Post-automation

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ABSTRACT

Tremendous research, policy, and investment is directed towards a new wave of automation in modern societies. Most notable within discourse for the Fourth Industrial Revolution, but also in radical ideas for Fully Automated Luxury Communism, automation appears essential to the future. Advocates claim it will renew capital accumulation, boost labour productivity, and extend managerial control in sustainable systems of production and consumption. Noting criticism about future essentialism in this automation advocacy, this essay will turn to innovations in marginal industrious spaces within industrial societies. Here people are hacking, subverting and appropriating ostensibly automating technologies for purposes of creativity, collaboration, and care. Social capabilities in post-automation are being cultivated. Perhaps greater attention to the politics implied in post-automation can help open our futures to more democratic deliberation?

1. Introduction

Tremendous research, policy, and investment is directed currently towards a new wave of automation in modern societies. Advocates of the Fourth Industrial Revolution (4IR) argue further automation will renew capital accumulation, boost labour productivity, and enhance managerial control in the production of sustainable goods and services, for the benefit of consumers and society (Schwab, 2017; Trauth-Goik, 2020). Public debate, expert analysis, and policy development urges responsible innovation in automation, and considers how best to adapt society to its impacts. More radically, advocacy within a Marxist framework anticipates socially revolutionary possibilities in automation. An acceleration in technology is promoted in conjunction with a counter-hegemonic political strategy for winning state control over automation, thereby enabling a post-capitalist future of "fully-automated luxury communism" (FALC) (Bastani, 2019; Mason, 2015; Srnicek & Williams, 2015).

These arguments update debates about social adaptations to automation evident in earlier waves of technological advance (Ad Hoc Committee, 1964; Bagrit, 1966; Bassett & Roberts, 2019; Benanav, 2020; Wajcman, 2017). The aim in this essay is different. Noting criticism about automation's future essentialism, we question whether automation will be as fully in control of future events as advocates imagine. Attention is given instead to activity that subverts automation by radically repurposing the latter's technologies. In so doing, capabilities are fostered which are important for more democratic deliberations about more plural and less essentialised futures with technology. We call these capabilities post-automation.

Post-automation arises most prominently in an emerging industrious space, where grassroots networks subvert technologies and reconstruct them for different purposes (Arvidsson, 2019; Smith, Fressoli, Abrol, Arond, & Ely, 2017). In place of automation's foundations in capital accumulation, managerial control, and labour productivity, post-automation commits to more plural relations rooted

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in human creativity, conviviality, and care. Developers, activists, artists and other protagonists explore futures whose diverse horizons are appropriate to their situations and aspirations for sustainability. Whilst the social resources dedicated to post-automation are marginal compared to 4IR, the politics of the former is nevertheless deeply significant for sustainable and democratic futures.

At least, that is the argument in this essay. Section two begins with the foundations of automation, before concurring with Kasper Schiølin in section three that a central difficulty with 4IR (and FALC) is its 'future essentialism' (Schiølin, 2019). Section four introduces examples of industrious subversions of automation technology, which we conceive as post-automation in section five. Section six discusses the politics of post-automation and the challenges of building appropriate institutions for circulating post-automation more widely in society.

2. Automation

"[Automation] is a concept through which a machine-system is caused to operate with maximum efficiency by means of adequate measurement, observation, and control of its behaviour. It involves a detailed and continuous knowledge of the functioning of the system, so that the best corrective actions can be applied immediately they become necessary. Automation in this true sense is brought to full fruition only through a thorough exploitation of its three major elements, communication, computation, and control – the three 'C's." (Bagrit, 1966, p. 14)

Automation has been a long-standing feature in modern industrial development. Propelled by competition for greater labour productivity, managerial control, and capital accumulation, automation is also a recurring site of social struggle (Noble, 1984). As a discourse, 4IR updates the foundations of automation summarised above by Leon Bagrit in his 1966 public lectures about the 'Age of Automation'. Today, economic exploitation of the three 'C's encompasses vastly more complex systems; the kinds of feedback and interactions are more sophisticated; and the scope of application is more ambitious. Automation spreads beyond workplaces and households, into the computational control of urban systems, farming and food, health services, energy grids, policing and warfare, mobility and logistics, social welfare and public affairs.

2.1. The fourth industrial revolution

The latest wave of automation is promoted most vigorously through discourse about the Fourth Industrial Revolution (4IR) and policy frameworks for Industry 4.0. Automation in 4IR extrapolates advances beyond systems that are already operating globally, and anticipates technological breakthroughs that promise even greater control in a highly engineered future. According to leading proponent Klaus Schwab, Executive Chairman of the World Economic Forum:

"The fourth industrial revolution creates a world in which physical and virtual systems of manufacturing globally co-operate with each other in a flexible way. This enables the absolute customization of products and the creation of new operating models. The fourth industrial revolution, however, is not only about smart and connected machines and systems. Its scope is much wider. Occurring simultaneously are waves of further breakthroughs in areas ranging from gene sequencing to nanotechnology, from renewables to quantum computing. It is the fusion of these technologies and their interaction across physical, digital and biological domains that make the fourth industrial revolution fundamentally different from previous revolutions." (Schwab, 2017, pp. 7–8)

Global business platforms will operate through advanced deployments of cloud computing, the Internet of Things, robotics, 3D printing, Big Data, machine learning, synthetic biology, material science, and ecologically modern technologies. It is a future promoted by leading businesses, management consultancies, and increasingly by national governments who orchestrate programmes of public and private investment in innovation partnerships (Schiølin, 2019). 4IR justifies its future as propelled inevitably by long-waves of techno-economic creative destruction within capitalism (Mason, 2015; Perez, 1983). Automation cannot be stopped, nor should it be. Rather, social adaptations have to be made in order to manage the inevitable production of winners and losers.

"The great beneficiaries of the 4IR are the providers of intellectual or physical capital - the innovators, the investors, and the shareholders, which explains the rising gap in wealth between those who depend on their labour and those who own capital" (Schwab, 2017, p. 251).

