Science and Technology for Humanity: An STS view from Singapore

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[ESSAY]

With this short essay, we aim to raise awareness of the NTU Institute of Science and Technology for Humanity (NISTH) initiative and to invite our colleagues to partake in the research programs we hope to see initiated at NISTH in years to come. In particular, building on the launch of the Institute, supplemented by the extraordinary global experience of COVID-19, we suggest ways in which STS scholars from around the world might contribute to the public conversation regarding the 4IR (see, e.g.,World Economic Forum 2015; World Economic Forum 2020; Marr 2018; Schwab 2017), and thereby also to the ways in which the relationships between technology, states, and citizens might be imagined with specific reference to Asia's future.

The version of STS that will inform our work at NISTH is the deeply synthetic field that has developed under the theoretical umbrella of co-production (Jasanoff 2004). This represents in the first instance a confluence of two originally distinct bodies of research: the first focused primarily on the internal dynamics of science and technology as social and

cultural institutions, and the second concerned more with the external relations and social impacts of science and technology. The co-production framework holds not only that these are never distinct in practice, but also that, in making the world through our knowledge practices and their technological applications, we shape our normative expectations of and orientations toward the world. Through science and technology, we constitute both what we believe the world is and how we wish it to be. Work in this vein is profoundly informed by history. At the same time, such work is also centered in the present, animated by social theory, and oriented toward the future, because advances in science and technology continually force us to ask what problems in today's world we want to solve and what future worlds we wish to bring into being. As nations grapple with the multiple challenges of the coronavirus pandemic, all these dimensions of STS research and thinking seem intensely relevant, as if they were invented for this moment in time.

STS in Postcolonial Asia: The Singapore Example

Singapore has long held a position as a crossroads between East and West: English-speaking but located in Asia and governed by Asians; a trading and trans-shipment zone not just for goods but also increasingly for ideas and values; a nation that embraces aspects of both liberal democracy and Confucian traditionalism. More than ever before, today's scientific and technological developments are playing out on a field of global competition. As a long-standing global trading post, Singapore is uniquely positioned not only to benefit from global competition, but also to act as go-between, broker, and mediator. This opens new possibilities and opportunities for STS too - from Singapore, one can observe the different valences and values that technologies take on in different social and political contexts; one can investigate how technologies are shaped by local histories and cultures; and one can reflect on sharply

different alternative techno-political futures. Some of these flexibilities have marked Singapore's creative engagement with global research powerhouses, such as MIT (Pfotenhauer and Jasanoff 2017). The emergence of Singapore's distinctive response to Covid-19 offers additional opportunities for exploring the links between expertise, governance institutions, and the risks of contemporary globalization. An "Institute of Science and Technology for Humanity" situated in Singapore is especially well-positioned to make important contributions to Singapore's burgeoning STS scholarship (See Clancey 2018) over the next decade, offsetting the field's past tendency to draw predominantly on Euro-American analytical terms and perspectives (Anderson 2020; Fischer 2018; Fu 2020; Law and Wen-yuan 2017; Wen-yuan and Law 2019). It is from this Asian location, and with this reflexive awareness of our field's and our location's history, that we raise some questions about the appropriate intellectual response to the 4IR.

Key Insights from STS

In keeping with spirit of the NISTH launch, further sensitized by the impacts of Covid-19, and in cognizance of the growing public conversation about the potential consequences of emergent technologies (particularly the assembly of technologies and applications collectively termed artificial intelligence, AI), we would like to present three key insights from the field of STS that we believe are essential in engaging the concept of the 4IR today. These recapitulate three of the most relevant principles of good thinking about the relationships between science, technology and society. The first principle is 'co-production' (Jasanoff 2004) the second is 'escaping technological determinism,' and the third is 'sociotechnical imaginaries' (Jasanoff and Kim 2015). By thinking with and through these concepts, we contend that the 4IR can be framed as a set of relationships between citizens,

technologies, and governance structures that raise particular questions for reasoned democratic governance. These, accordingly, might also be considered foundational for the shared conceptual outlook necessary for a global, transdisciplinary conversation about building a collectively prosperous and peaceful future.

