrum disorder is a diagnosis characterized by differences in social communication, and repetitive patterns of thinking and behavior (Institute for Behavioral Health, 2023). These differences often lead to the exclusion of autistic individuals. Some of the most damaging aspects of autism are that individuals diagnosed often have trouble with executive function and social interaction, making everyday activities difficult (Institute for Behavioral Health, 2023). Virtual reality can emulate environments without the social consequences, allowing autistic individuals to navigate these challenging environments. Virtual reality could also alleviate the stress placed on educators to provide specialized support. There could also be positive secondary effects. For instance, an autistic individual may have behavioral problems in the classroom. VR may mitigate behavioral concerns and allow students to integrate into their communities and learn more effectively. This would have the additional effect of their unique perspectives enriching the perspectives of all. While this technology shows promise, one risk not discussed by Dechsling and Nordahl-Hansen is that of dissociation. Training individuals in a virtual environment separates people from consequences. While VR might help to alleviate anxiety, it might also encourage bad habits or create unrealistic expectations for social interactions. These possibilities have been observed in the use of video games, which would seem to be associated with dissociative phenomena and maladaptive strategy for coping with life stress (Guglielmucci *et al.,* 2019).

An additional consideration is that virtual reality provides a social environment that is constructed in a deterministic manner. It is the nature of social interaction to deviate in a stochastic manner. This deviation may cause greater stress in that autistic individuals are being conditioned on a subset of social mores through their experiences. Thus, the constrained environment that emphasizes preparation, while safe and supportive in earlier stages, could pose a risk. The configuration and nature of the instruction provided through VR is very significant, encouraging coping mechanisms when unexpected variance is experienced in everyday life.

The relationship between inequality and technology is explored throughout this work. However, two chapters are worth observing together as they emphasis the role of skill building and education as mechanisms for inequality through the frame of failing institutional intervention. Nordum introduces the issue of skill inequality as a hierarchical problem. This seems to parallel the hierarchy of needs of Erik Erikson (1959), but in digital development. The first layer of the divide is based on the availability of hardware. The argument is that more developed economies have greater access to hardware and infrastructure. This is how the digital divide issue is usually framed, but it limits the scope of the problems and obscures sequential layers. The second is disparity in digital skills. The first level in the hierarchy acts like a funnel and eviscerates inequalities. For instance, consider how typing affects the ability to leverage technology. If you can touch type, you can communicate and interact with the internet and access subsequent sources. You may even program and develop higher level technological skills. However, if you are unable to type, you are quagmired in searching for the right key. This begets the third layer of inequality. While your typing counterpart learns to code and can leverage their skills for a higher wage, you are marginalized as your skills stagnate and remain less valued.

Education is a significant factor in how these divides manifest. Selwyn's chapter discusses how online education may magnify this skill disparity. One of the core arguments is that the resources provided via online education suit the circumstances of those in more developed countries. Additionally, the resources fit a pragmatic approach defined by incrementality. A more significant approach that challenges social mores is required to provide meaningful support to marginalized communities. For instance, one approach was to provide computer kiosks (Mitra and Dangwal, 2010, p.680). This was a widely accepted failure. There was a lack of institutional support or broader social structure to encourage and guide engagement in a coordinated campaign. A more pragmatic approach was simply to provide a defined resource to give adequate support to those who need it. More sustainable education outcomes require more effective use of technology.

Selwyn's discussion focuses on the differences between a Global North and South. The role of technology and its place in mitigating inequality seem to differ. Nordum considers a more singular unit of analysis and inequality on a national scale. The focus of Nordum's chapter is skills. The author notes that inequality within countries is increasing. The Gini index is the standard measure of inequality in an economy. A value of 1 indicates total inequality. For instance, in the US, the Gini index increased by 1.2% between 2020 and 2021 from 0.488 to 0.494 (Semega and Kollar, 2022). This phenomenon is also evident in an increasing number of countries. This troubling trend intersects with other layers of inequality.

Economic

Capitalism is the dominant economic system and has largely been credited with achieving decades of economic growth. In Borgebund's chapter, capitalism is defined by three factors: mass production and mass consumption, creative destruction and technological progress (Schumpeter, 1942). Creative destruction is likely the most meaningful. It is the spark that keeps capitalism running as an economic engine. Creative destruction relates to the drive to innovate. Technological progress is considered one of the main drivers of growth. The Solow growth model is useful when observing capitalism segmented into these three parts. In the Solow model, the total factor of production represents the level of technology and is the parameter that provides the most impact on growth. Labor and capital are included in the production function. However, diminishing marginal returns to capital and labor weaken the contributions (Solow, 1956). This may suggest that mass production and consumption are quantitatively less important, while technology and innovation are more significant and encapsulated in the idea of the total factor of production and technology progress provided by Borgebund.