Economic studies estimate impacts on jobs and the opportunities and risks for future labour markets and incomes (Autor, 2015; Brynjolfsson & McAfee, 2014; Frey & Osbourne, 2015). Welfare policies explore the mitigating possibilities of basic incomes, robot taxes, and how best to promise future work and social benefit. Education specialists debate training the future workforce needed to operate the automated systems (Nedelkoska, Quintini, & Quintini, 2018). Similarly, the environmental impacts in automation will be managed through responsible greener technologies incentivised with market-based techniques for carbon trading, offsetting measures, ecosystem services, and geo-engineering. Manufactured wealth will become more sustainable through precise control of resources, sinks and services in more circular economies; all powered by abundant and cheaply harnessed renewable energy and nuclear power; and all operating efficiently through the harvesting of Big Data (Bonilla, Silva, Terra da Silva, Gonçalves, & Sacomano, 2018; de Sousa Jabbour, Chiappetta Jabbour, Foropon, & Godinho Filho, 2018).

In these ways, imperatives for economic growth through automation are presented as not worsening already damaged ecological carrying capacities. Indeed, advances in material science, synthetic biology, and deeper engineering (and economic) enclosure of 'natural' processes promise a total management of reconstituted ecologies within automated cyber-physical systems (Dauvergne, 2020). With the future technological direction thus set, policy-makers are expected to adapt to an automated future. Curiously, those developing governance arrangements for adapting society to automation are expected to keep-up with policy decisions taken elsewhere to promote these techno-economic advances.

2.2. Fully automated luxury communism

On the political Left, some theorists anticipate socially revolutionary possibilities in automation (Bastani, 2019; Mason, 2015; Srnicek & Williams, 2015). Automation should be pushed "beyond the acceptable parameters of capitalist social relations" into a future of fully-automated luxury communism (FALC) (Srnicek & Williams, 2015, p. 254). Accelerating automation provides the technological means for transcending contradictions already evident in capitalism. Counter-hegemonic strategies are proposed for transforming social discontent into widespread public and political support for moving automation over to a post-capitalist political economy better equipped to manage structural underemployment and unemployment, worsening ecological degradation, diminishing costs and falling profitability (Mackay & Avanessian, 2014). FALC argues socialised automation will deliver an abundance of socially useful goods and services at diminishingly marginal cost. Automation will finally liberate people from labour and enable them to enjoy flourishing and meaningful lives. Abundant automated production provides the material basis for transforming ideas and expectations about work, income, leisure, and sustainability. Counter-hegemonic strategy needs to work the current political and economic conjuncture in ways that mobilises widespread social support for state-led initiatives in the socialisation of automation.

The question becomes how to organise an equitable distribution of the products of automated abundance. Core demands in FALC include a generous universal basic income (UBI) oriented towards transforming social relations, drastic reductions in working time without reductions in pay, a cultural shift away from the centrality of work, and the provision of universal basic services. These social demands are supposed to induce greater automation, by making labour exploitation more costly, and thus accelerating developments in labour-saving technologies. As for ecological impacts, FALC shares with 4IR an ecomodernist optimism towards future technology fixes for the total management of sustainable production and consumption (Bastani, 2019). Under FALC, automation becomes a determining driver of political strategies for recuperating left-wing hope in the future, after years of defensive resistance to neoliberalism. And yet, like 4IR, FALC embraces automation as though it were an inevitable feature in future societies. Each situates automation within a different political framework, but both anticipate societies where automation itself is unquestioned.

Not everyone is so sanguine. As with earlier waves of automation, there remain persistent anxieties about: the kinds of society required to make automation pervasive (Frase, 2016); the implications for citizen rights and authority (Zuboff, 2019); the uneven developments and deepening inequalities that might ensue (Norton, 2017); and the ecological consequences of endless productivity growth (Dauvergne, 2020; Hickel & Kallis, 2020). But given the powerful grip automation has across the political spectrum, what scope is there for hopeful futures beyond its horizon?

3. Questioning automation's future essentialism

Analysing the rise of 4IR, Kasper Schiølin traces how organisations like the World Economic Forum imbue automation with "future essentialism":

"[The] discourses, narratives or visions that, through different means and practices – from historical analyses to speculative estimates to hard statistics and calculation – produce and promote an imaginary of a fixed and scripted, indeed inevitable, future, and that can be desirable if harnessed in an appropriate and timely fashion, but is likewise dangerous if humanity fails to grasp its dynamics." (Schiølin, 2019, p. 4).

Multilateral and intergovernmental agencies, industrial associations, national governments, universities, investors, corporations, and so forth, all benefit by mutually reinforcing commitments to an automated future. As momentum builds, so states feel increasingly compelled to join the global race towards a universalized technological frontier. In so doing, attention is drawn away from alternative approaches to technology in society and futures are closed down.

3.1. Present tense technologies

In orchestrating political support and directing huge investments, 4IR perpetuates what Mike Cooley once called (in relation to automation in the 1980s) 'present-tense technology'. Seemingly radical technologies are promoted in ways that project into the future our current economic and political structures (Cooley, 1987). Ostensibly disruptive innovations actually conserve these deeper structures: perpetuating the priorities of privileged interests wishing to maintain control in the future (Feenberg, 1999; Trauth-Goik, 2020). Democratic practices suffer, "when those who imagine the future and decide upon its values are the same as those who own and sell the technologies that are imagined as driving it" (Schiølin, 2019, p. 18).

FALC anticipates democracy operating through state control: "At the level of the state, there is an equally strong case to be made for democratic control over technology development, given that most significant innovations come from public-sector financing rather than the private sector" (Srnicek & Williams, 2015, p. 342). The democratic details are scarce. Many states actually promote automation with little regard for democratising technology. When, where and how will 4IR automation be interrupted and transcend into FALC automation? Benjamin Noys argues the accelerationist argument in FALC repeats a history on the left of neglecting precisely how technology-based instruments developed for capitalist control will transform into tools for socialist liberation (Noys, 2014). Were counter-hegemonic strategies to eventually (or suddenly) win state power, might the new administrators find themselves locked into constraining technological trajectories and infrastructures already set by 4IR (Walker, 2000)?