Co-production

The idiom of co-production, one of the most salient concepts in recent STS, emerged from work at the Harvard Program on STS in an effort to understand how broader societal contexts and values get woven into the minutiae of scientific discourse and technological design, and in reverse how the wider social impacts of scientific and technological innovations enter into legal, political, and ethical thinking outside of the laboratory. As a reading of the relationship between science, technology and society, or, more specifically for this essay, the relationships between the 4IR and its imagined societal impacts, co-production asserts that "the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (Jasanoff 2004: 2). One can thus think of co-production as a kind of on-going dialectic between society and its inventions. Rather than a one-way synthesis, technology and society are 'co-produced.' It is a way of grasping how our understanding of society is thoroughly conditioned by science and technology, down to the nuts and bolts of the material infrastructures of modernity; and, reciprocally, how the nature of the knowledge and technologies we build are a consequence of societal deliberation and the implementation of varied collectively held values. For a mundane but pervasive example, the very wires and poles of telecommunications networks 'make up' aspects of how society functions, practically and economically, just as much as human design sensibilities, technological skills, and societal aspirations for connectivity

influence the look and functionality of communication technologies. They may, for example, reproduce existing social inequalities and vulnerabilities. Putting lines underground may be more expensive than stringing them above ground, and hence out of reach in older and poorer communities, whose exposed networks are also more vulnerable to storms or wildfires induced by climate change.

This way of conceiving the societal entanglements of S&T assumes that S&T are constitutive of social life and at the same time realized within its constraints. The interventions we make through S&T may be material in the first place, such as building a dam or editing a genome or creating a smart phone app, but the applications of S&T also influence how we order ourselves as human collectives and thereby reshapes our culture and social relations. In this respect, developments in S&T may give rise to struggles over competing visions and forms of social life, generating fields of political action where people compete to advance some futures at the expense of others. To understand the dynamics of society, especially during periods of significant technological change, we must thus attend to the socially constitutive dimensions of S&T, particularly the shared imaginations of progress that they instil in us.

This dynamic became evident in one line of conversation that arose again and again during the roundtable discussion at the NISTH launch in 2019: the issue of the right human skills to nurture in the era of the 4IR. Participants asked what skills university graduates of tomorrow will need. What skills will become redundant? How might we recalibrate university curricula to better prepare students for the job market? And how long will the 'shelf life' of newly acquired skills be before they too are made redundant by technological replacement? Much of the conversation pointed towards the importance of responding to the

upcoming changes by ‘upskilling’ students and adapting to the anticipated future needs and demands of the market.

There is no question that significant curricular changes are needed and for the most part welcome. As STS scholars, however, we should be attentive to the ways in which such conversation seems at times to black-box and even erase the underlying political questions. It is ultimately a societal value choice what skills we wish to protect and shield from becoming displaced through technology. Must we embrace the imposed ‘downskilling’ of certain professions, and if so which ones? For example, if a machine could weave nubbled silk, make a pizza, write detective stories, or cut hair as well as a trained professional, but more consistently and at lower cost, would we necessarily want to eliminate such creative human activities from our societies? These questions, of course, invite consideration of a wide range of issues, but how we decide fundamentally hinges on human values and democratic aspirations. For example, each named activity involves not merely a development of skills but also a relationship between the creator and the audience or user -- in short, a public. Our collective decisions need not be determined by the seemingly purposive rationality of technology. As new technological potentials emerge, we should consider not only the need to react to and prepare for technology’s anticipated outcomes and impacts. It is perhaps just as important to begin conversations about which professions, skills, industries, and opportunities for human flourishing ought to be afforded immunity from a technological onslaught, if only to allow more time to adapt, and for the established professions to have more say in the steering of new technologies. Impacts are never inexorable. They too are co-produced along with what society imagines, chooses, and enables through its collective actions.

Escaping technological determinism

STS and historians of technology have long recognized the insufficiencies of technologically determinist accounts of social or political change. Indeed, the theory of co-production implies that technology cannot ever be taken as an autonomous, determining force in history. Technologies are made by real people, embedded in times and places, with particular objectives and subject to available resources. Moreover, technologies are used, re-used, and re-shaped by people who may or may not share the original designers' visions.

Accounts of the 4IR, then, must be freed from the notion that the changes associated with AI or 5G or any other emerging technology are inevitable or that they will have a predetermined impact on all societies and all peoples. Ultimately, it is "we the people," the repository of democratic judgment, who should choose what technologies to build, how to build them, and how they should be used. We have choices, even if sometimes quite limited ones because of our economic or social positions, and therefore we have power over technology, even as it sometimes seems to have power over us. The trajectory from the first electronic digital computers in World War II, to the IBM mainframes of the 1960s, to the MacBook and iPhone was hardly linear or inevitable. It was shaped by the visionary individuals that human societies continually bring forth (Steve Jobs, for example), but also by social, political, and economic forces (the Cold War, the 1960s counterculture, the globalization of supply chains, and the corporate appropriation of personal data, for example).