The underlying argument is that capitalism will promote sustainability over time as creative destruction replaces current technology with new forms of technology (p.167). This is particularly noticeable in the cost reduction in solar energy. Since 2010, there has been a 64%, 69% and 82% reduction in the cost of residential, commercial-rooftop and utility-scale photovoltaic systems respectively (National Renewable Energy Laboratory, 2021). Additionally, as firms act to optimize their marginal benefits, the increasing difficulty of accessing oil deposits will promote substitution effects in production. The cost of developing upstream oil and gas assets, as tracked by the IHS Markit Upstream Capital Costs Index, increased by 1.8% in the third quarter of 2022 (Wahab, 2022). With these concurrent forces, capitalism and self-interest will promote sustainable development goals.

Many are unhappy relying on capitalism to promote sustainability. One of the concerns Borgebund discusses is that capitalism promotes short-sighted behavior at an environmental cost. One argument against this criticism is that it is just a trade-off that should be accepted. Capitalism will promote more prosperity for generations, but it comes at the cost of climate change. There were periods of great technological and economic growth, but with great social and environmental costs. The disparity in the Global North and South may be partly attributed to one group accepting this trade-off.

One point that should also be considered is that climate change will likely be against the self-interest of firms. Climate change begets storms and disaster and increased volatility in markets. While firms may behave in sub-optimal fashions when considering short-run economic theory, this is not the case when considering the long-run horizon. In the long run, firms will act rationally and should adhere to cost minimizing behavior, which should include taking more environmentally directed action. A secondary concern is that capitalism is seen as unreliable, and that the tragedy of the commons will undermine sustainability. The problem is that individual countries will let others bear the costs of reducing carbon emissions while avoiding reducing emissions themselves. The counter-argument is that collective action is possible when driven by significant external forces. One only has to look at the Paris Agreements to find evidence for this view.

The underlying issue with carbon emissions is a free-rider problem. The solution is to internalize the costs that are being externalized. An externality is essentially a cost of production that is not being borne by the producer: it is the pollution being generated. The general economic solution for this internalization is the Coase theorem, the notion that, given certain conditions, parties can negotiate internalizing an externality through leveraging well-defined property rights and borders (Coase, 1960). Cap-and-trade is one policy that is actively based in this framing, the policy being that parties will agree to a set of caps to their emissions. If a party does not exceed their cap, they trade the excess of their allowable carbon emissions to another party to produce emissions beyond their cap. In this manner, the cost of producing an inequitable amount of carbon is internalized and emissions are curbed through using market and capitalist mechanisms.

Conclusion

Technology can help reach various sustainability goals. At the individual level, through VR, it helps people to become more independent. Through software like the Shinigami Eyes, it protects people and allows them to engage online. At the meso level, it empowers and strengthens communities. And on the macro level, it is able to support governmental policy and shape collective action. Nudging has shifted the UK's environmental policy. At each level of analysis, technology has the potential to support people socially, economically and environmentally through providing the means for change.

While technology has the potential to do good, it can also have unintended consequences and may cause harm. At the individual level, technology is supporting disparity. Those that lack digital skills and access to hardware are being left behind. Promoting digital education is an inadequate solution to the problem and may actually worsen inequality. At the meso level, the environment is being stressed. Consider the development of AI. To train neural networks and to run inference on these large models requires vast resources. Our digital infrastructure is creating a larger environmental footprint, compounded by the rise of Chat GPT. And on the macro level, capitalist systems and collective action are defining the role of technology. It remains uncertain whether governments will be able to cooperate and if capitalism will become a force that supports sustainable innovation or continues to support unsustainable consumption. Overall, the role of technology and whether technology supports sustainability is dependent on society. People and governments will continue to set priorities.

References

bethylamine (2023a) 'AI integration', 8, available at https://github.com/bethylamine/bethylamine.github.io/issues/8, accessed August 2023.

bethylamine (2023b) *Beth's Anti-Transphobia Library*, available at https://bethylamine.github.io/, accessed August 2023.