Whilst FALC's attention to future political economies and states is undoubtedly important, so too is an appreciation of the human cultures, creativities, and relationships that shape the details of technology politics. Who is going to redesign, innovate and maintain communist cyber-physical systems for production and consumption? How are (unspecified) protagonists going to equip themselves with the skills and resources to guide automation out of capitalism and into a socialised version? What kinds of democratic processes will transmit society's aspirations and priorities into the development of its technologies? How will non-human species and our

common ecosystems participate in automated production systems? What capabilities, organisational models, and infrastructures will regulate and maintain automated systems that are ecologically and socially durable? Who will own and control specific automation systems? How will benefits be shared, problems negotiated and conflicts managed?

3.2. Automation may not be so automatic

Quite apart from practical questions, to which we return soon, automation is founded upon three assumptions that are deeply problematic for democratic futures. The first is automation's presumed expansion towards full implementation. The second is automation's premise of total control over objects drawn into its cyber-physical systems. And the third problematic assumption is that automation applies universally. Each assumption is questionable.

First, analysis questions the likelihood of universal, fully-automated futures (Autor, 2015; Benanav, 2020; Thompson, 2020). Firms can find it easier and more profitable to deploy technologies for micro-managing workers and intensifying human tasks. Labour becomes controlled like robots rather than replaced by robots. Even within automated systems, their smooth operation can require human operatives undertaking 'ghost work' (usually exploitative), such as cleaning data, training algorithms, overseeing platforms, and tending to uncertain interfaces with society (Gray & Suri, 2019). In contrast to the workerless factory promoted by management consultants, automation has been accompanied historically by the emergence of new classes of human tasks, jobs and occupations (Freeman & Soete, 1994; Kaplinsky, 1984; Senker, 1986). That said, even the higher-skilled tasks can turn out to be alienating and unfulfilling for workers. So, whilst it is undeniable that livelihoods have been lost to automation and communities destroyed, the relations between human labour and technology are more complex than machines substituting for humans.

FALC argues communist automation will be different (Fuchs, 2020). But even under communism the point remains: there is nothing automatic about automation. The practicalities of implementing automation turn upon complex dynamics in labour processes, business models, political economies, cultures and situations particular to places and times. Considerable capabilities will be needed, right down to the shopfloor, in order to navigate such complexities and shape democratically the contours and the limits of automation.

Second, for all its enhanced controls and efficiencies, the environmental charge sheet against automation remains considerable. Most obvious is ecological damage in mining and processing the resources for building automated systems; and the destruction and contamination generated by the aggregate increases in global productivity that outstrips relative efficiencies in specific technologies (Berkhout & Hertin, 2004; Ferreboeuf, Efoui-Hess, & Kahraman, 2019; Williams, Ayres, & Heller, 2002). Escalating upgrades typical in digitalisation also risk drawing into faster obsolescence the materially heavy infrastructures that have been integrated into smart, automated systems. Creative destruction might be good for economic growth, but it has not yet decoupled productivity from ecological collapse (Jackson & Victor, 2019). FALC is no different to 4IR in responding to ecological concerns by doubling down on automation's control strategies. Both have faith in enhanced technological controls. Environments are perceived instrumentally, as mixtures of raw materials, waste sinks, and eco-services appearing as objects within cyber-physical systems. Managers have synoptic control.

Hubris in this form of total environmental management has, arguably, been one of the most profound causes underlying the ecological crisis. Feminist research in technology studies, for example, reminds us how automation's objectification of natures must eventually confront realities in which systems are only ever partially comprehensive of the situations in which they are entangled. Automation is trying to objectify and articulate into its operations a plurality of sometimes troublesome and lively subjects. Multiple relationships between humans and non-humans spill beyond system schemas and boundaries. Values and behaviours exceed algorithmic formulations (Haraway, 1991; Latimer & Gómez, 2019; Puig de la Bellacasa, 2011). With automation having less of a controlling grip than imagined, so greater attention turns towards the care work required in the (overlooked or undervalued) relationships that systems rely upon (Arora, Van Dyck, Sharma, & Stirling, 2020).

Third, given the complexities, universalised automation is unlikely to work. Standard models will have to give way to situationally sensitive starting points. Cultural considerations unsettle cyber-physical formulations. Working systems attentive to their own situationally-specific needs for care, repair and meaning that have to be nurtured and maintained. Universal technological templates are less equipped for such plurality than appropriate technologies (Bellacasa, 2017). Moving automation's universal conceptions, and caring instead about plural situations, resonates with histories that call for more appropriate and convivial technologies (Illich, 1973; Pansera & Fressoli, 2020; Smith et al., 2017; Willoughby, 1990) – a point to which we return.

In sum, foundational assumptions in automation are troubled by complexities and uncertainties evident in human relationships with technology in workplaces, in societies, and with ecologies. Notwithstanding the industrial power invested in automation's future essentialism, there are grounds for questioning how fully operational and fully in control automation will be in future. Perhaps more essential questions relate to how to cultivate and circulate social capabilities for deliberating more democratic, plural and careful futures with technologies? Intriguingly, around the world different communities are already subverting piece by piece the questionable foundations of automation. Amongst other things, they do this by experimenting with alternative social arrangements for technologies hitherto associated with automation, whether it is sensors, data, 3D printing, design software, materials science and biology, digital platforms, video, logistics and decision systems, or other appropriable components. In pursuing social purposes different to automation, participants hack and re-signify possibilities in technologies amenable to plural futures.

4. The industrious subversion of automation

In a recent study, Adam Arvidsson argues a by-product of neoliberal restructuring and relocation of industrial production, including intensifying automation, has been the emergence of a new "industrious modernity" on the margins of capitalism. Two sources of

agency are building in this industrious space. Both are distinct from the industrial modernity in 4IR and FALC.