Moreover, the purposes of technologies are not fixed in advance -- just because we have AI doesn't mean we have to have the Terminator. What technologies eventually become, and how we shape ourselves to live with technology, depend not only on choices of

material design but also on how we design the social, political, and educational systems in which they are embedded. Genetically modified foods, for example, might be quite different technologies if they were used primarily by non-profit organizations to feed the world's poor rather than monopolized by large corporations to maximize profits. Indeed, nations have diverged considerably in their policies for developing biotechnologies precisely because they entertain and enact different conceptions of risk and benefit (Jasanoff 1987, 2005; Hilgartner, Miller and Hagendijk 2015). This implies that -- rather than planning for a future inevitably steered by altered genes, intelligent robots or ubiquitous wireless devices -- we should begin to think more seriously about which kinds of societies we wish to live in and which forms of particular technologies humanity should wish to develop in order to realize those visions.

Freed from technological determinism with respect to 4IR, we will likewise be free to imagine different possibilities for AI, and even futures in which we reject some technologies altogether, deciding that their costs far outweigh their benefits.

Sociotechnical imaginaries

Social scientists have recognized for some time that modern nations originate in the shared imaginations of individuals who see themselves as members of a single national society (Anderson 1983). Communication technologies, such as print media, have been essential in maintaining these collectively shared imaginations and the performances they entail. In short, the psychology of individual belonging underwrites and structures the social, just as the social collective forms and trains the sorts of subjective identities that are capable of particular kinds of envisioning. Of course, all kinds of technologies can help hold worlds together and foster the imagination of community. S&T can play a role in reinforcing the

imagined cohesiveness of a shared national community, a global scientific community, or indeed any technologically savvy group or organization. Jasanoff and Kim (2009, 2013, 2015) provide an explicit framework for understanding this dimension of the global politics of science and technology. They define "sociotechnical imaginaries" as "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (2015: 4). The concept of sociotechnical imaginaries allows us to consider, very specifically, how ethical, social, and political commitments are built into national visions of technoscientific development and also how science and technology are used by people to reimagine their citizenship, social identity, and participation in public life.

The concept of sociotechnical imaginaries opens up the possibility of radically rethinking alternatives for fitting together technology and society. Instead of taking AI, for example, as a force pushing us toward preordained ends, we can ask new questions that recognize our own capacity for imagining the future. How might AI create new possibilities for democratic participation? How might it be embedded into society in ways that enhance rather than displace valuable skills? How might "driverless cars" -- rather than just replacing existing automobiles -- open up new ways of configuring the relationships between passengers, transport, and urban space? How might we re-think institutions, governance structures, or deliberative processes along with the technologies of AI? The reawakening of forms of sovereignty in recent years, further spurred by nationalistic responses to the coronavirus, have created urgent new openings for work on imaginaries, for example in debates about the use of digital tracking and data gathering mechanisms that may stall the

spread of disease but also raise new barriers against migration and concerns about privacy and surveillance (Stevens and Haines 2020).

The idiom of socio-technical imaginaries highlights the ways in which the discourse of the '4IR' itself fosters an imagination of a particular political worldview, one that is deeply (if tacitly) technologically deterministic (Schiølin 2020). In this discourse, it is the technical development that is active and progresses, while the human side is represented as the passive recipient, lacking agency. What would happen if instead we begin to explicitly unpack what the political and economic vision of the 4IR entails? What assumptions about human behavior and desire is it based on? And how might we begin to think of alternatives?

Re-imagining the Fourth Industrial Revolution

What do we imagine when we imagine the 4IR? In the first place, our imagination relies on a vision of the "first" industrial revolution – the one that took place at the end of the eighteenth and the beginning of the nineteenth century. In most accounts of the industrial revolution, it is represented as driven by technological innovation (steam power), the rapid replacement of "traditional" jobs (e.g. hand weaving) with "factory" jobs (e.g., steam-powered looms), and as a movement opposed by small groups of workers who were "anti-technology" (usually labeled as "Luddites" after their supposed leader Ned Ludd). Significantly, this revolution is also imagined as widespread and wholly successful, demonstrating the triumph of scientific and technological progress. In this vision, the Luddites lost and were rightfully consigned to the dustbin of history. To this day, the term Luddite is used to connote a foolish, misguided, and ultimately doomed opposition to the presumed to be progressive march of technological advancement.