Brevini, B. (2021) *Is AI Good for the Planet?* John Wiley & Sons, Hoboken NJ.

Brundtland, G., Khalid, M., Agnelli, S., Al-Athel, S. and Chidzero, B. (1987) *Our Common Future: Report of the World Commission on Environment and Development*, General Assembly Document A/42/427, United Nations, New York.

Chater, N. and Loewenstein, G. (2022) 'The i-frame and the s-frame: how focusing on individual level solutions has led behavioral public policy astray', *SSRN*, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4046264, accessed June 2022.

Coase, R. (1960) 'The problem of social cost', *Journal of Law and Economics*, 3, pp.1–44.

Danaher, J. (2022) 'Techno-optimism: an analysis, an evaluation and a modest defense', *Philosophy and Technology*, 35, paper 54.

Erikson, E. (1959) *Psychological Issues*, International University Press, New York.

Guglielmucci, F., Monti, M. Franzoi, I., Guglielmucci, F., Santoro, G., Granieri, A. and Billieux, J. (2019) 'Dissociation in problematic gaming: a systematic review', *Current Addiction Reports,* 6, 1, pp.1–14.

Institute for Behavioral Health (2023) 'How autism affects daily life', available at https://www.ibhcare.com/tips-for-writing-great-posts-that-increase-your-site-traffic#:~:text=Individuals%20with%20autism%20often%20experience%20difficulties%20with%20executive%20functioning%2C%20which, accessed September 2023.

Kiran (2023) Shinigami Eyes, available at https://github.com/shinigami-eyes/shinigami-eyes, accessed August 2023.

Krishnan, S. and Faust, A. (2022) 'Quantization for fast and environmentally sustainable reinforcement learning', *Google Research*, available at: https://ai.googleblog.com/2022/09/quantization-for-fast-and.html, accessed August 2023.

Mann, A. (2021) *Food in a Changing Climate*, Emerald Publishing, Bingley, UK.

McQuate, S. (2023) 'Q&A: UW researcher discusses just how much energy ChatGPT uses', *UW News*, available at https://www.washington.edu/news/2023/07/27/how-much-energy-does-chatgpt-use/, accessed September 2023.

Mitra, S. and Dangwal, R. (2010) 'Limits to self-organising systems of learning: the Kalikuppam experiment', *British Journal of Educational Technology*, 41, 5, pp.672–88.

Murdock, G. and Brevini, B. (2019) ‘Communications and the capitalocene: disputed ecologies, contested economies, competing futures’, *Semantic Scholar*, available at https://api.semanticscholar.org/CorpusID:202296366, accessed August 2023.

National Renewable Energy Laboratory (2021) ‘Documenting a decade of cost declines for PV systems’, 10 February, available at: https://www.nrel.gov/news/program/2021/documenting-a-decade-of-cost-declines-for-pv-systems.html, accessed September 2023.

Probst, B., Toetzke, M., Andreas, K., Laura, D. and Volker H. (2023) ‘Systematic review of the actual emissions reductions of carbon offset projects across all major sectors’, ETH Zurich, available at https://doi.org/10.3929/ethz-b-000620307, accessed September 2023.

Rotman, D. (2021) ‘Are you ready to be a techno-optimist again?’, *MIT Technology Review*. 24 February, available at https://www.technologyreview.com/2021/02/24/1017782/are-you-ready-to-be-a-techno-optimist-again/, accessed September 2023.

Schumpeter, J. (1942) *Capitalism, Socialism, and Democracy,* Harper, New York.

Solow, R. (1956) ‘A contribution to the theory of economic growth’, *Quarterly Journal of Economics,* 70, 1, pp.65–94.

Thaler, R. and Sunstein, C. (2008) *Nudge: Improving Decisions about Health, Wealth, and Happiness*, Penguin Books, New York.

Trevethan, R. (2017) ‘Sensitivity, specificity, and predictive values: foundations, pliabilities, and pitfalls in research and practice’, *Frontiers in Public Health*, 5, paper 307. Available at https://doi.org/10.3389/fpubh.2017.00307, accessed September 2023.

Wahab, Z. (2022) ‘Upstream costs continue to rise with only limited relief from lower material prices’, *S&P Global Commodity Insights*, available at https://www.spglobal.com/commodityinsights/en/ci/research-analysis/upstream-costs-continue-to-rise-with-only-limited-relief-from-.html, accessed August 2023.

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