First, there are the small and informal producer networks seeking livelihoods on the margins of industrialisation. Wherever industrial capitalism fails to absorb workers migrating to the industrial centres of the global South, or renders more precarious the knowledge and service workers in the global North, so Arvidsson detects a turn to "commons based petty production" amongst the marginalised (Arvidsson, 2020, p. 17). Thrown out and brought together by industrial forces, people collaborate in trying to forge livelihoods, obtain goods and services, and thereby find meaning and survival in entrepreneurial projects. Industrious networks become highly skilled in fashioning livelihoods from digital technologies whose antecedents developed within industrial automation. A 'commons' of skills, know-how and livelihood networks shares use of increasingly accessible and hackable technologies (Arvidsson, 2020).

Second, there are those employed formally in the industrial and service economy, but who find their work so unsatisfactory that they seek fulfilment, and sometimes work, in the industrious space. Even if not so marginalised or insecure, and benefitting from conventional, well-paid jobs, this group nevertheless feels alienated. They lack autonomy in their labour process, and have little say in the purpose to which their work is used. The industrious space offers more creative and meaningful possibilities towards fulfilment. Professional skills are brought into the industrious space, such as computer programming, architecture, engineering, science, and business. Orientations to social innovation are prevalent, helping cultivate community-skills and new methods for collaboration, including working with diverse and marginalised groups. Projects often aspire to more socially just and ecological patterns of production and consumption (Seyfang & Smith, 2007; Thackara, 2015), which feeds back into the development of technologies in the industrious space.

These two groups intersect. Social innovators collaborate with petty producers. Both cultivate capabilities for working collaboratively and creatively, hacking and adapting technologies, and following a commons-oriented ethos that helps practices circulate widely. At heart, both seek dignified work with technology. The rest of this section introduces some examples.

4.1. Commons-based peer-production

Emblematic of the industrious space has been rapid growth globally of workshops and networks practising commons-based peer-production. Commons-based peer-production manifests in people openly accessing versatile digital design and fabrication technologies, and finding opportunities for skilfully appropriating these technologies for peer-production goals (O'Donovan & Smith, 2020). Attention tends to focus upon activities in workshops, but developments are buoyed by broader networks promoting and facilitating commons-based peer-production (Smith, 2017).

Digital platforms enable the sharing of: online repositories of designs, code, instructions and advice; how-to videos; distributed training sessions; distanced collaboration and work organisation; design patterns and toolkits; and so forth. Online fora and campaigns advocate open access to tools, know-how, and transmit enthusiasm for collaborative development and mutual acknowledgement, usually following modular and project-based approaches. There is a recursiveness in this activity, in the sense that technologies and projects are themselves open to re-use, modification and further development.

All this provides an infrastructure that radically redistributes prototyping capabilities in society and opens up technological futures to practical deliberation. People are able to participate in opening modern material cultures up to practical scrutiny and development. The political and economic contours for 'designing globally and manufacturing locally' are explored (Kostakis, Niaros, Dafermos, & Bauwens, 2015). Flexibility and adaptability in neighbourhood-centred facilities situates and grounds networked capabilities for value creation, thereby enabling local circular economies, community wealth building, and nurturing local creativity (Prendeville et al., 2017; Smith & Light, 2017). Cultivated carefully, these facilities can overcome the imposition of a misplaced universalism evident in institutionalised technology transfer (Coban, 2018; Dias & Smith, 2018; Fox, Ulgado, & Rosner, 2015; SSL Nagbot, 2016). The fact that local adaptations can be instigated, and experiences shared globally, is illustrative of capabilities for more careful and equitable attention to different situations, different relationships, and different aspirations.

4.2. Citizen sensing environments

Automation perceives environments instrumentally, as raw materials, waste sinks, and eco-services for objectified control. In contrast, widening access to low-cost, low-power sensors, micro-controllers, platform-based data-storage, analytical visualisation, and wi-fi or mobile connectivity, enables more communities to sense, map and relate to a growing range of environmental phenomena. Citizen scientists, artists and activists are able to explore relations with environments they care about (Balestrini et al., 2017): from noise and pollution, through to animal species and radiation; from mapping cycle routes, to sensors for food growing; and from overlooked histories in places, to imaginative augmentations that envision the world from the perspective of other species.

Participants do not simply measure these environmental phenomena, they also re-signify and reclaim them (Gabrys, 2017; Tironi & Sánchez Criado, 2015). Connections between local projects circulate capabilities for making sensible that which is otherwise overlooked, invisible or under-appreciated. These capabilities can generate data and awareness of situations that official monitoring either ignores, fails to reach, or approaches quite differently. The creativity in this activity extends to nurturing communities that care about matters of concern (Puig de la Bellacasa, 2011). Indeed, the success of collaborative sensing depends upon communities mobilising action. Co-designing and implementing sensing activity brings people together, whether in workshops, or through events, or online fora linked to the data produced. Indeed, when trying to mobilise data into social change so the importance of other forms of knowledge beyond digitised codifications become pronounced. Anthropological and sociological knowledge about the environments being sensed become central for strategies of change, relationship building, and maintenance.

Citizen sensing thus makes use of open designs, software, hardware, and collaborative methods in ways very different to the proprietary enclosure and objectification of natures in automation. Sensibilities are cultivated towards a broader spectrum of human relationships with environments and species. More caring and less exploitative connections are made compared to the imperatives driving objectifications in automation (Kostakis, Roos, & Bauwens, 2016). Interest shifts, from cyber-physical systems for global enclosure, to convivial systems for exploring natures in common.

4.3. Right to repair and digital durability

Given the environmental charge sheet against digital technologies, grassroots responses to ecological challenges include practices of repair, care, and durability in digital technologies. Activities like repair meet-ups, how-to-guides, and videos on platforms, have become a mobilising component within a social movement pressing for the right to repair. Demands include businesses investing in design and infrastructure for repair and repair services.