This imaginary structures our anticipation of the 4IR in critical ways. Once again, we imagine a revolution as driven primarily by technological invention – in this case, the constellation of technologies associated with computerization, data processing, and artificial intelligence. Likewise, we imagine the 4IR as engendering massive job displacement as robots and AIs replace human tasks and workers. Just as human physical labour was supplemented by steam power in the nineteenth century, so we imagine human creative and mental labour as being supplanted and rendered obsolete by machine learning (and other technologies) in the twenty-first century. Economists warn of the dangers of "Engel's pause" – a stagnation of worker wages despite productivity growth. Furthermore, and perhaps most critically, much of the march of technological progress towards artificial intelligence and the subsequent replacement of human jobs is perceived as being inevitable. Those who stand in the way will, like the original Luddites, end up on the wrong side of history because history must do as technology promises. We also imagine the changes promised by 4IR to be global in reach and transformative of almost every aspect of our lives: health, food, communication, social life, work, play, transportation, education, entertainment, faith and belief, and so on. Implicitly, all this is taken as, in some sense, progressive.

What might be left out of this imaginary of 4IR? Again, we can interrogate this question by considering what was left out of the conventional vision of the "first" industrial revolution. First, there is widespread disagreement about what major transformations constituted that industrial revolution and what caused them. Indeed, some of the most significant changes associated with the original industrial revolution were social as well as technological. Urbanization is one important factor here – a massive migration to cities generated new workers who took up jobs in factories. The rise of cities and ways of life and

politics associated with cities was perhaps the greatest transformation of the first half of the nineteenth century in Europe. Historians have pointed to the significant role of other political and social changes in enabling the new industrial economy: the rise of a middle class in England and the political changes that swept Europe after the overthrow of the monarchy in France, for example (Smelser 1959, Thompson 1963, Landes 1969, Hartwell 1971). Moreover, the operation of factories themselves was contingent upon not just steam engines but other, less material innovations of the late eighteenth century. One was the modern banking system. This allowed entrepreneurs to borrow the amounts of capital necessary for financing large buildings and machines. Another was discipline: the factory system required the surveillance and monitoring of large teams of workers engaged in the assembly line, possibly the most soul-deadening form of work invented by modernity.

Second, telling the story of the industrial revolution from a European perspective leaves us with, at best, a partial picture. While England was industrializing, it was also consolidating its hold on vast tracts of the rest of the world, along with their resources. That these things were occurring simultaneously was not a coincidence. Most of the cotton that was woven into cloth in the new industrial centres in Manchester and Liverpool (and other cities) was produced by Indian farmers who were forced to sell it at below-market prices. The finished cloth was then shipped back to India to be sold to the growing population there at inflated prices. In other words, the first industrial revolution depended on the exploitation of human bodies and resources in other lands under the colonial system. Meanwhile, the great weaving traditions of Bengal, famed for making some of the finest textiles ever created by humans, languished and the skills all but disappeared. All this should challenge any view that the industrial revolution was unambiguously progressive in its causes or effects. In fact, the economic and social “progress” of some parts of the globe (Europe and also America) came

at the direct expense of people in other parts. Even today, the wealth-creating effects of the first industrial revolution remain patchy and uneven, partly as a result of these colonial legacies. Large swathes of India and China (let alone most of Africa) still, in the twenty-first century, remain far from "industrialized" economies.

Finally, we might also consider the effect of the industrial revolution on the planetary environment: on air, water, land, plants, natural resources, and non-human animals. The ubiquitous charts showing the emission of carbon dioxide and other greenhouse gases into the atmosphere demonstrate that the industrial revolution was an environmental watershed, and not for the collective good. Some have labeled the period beginning around this time as the "anthropocene": the time humans began to have a marked geological impact on the planet. Others use the more ironic term "capitalocene" to call attention to a form of rapacious overexploitation that has brought all of humanity to a sorry state. The increased use of fossil fuels to power machines is just one aspect of the industrial revolution's impact on the environment; deforestation, strip mining, pollution of waterways, massive uses of cement and plastics, radioactive waste, and the widespread application of synthetic chemicals in agriculture might also be considered here. These, too, are an important, indeed persistent, legacy of the first industrial revolution.

Given these complexities, what alternative visions could we begin to develop of 4IR that might yield a less chequered balance sheet? First, we should begin to question the idea that any coming "revolution" will be driven only by technology. To regard technology as an autonomous driving force misses the crucial role of geopolitical changes (e.g., the rise of China and Southeast Asia), environmental changes (e.g., global warming, biodiversity loss), demographic changes (e.g., aging populations, migration), and political changes (e.g.,

challenges to liberal democracy, rise of authoritarianism). All these are already profoundly affecting the twenty-first century. All of these are, of course, interdependent with technological change, but they are not caused by technology.