Restart Parties, for example, provide meetings and events where people can bring broken devices and learn how to fix and upgrade them with the help of volunteers (Lepawsky, 2020). Considerable environmental impacts are avoided. In addition, participants confront in a very practical way artefacts whose assembly is usually designed for linear, high-consumption economies. Disassembly runs against product warranty restrictions intended to discourage tinkering. Care and repair activity cultivates capabilities lacking in automated industrial production systems, by looking to the realities of widely distributed products needing versatile repair skills (Strebel, Bovet, & Sormani, 2019).

Not only do these repair capabilities cut environmental impacts, but they also cultivate a relationship with technologies as a commons (Zapata Campos, Zapata, & Ordoñez, 2020). Repair is easier if designs, instructions, components, and so forth are openly available to people, and where design for modularity and interoperability permits adaptions, component switching, and remanu-facture. Open guides support participants in tinkering and reshaping the technologies in adaptable ways. There is both a practical and ideological basis to this conception of technology as commons. Practically, because territorially rooted repairing is faced with a plethora of different devices to care for, and will need versatile facilities to make or access components and swap and splice devices into renewed, upcycled and remanufactured devices. And ideologically, because repair embodies an ethic of caring for technologies as part of the fabric of modern societies.

Of course, unsustainable practices are evident in industrious spaces too. They are not a panacea (Arvidsson, 2019). Nevertheless, the participatory experimentation celebrated in this space builds important capabilities for deliberating material issues in very practical ways (Marres, 2012; Smith & Stirling, 2018). Practices from free software and open hardware - concerning modular designs, rights to access and modify, and responsibilities to keep modifications open – are influencing more general relations towards tech-nologies. Bicycles, furniture, farming equipment, clothing, manufacturing technologies, and more, are being rethought in these commons-based terms. Capabilities for local durability, repair, and re-manufacture open up quite different futures compared to 4IR and FALC (Fonseca, 2015).

4.4. Decolonising technology

Historically, promoters of well-intentioned 'appropriate' technologies had to learn quickly how to enable 'beneficiary' commu-nities to build their technological autonomy, such that those communities could themselves shape technologies appropriately (Smith et al., 2017; Willoughby, 1990). Capabilities and methods for more equitable encounters were developed (Fals-Borda, 1979). The advent of digital technologies has renewed this process. Indigenous populations and excluded communities are appropriating digital technologies using capabilities that challenge hegemonic narratives and build up their own voice (McLean, 2020). These efforts to decolonize technology, by challenging Western assumptions, give visibility to diverse conceptions and practices in technology (Hui, 2016; Philip, Irani, & Dourish, 2012).

Networks for digital fabrication in Latin America, for example, have been working to foster craft traditions and complement skills of indigenous communities. The incorporation of carefully appropriated digital design and fabrication tools is used to enrich traditions rather than to displace them (Herrera, Montezuma, & Juárez, 2018; Pascale, 2018): a tool for resistance and autonomy. Priorities can involve digitising and representing to new generations and diasporas the plural knowledge, language, practices, claims and rights of communities. Valued practices, subjectivities and culture inform future sociotechnical possibilities. Some go further, to debate how indigenous practices of kinship (including with non-humans) can inform developments in AI (Lewis, Arista, & Pechawis, 2018). There is an insistence here that diverse cosmologies shape more plural futures in technology compared to the future under modernity (Escobar, 2018; Hui, 2016).

Experiments in local technological autonomy is helped by free culture activism and hacktivism projects. Stefania Milan describes how activists re-signify technologies and build their own digital infrastructures in order to gain autonomous spaces of communication, including a wide variety of media, like secure email accounts, non-profit web hosting services, but also pirate radio stations (Milan, 2013). Grassroots groups are building wi-fi mesh networks to extend internet access into areas where there is no commercial provider. Projects develop online resources in local languages. Others train activists in digital self-defence against surveillance and use it to empower vulnerable groups to protect and claim their rights (see Fundación Karisma in Colombia, Rancho Electrónico in Mexico).

In building capabilities for autonomy, so more diverse futures open up in comparison to the universal frontier assumed in 4IR and FALC. Whilst official national strategies for development seek usually to catch-up and keep up with that frontier, communities and activists resist, adapt, reject, and subvert technologies.

4.5. Platform co-operatives, data commons, and technopolitics

Digital platforms feature prominently in automation (Srnicek, 2016). Platforms coordinate (and discipline) producers, workers and consumers, whilst simultaneously enabling the extraction of valuable data (Gillespie, 2010; Sadowski, 2020; Woodcock, 2020). In criticising platform capitalism, activism has generated considerable interest in alternatives. Platform capabilities have been adapted to the causes of co-operativism, for example, most notably with worker-owned and consumer co-operative platforms (Scholz, 2016).

Capabilities are developing in commons-based approaches to data creation, use, stewardship, and circulation; as well as platform technologies for organising and coordinating co-operative work. Platforms are being used, for example, to help workers organise, gather data, lobby and bargain against exploitation in gig economy platforms. Data cooperatives initiatives are emerging in areas like health and urbanism. Meanwhile, technopolitical activists are developing digital platforms for direct democracy, which have found traction in sympathetic municipalities and organisations globally. These technopolitical platforms allow citizens to propose, debate and vote on policies and budget spending (Smith & Prieto Martín, 2020). As free and open infrastructures, these platforms are also being adopted by co-operatives in sectors like energy, mobility, and housing to enhance their internal governance capabilities.

Typically, these alternative platform initiatives are about creating local, decentralised, and democratic tools. They are more socially embedded than capitalist platforms, such as Uber, Deliveroo, and Uptasking (Graham, 2020). Platforms are built with and for those operating across them, with transparency, deliberation, and dignity sought in platform ownership, governance, and use. The value produced circulates more equitably amongst participants. As such, platform configurations are opened to the specificities of different places, groups, and purposes. Deliberations adapt the functions across platforms, and negotiate relationships between activities online and offline.

5. Post-automation

The examples in section four are suggestive of far richer fields of practical activity. What are we to make of such heterogeneity? First, the subversive use of technology erodes future essentialism by demonstrating diversely adaptable social arrangements for technologies beyond automation. Second, these activities develop social capabilities for materially deliberating alternative futures beyond the horizon of automation. Third, the circulation and expansion of these capabilities can help democratise technology and open the politics of technology to broader social questions than efficiency, productivity, control and accumulation.

5.1. Post-automation as capability

Post-automation is defined as the common *capabilities* that enable people to subvert and appropriate technologies for more open futures and thereby challenge through practical demonstration automation's future essentialism. Capabilities refers here to the skills, know-how, resources and infrastructures available to people to adapt technologies into developments that matter to them (O'Donovan & Smith, 2020; Oosterlaken, 2016). Each initiative in section four cultivates capabilities for: embedding technology systems appropriate to places and contexts; in which human creativity is central; based in open collaboration deliberated with others (including non-human species). Typically, commons-based approaches in technology and production are pursued. Ideally, all this is done in ecologically durable ways involving dignified work. Post-automation capabilities open up sociotechnical *means* towards practices of
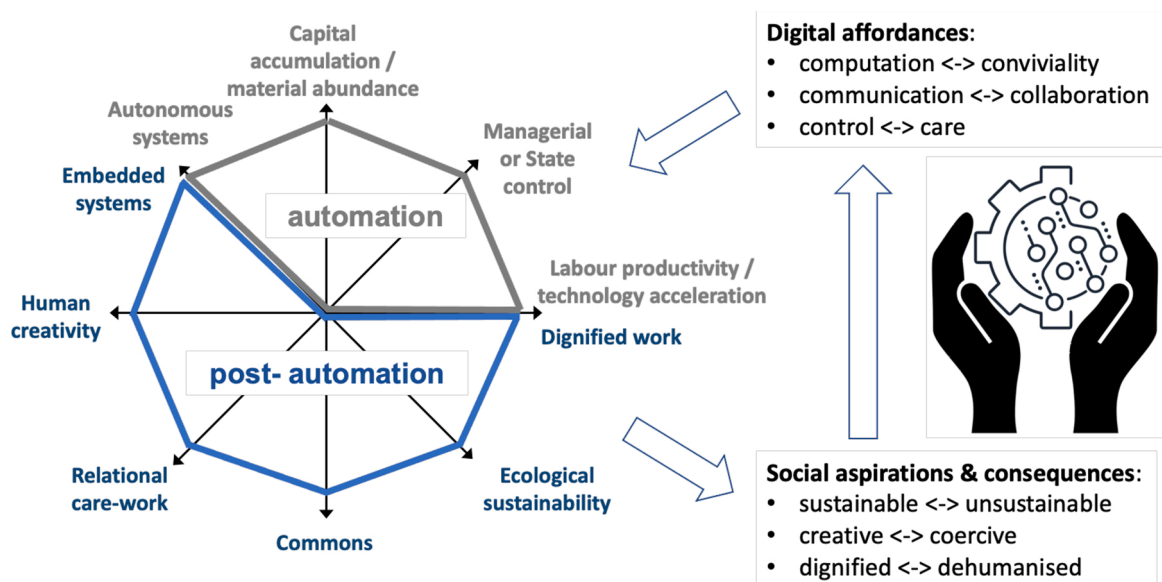

Fig. 1. automation and post-automation.

care, maintenance and wellbeing. Fig. 1 provides a schematic summary of capabilities recurring in the examples.

In contrast, automation is propelled by relations imposed as universal and pursuant to abstract system efficiency, capital accumulation, managerial control, labour productivity, material abundance, and technology acceleration. These *ends* are the foundations for automation. Faced with sustainability challenges, automation redoubles its control strategies by extending them further and deeper into struggling ecological and social systems. By contrast, in post-automation hierarchical control gives way to forms of digitalisation reconceived and reoriented instead towards more creative, collaborative and caring relationships with others in ecologies and societies.

There is a risk in drawing together diverse activity within a concept like post-automation and delineating it so starkly against automation. Complex, dynamic and situated practices are inevitably simplified into typical features like those in Fig. 1. The intent is not to reduce versatile heterogeneity into a formula for post-automation. That would merely swap one essentialised future for another. Rather Fig. 1 illustrates capabilities that post-automation helps to redistribute in societies.

There is a further risk, which relates to our choice to position the point of departure for post-automation in the digital technologies normally associated with automation. Post-automation risks being conceived as only opening up alternative digitalisations. In place of computation, communication and control, is emphasis in digital affordances for collaboration, conviviality and care. But for all the claims to flexibility and versatility, perhaps future horizons remain constrained if emphasis is limited to adapting digital technologies over non-digital technologies? Some durable relationships between people and their ecologies might be constrained by the parameters of digitalisation, for example; or some human values and creativity simply cannot be codified, represented, or mediated adequately; or ideas like post-growth are hard to realise through digital technologies (March, 2018)? This limitation points beyond an initial departure in contesting automation, and that truly subversive activity in digital technologies will include the possibility of rejecting or subordinating some of them in favour of other technologies. Capabilities in Fig. 1 can certainly help to situate digital more equitably and openly alongside other technologies. Post-automation therefore implies that the relative standing of digital and combination with other technologies needs to be less hierarchical, and that the appropriateness of technologies is of more value to privileging a priori what appear to be the most innovative.

5.2. Appropriate conditions for post-automation

4IR, FALC and post-automation each approaches technology in futures in distinct ways. Table 1 summarises the orientations and approaches of each in terms of key protagonists, strategies, material and organisational basis, and their temporality towards the future. Of course, these futures are not equipoised. Political and economic power is inscribed and invested in 4IR: hence the counter-

Table 1
Futures under 4IR, FALC and post-automation.