Second, we should reconsider the presumed inevitability of the promised technological changes. Ultimately, as noted earlier, we choose what technologies to adopt and how to use them, even if only through mindlessness and inaction. This process of choice might occur through democratic means (e.g., voting for leaders who support certain technologies), through consumer choice (e.g., buying particular technologies and not others), through financial strategies (e.g., investing in or divesting from particular companies), or other means. Users can also shape technologies and their meanings; technologies are malleable and have multiple uses (Bijker, Hughes and Pinch 2012). Steam engines power both factories and trains. Genetically modified foods can be used mainly to enrich agricultural companies or to grow more food in places where conditions are inhospitable or both. Artificial intelligence can be used for destructive weapons or for enhancing access to education or putting chess masters out of work. What matters is who is doing the envisioning and imagining that co-produce a social order along with a technological system.

Third, the 4IR may comprise multiple, networked revolutions. There was not one "first" industrial revolution but many partially overlapping ones: they happened in different times, at different rates, and in different places, with significantly different drivers and effects. The 4IR is likely to play out in the same way. That is, it is likely to unfold heterogeneously in multiple sites, taking on different forms in different places. The effects are likely to be uneven too. This not only makes it hard to predict what "the" 4IR will accomplish, but also suggests that our own imaginations need to be more encompassing: they

need to include more nuanced and disparate views of possible futures, and not allow one deterministic tidal wave to drown out potentially more far-sighted and humane developments.

Finally, we should take seriously the possible environmental costs of these parallel 4IRs. The historian of computing Nathan Ensmenger writes about the growing costs of computing in terms of resources (e.g., mining rare earths), energy, and toxic waste (Ensmenger 2020). As the 4IRs develop, how will we mitigate these harmful environmental effects, in addition to the displacement of the dirtiest, most dulling jobs to less advantaged communities around the world? How might we imagine a future for machine intelligence and the Internet of Things that also include human caring and stewardship of the natural world and of the other beings who thrive upon it?

Conclusion

The launch of NISTH at NTU signals a move to raise awareness of the social and political challenges ahead as a global community considers how best to integrate new technologies into our lives while mitigating the myriad negative impacts and consequences. In many respects, Singapore is an ideal location for this ambitious experiment. For starters, Singapore's location, as a global hub for economic and technological exchange with long-standing ties to several continents, places the Institute in a strong position to take a leading role in shaping the public conversation on these crucial matters. NISTH also carries institutional weight as an NTU initiative: while many technical universities have programs and departments of STS, some offering undergraduate and graduate teaching, none incorporates the mandate to serve humanity so explicitly into its name or its core mission. As a first mover, the Institute is well-placed to capitalize on its unique ambition. With technical

tools and personnel at its disposal, and yet with a distinctly humanistic mindset, it can attempt to offer some templates to much of the rest of the world for ways to integrate thought across disciplines, to avoid the pitfalls of deterministic thinking about technology, and to train tomorrow's theorists and practitioners of science and technology in society to be more deeply attuned to each other's abilities and potential for making transformative change.

NISTH also represents a welcome effort to generate a transdisciplinary conversation about the future of S&T in the world. The Institute will provide a platform from which to explore the possibility of postcolonial STS from the privileged position of an elite technological university rooted in the global South. Reciprocally, as STS scholars we have an invaluable opportunity to share with colleagues in Singapore the important insights that the field has yielded in previous decades. In particular, we have argued that the STS concepts of 'co-production,' 'escaping technological determinism,' and 'sociotechnical imaginaries' are indispensable in conducting rigorous analyses of the multifarious ways in which emergent technologies may become entangled with social change.

In beginning this conversation, we suggest that it is essential to consider the historical precedents of the so-called 4IR. That exercise demands thinking in a nuanced, regionally specific, and pluralistic way about the idea of an industrial revolution and its uneven evolution and consequences. If we embrace the term 4IR for its heuristic utility, it is important to keep in mind that this so-called revolution too will unfold at different temporal rates and along divergent pathways with different effects across the globe. This multifaceted development makes the case for a more precise and fine-tuned assessment of the ways in which government policies and modes of deliberation should address what kind of 4IR to authorize and pursue. Crucially, we must remember that it is not technology that drives social

change per se, but rather the dynamic relations between citizens, technologies, and governance structures that determine the future courses of history. For this reason, we have argued that discussions about the future societies we want to build necessitate a foregrounding of the political and ethical values of informed and engaged citizens from all walks of life all over the world. We are optimistic that NISTH will provide an important venue for convening and continuing these conversations and will help pave the way towards wiser and more just principles of the governance of S&T for humanity.

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