Feature	Fourth Industrial Revolution	Fully-Automated Luxury Communism	Post-automation
Protagonists in the future	• Business leaders and industrial associations (e.g. WEF) • Multilateral agencies (e.g. OECD, ECLAC, EU) • Capital and neoliberal governments	• Left political programmes • Socialist states • Post-work citizens liberated from labour	• Industrious space • Social entrepreneurs and social movements • Hackers
Strategies for the future	• Future essentialism • Top-down disruptive innovation • Universalised controls • Capitalist growth and ecomodernism	• Future essentialism • Top-down socialisation of technology • Universalised controls • Counter-hegemonic politics • Acceleration and ecomodernism	• Democratization of futures • Open experimentation and appropriate prototyping • Convivial livelihoods situated in diverse ecologies
Material basis of the future	• Technology-driven • Cyber-physical systems • Markets and consumers	• Technology-acceleration • Automated abundance • Socialised economy	• Radically redistributed prototyping • Post-growth technological sufficiency • Capabilities for subverting and appropriating technologies
Organisational basis of the future	• Large firms • Platform capitalism • Consumer markets • Public-private partnerships • Limited universal basic incomes	• Automated production centres • State redistribution of surplus • Universal basic services and incomes • Radically expanded 'free' time	• Horizontal networks and redistributed capabilities • Commons-based peer-production • Platform cooperatives • Care in social and solidarity economy
Temporality	• Already installed in dominant R&D agendas • Superficial disruptive innovation, with underlying social structures remaining the same • Automation develops at rate set by its profitability and public investment	• Transcendence through acceleration of current trends • Revolution in social structures driven by new technological capabilities • Automation develops rapidly through state promotion	• Present day subversions through social entrepreneurship and hacker ethic • Cultivating caring relations through open and durable technologies • Temporality based in expanding the social conditions for circulating post-automation capabilities

hegemonic strategies in FALC. Post-automation is peripheral to centres of political and economic power. It rarely features in the agendas and programmes of state and corporate strategies for technology development. Nevertheless, this essay argues post-automation merits wider social attention. The question is, what social conditions will widen and deepen attention beyond the industrious space?

Such a question recalls and updates a critical issue raised for appropriate technologies half a century ago. Back then, the main thrust in international development emphasised modern blueprints for industrialisation. The appropriateness of this approach came under question and prompted arguments for alternatives (Bookchin, 1967; Cooley, 1987; Illich, 1973; Schumacher, 1973). Critics warned of the social and ecological consequences of industrial blueprints. There was unease over a future essentialised around large-scale, universalised technological advances, including automation. Alternatives emphasised locally appropriate capabilities for shaping and adapting technologies in more convivial and socially useful ways. Appropriate technology centres and programmes opened in both industrial and 'developing' contexts (Jequier & Blanc, 1984). Some activities became mired in debates about abstract specifications as to what did and did not constitute appropriate technology (Willoughby, 1990). More productive was work in developing the social conditions and capabilities locally conducive to cultivating capabilities in appropriate technologies in different contexts (Edquist & Edqvist, 1979; Smith et al., 2017). Scope for developing these social conditions deteriorated with structural adjustments in the 1990s and the turn to neoliberalism. The institutional landscape ceded social choices in technology to market-based investment decision (Kaplinsky, 2011). One unintended by-product of those structural changes has been the industrious space. Compared to appropriate technology centres, however, the industrious space today connects practitioners and communities across networks in ways unheard of in the earlier programmes. Capabilities circulate in ways unavailable to earlier generations. Post-automation nevertheless faces a similar political challenge in terms of influencing social conditions beyond its originating space, and thereby expanding the circulation of capabilities in ways that are more influential for societal futures.

6. The politics of post-automation

Given post-automation develops through heterogeneous cultural and economic activities, so its protagonists will have different ideas about what they are doing and what it means. Critics can reasonably argue that it isn't clear what a focused programme for post-automation looks like. Industrious ambitions appear limited to pursuing meaningful activity in specific projects that are either personally fulfilling, contribute to livelihoods, or provide specific community benefits. Coordinated developments exist in some areas, such as for data commons and platform cooperatives, or commons-based peer-production and citizen sensing. But this does not amount to a programme for post-automation as an alternative to 4IR or FALC. How could post-automation develop into something much more transformative?

Future essentialism in 4IR and FALC leads both towards politics conceived in terms of compelling visions and programmes. In each case, the primary site for politics is in the articulation, consolidation, and coordination of programmes in which automation is an end itself. In contesting future essentialism, post-automation deliberately becomes less programmatic. Any programme, such as it is, involves bringing about the social conditions for expanding capabilities beyond the industrious space (cf Coleman, 2004). The more open and plural futures thus enabled invite diverse visions and programmes. The politics of post-automation is based in winning societal support for its democratic capabilities for opening up technologies and futures. Of course, it still confronts the dominance of 4IR, and therein lies the political dilemma for post-automation: can open capabilities thrive without a future vision and programme? In this final section, we consider the political dilemma across three related sites: institutions, social movements, and political economy.

6.1. Institutional politics

In contributing to commons-based practices, even those industrious practitioners who are agnostic towards post-automation as a transformative idea nevertheless contribute to the circulation of relevant capabilities. Whilst post-automation relies upon such work, so others can profit from it. Business and policy entrepreneurs within market and public institutions can see opportunities in industrious innovativeness for realising their own agendas. The politics of post-automation here involves struggles over autonomy and mutual benefits in these institutional encounters (Fressoli et al., 2014).

Within market institutions, politics plays out in the terms negotiated with for-profit tech companies who commercialise particular innovations originating in post-automation. Open innovation firms already use hackathons, prizes and licencing to identify useful inputs for new products and services. Winning industrious innovators benefit, but the collaborative, commons-based ethos underpinning industrious activity tends not to. Open innovation reinvests relatively little into the wider conditions producing the creativity originally. In public institutions, policy entrepreneurs and governments take up issues where post-automation activity suggests promising policy potential. The right to repair is an example, as are turns to smart citizenship in digital urbanism.

Post-automation protagonists have to become politically adept at working to their advantage whatever institutional openings and resources become available. For example, when training, entrepreneurship and innovation programmes periodically turn to concerns for social inclusion or responsible innovation, so some post-automation initiatives will become of interest and can attract institutional attention. At best, institutional invitations win temporary support for limited possibilities. They tend not to change the social conditions for post-automation more generally. Institutions bend post-automation creativity towards their own agendas. Indeed, those agendas can include capital accumulation, labour productivity and managerial control.

6.2. Social movement politics

Politics at this second site is about forging alliances with social movements whose values, demands and repertoires of activity are mutually supportive. Common cause is made in mobilising for social changes that are simultaneously helped by post-automation and supportive towards its further expansion. An example is social movements working with data cooperatives in order to produce and disseminate data that best represents the interests, experiences and identities of the movement on its terms, compared to distortions or absences in official or commercial data. Health movements, anti-racist movements, worker movements, environment movements and others engage increasingly in this politics of digital representation. Similarly, movements trying to decolonize their territory may use mapping capabilities to emphasise and defend features absent from institutional maps. Another example is neighbourhood movements reclaiming public spaces through the manufacture of street furniture in makerspaces. Under these conditions post-automation capabilities are expanded by becoming useful additions to the repertoires of action of social movements.

Post-automation can also become emblematic for social movements contesting injustices specific to automation. Post-automation provides useful infrastructure for mobilising alternatives around algorithmic justice, smart citizenship, data commons, platform cooperativism, or rights to repair. More broadly, in societies where state and economic power is reinforced through technology, so movements contesting power effectively challenge its technologies too. Pressure builds for alternative approaches in technology.[1] Mobilisations for climate, decolonization, just transitions, labour rights, postgrowth, feminism, anti-racism, LGBTQ+, rights to the city, and so forth can and do trouble the institutions for innovation in society by contesting the prevailing culture. Institutionalised assumptions, priorities, and criteria in innovation become drawn into struggles for social change. The politics of post-automation in institutions thereby opens to its politics in social movements.

6.3. Political economy

Innovation in society is understood and promoted within a growth-dependent political economy in which capital accumulation, labour productivity, and managerial control are paramount (Pansera & Fressoli, 2020). This political economy underpins automation. It is less conducive for post-automation. Building agency in technology politics at this site is challenging because struggles are filtered through structural relations between capital, labour and ecologies, for example, or the role of the state in society and prevailing ideologies.

Practising technology as a common good, for example, is difficult when economic systems invest in technologies for exclusively private utility potentials and as a source of competitive advantage. Political and economic institutions that prioritise a market-based scaling-up of social innovations provide much more limited opportunities for creative activities whose motivating social value is rooted in the local scale. Developing durable, repairable and well-maintained systems is hard when political economy sees long-term care as an unwelcome operating cost or impediment to the profitable turnover of future novelties. Entrepreneurial states in a global race to catch-up with the universal techno-economic frontier are unlikely to devote serious attention to decolonizing technologies. Nor will ecomodernist controls over nature be so open to convivial technologies seeking relations of care in natures.

Informal institutions conducive to post-automation already consolidate its circulation within the industrious space. Norms and routines for commoning, for example, are developing in areas like design, code, instruction, data, and infrastructures. The open and collaborative ethos in social entrepreneurship draws upon the hacker ethic, which now surpasses the social base of the latter by becoming much more widely practised. Alignments with social movements help circulate post-automation further. But can post-automation become transformational in society more generally? What might a political economy for post-automation look like? These questions appear reasonable but might be somewhat misconceived. They anticipate political economies rebuilt purposefully around post-automation. For sure, FALC anticipates a communist political economy built upon the technologically-determined forces of automation. But post-automation is conceived differently. It offers potentially helpful capabilities for addressing more specific contradictions and accompanying changes in political economy, but not necessarily driving any of those changes.

More likely is that political pressure builds in issues where post-automation is relevant, like a future for dignified work, or postgrowth economies, and where politicians might eventually focus their campaigns. Those calling for structural change may have little time for the details of technology politics, or they may perceive technology as little more than a problematic 'fix' rather than understanding it as important terrain for consolidating the changes being sought. But if those struggling to transform political economy are to find agency in the future, then they need to counter spurious and beguiling technological determinism. Future essentialism plays a powerful role in modern society. Unsettling such essentialism, and loosening the reinforcing work it does for political economy, needs a politics of technology. Big structural issues - like dignified work, equitable prosperity, economic ownership, sustainable wellbeing, convivial communities, and healthy ecologies – needs a democratic politics that includes technology, rather than having the parameters for democratic politics ostensibly determined by technology. Post-automation demonstrates such political agency is possible; not least by releasing the powerful grip automation has upon our social imagination. Perhaps the political economic case specific to post-automation here is that it should become public infrastructure for democratising technology.

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[1] FALC calls for alliances with social movements as part of its counter-hegemonic strategy. Automation will have to appeal to social movements, who must identify the realisation of their goals with such future essentialism.

7. Conclusions

Future essentialism in technology politics is most pernicious when its effectively automates our futures. We need a more complex, diverse, and open approach to technology and its politics than that conceived in programmes for automation. This period of global crises should be a moment when automation's foundations for total control, limitless productivity, and insatiable material accumulation are reconsidered not redoubled. There is nothing automatic about automation. Its construction in complex societies means it is unlikely to be fully implemented nor fully in control. More democratic foundations for technology are required.

The central argument in this essay has been that capabilities relevant for more democratic futures in technology are cultivated across the multiple sites and networks of an emerging industrious space. Capabilities that we call post-automation. Post-automation enables versatile approaches to embedding technology systems appropriately in places by embodying their contexts sensitively into technology development; in which human creativity is central and based in open collaboration with others (including non-humans); and where commons-based approaches towards technology permit greater ecological durability and more dignified work for people. Post-automation is more open to the socially complex, uncertain, and diversely situated tasks of negotiating convivial social and ecological relations through technologies.

The industrious space is where post-automation finds its agency currently. The capabilities developing there are both subversive and constructive: they simultaneously challenge the foundations of automation and provide infrastructure for material deliberations about alternatives. The politics of post-automation is the struggle to expand the circulation of its capabilities beyond the industrious space. First, through articulations with opportunities arising in existing innovation institutions in society. Second, through alliances with social movements seeking mutually conducive social changes. And third, by bringing technology politics into the mass politics needed for structural changes in political economy. Only then can any potential in post-automation be developed in full.

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