Automation and the future of work: A social shaping of technology approach

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Automation and the future of work: A social shaping of technology approach

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Abstract

Recent years have seen enormous attention paid to automation and its potential implications for the future of work. This study rejects unhelpful speculation and, instead, poses the question 'what is shaping automation and its predicted effects?' In contrast to the technological determinism framing much of the current debate, this study utilises the social shaping of technology (SST) approach, a theoretically informed body of research largely overlooked by sociology of work scholars. Compared with mainstream commentary, which treats technology as separate from the social world, SST facilitates examination of how the development and use of technology are shaped by broader socioeconomic concerns and politics. The analysis presented is based on an understanding of how technology is shaped by existing technology, economics, social relations, gender and the state.

KEYWORDS
AI, automation, fourth industrial revolution, future of work, robots, social shaping of technology, technology

INTRODUCTION

Much commentary is devoted to the inexorable 'rise of the robots' (Ford, 2015) and the inescapable effects of automation on the future of work (Susskind, 2020), a discourse of 'the inevitable' (Kelly, 2016). The contemporary zeitgeist is dominated by images of anthropomorphised robots executing complex tasks and eliminating the need for human labour. Speculative predictions emerge in statistical studies (Frey & Osborne, 2017), with others declaring the end of work (e.g., Mason, 2015). Neglecting contingency and context, variance in labour market, job categories, tasks, skills and divisions of labour, a relentless determination to quantify social and economic change is identified (Morgan, 2019). Integral to these narratives is conjecture, that 'big bang' automation is imminent. If jobs or tasks can be automated then they will be, technology adoption is unstoppable and even unproblematic and wholesale job displacement inevitable. The sense of impending system-wide transformation is captured in the articulation of a paradigm shift, whether a Second Machine Age (Brynjolfsson & McAfee, 2014), a Fourth Industrial Revolution (Schwab, 2016), a 'fifth wave' (Mason, 2015), or a 'third disruption' historically comparable to the Neolithic and industrial revolutions (Bastani, 2019). Accordingly, widespread agreement prevails that the worlds of work and employment stand on the brink of a technologically driven seismic shift.

Considerations of automation during the 1930s, 1960s and 1980s were each accompanied by predictions of a fundamental transformation of work (Cherry, 2020), ranging from an optimistic alleviation of mundane and strenuous labour to pessimistic expectations of wholesale unemployment. There is a rich historical material that highlights the tensions arising from the question of what shapes automation and the future of work (see, e.g., Keynes, 1930; Turing, 1950; Toffler, 1970), debates that are far from settled. Disputation is reiterated today, as scholars hypothesise as to whether or not 'this time is different' (see Balsmeier and Woerter, 2019; Marengo, 2019).

Predicting paradigmatic change has become a big business, especially evident in contemporary debates on the impact of new technologies on the future of work (Sturdy & Morgan, 2018). Over recent decades, increasing numbers of analysts have engaged in projections regarding information technology's consequences, many of which turned out to be mistaken (Pollock & Williams, 2015). For example, the dot.com bubble of the late 1990s engendered 'speculation contagion', in which media commentary, consulting organisations, think tanks and economic modellers made inflated claims regarding inevitable expansion of the technologically driven 'new economy'. The National Association of Securities Dealers Automated Quotations crash in 2001 revealed that technology could not be relied on to secure an economic future of continued expansion (Peck, 2005). The present era reprises such 'cultural circuits of capital', in Thrift's (2001) term, although today's retread (Cherry, 2020) is distinctively reframed around robotics innovation, big data and Artificial Intelligence (AI). Legitimation is achieved as diverse speculative actors provide the 'motivational fuel' (Thrift, 2001) for constructing new visions, or paradigms, of capitalism. Concomitantly, a clutch of academics have achieved prominence, their headline, often millenarian, claims provoking controversy (e.g., Frey & Osborne, 2017; Susskind, 2020). Growing academic interest is evidenced by data from the AI Index Report (Perrault et al., 2019), demonstrating that the volume of peer-reviewed AI papers increased by over 300% between 1998 and 2018, in telling juxtaposition to the material fact that the share of AI jobs represented a mere 0.8% of US employment by 2019.

Of significant concern is the resurgence of a technological determinism that pervades future of work debates (Howcroft & Taylor, 2014). It is premised on the assumption that technology is an autonomous entity, with its own 'inner logic' that drives its adoption and direction. Societal development and social change are seen as determined by technology (Williams & Edge, 1996). Technology is often presented as a homogenous group of innovation and artefacts, so that the often quite different properties of emergent technologies—robotisation, AI, big data, three-dimensional printing and cloud technology—are bundled into a composite, which betokens a preordained future. Failure to analyse the distinctiveness of specific technologies and their differential impacts risks exaggeration, overgeneralisation and flawed prediction (Noble, 1977, 19).

Prophesies frequently take a binary Utopian or dystopian form. 'Tech Utopians' (notably Bastani, 2019; Mason, 2015; Srnicek & Williams, 2015) regard automation as delivering a postcapitalist society culminating in liberation from work and a commensurate expansion of leisure time. Dystopian perspectives, mostly concerned with automation's ability to polarise labour markets and eradicate 'susceptible' lower-skilled jobs, have focussed additionally on threats to the highly skilled and highly paid. Professionals, hitherto regarded as impervious to technological change in accountancy, law, health and architecture are now considered vulnerable to 'increasingly capable machines', which can routinise high-skilled work using large webs of interrelated rules (Susskind & Susskind, 2015).

The causal simplicity of predictions linking technological innovation to labour market transformation oversimplifies sociotechnical change and the emphasis on predicted 'effects' is problematic. First, the assumption is that technology exists beyond the realm of values, beliefs and interests, and thus from the social world within which it resides, and assigns a blameless, agency-free inevitability to technology-driven change. The belief that technology possesses an intrinsic momentum sustains the narrative of a jobless future and presupposes the futility of resistance and the absence of alternatives. Second, quantitative increases in technology, indicated by extending computer networks, exponential growth in computing capacity and the adoption of robotics, are leveraged to posit an emerging qualitatively different society. These developments are seen to reflect progression towards 'technological singularity', whereby ultra-intelligent machines surpass human intellectual activity (see Upchurch, 2016, for a critique). The conflation of quite divergent technologies into some form of looming 'big bang' automation neglects the ways in which sociotechnical change is complex, non-linear, contingent and unpredictable (Russell & Williams, 2002). This naïve logic fails to acknowledge the complexities and contradictions of technology adoption and the obvious but telling objection of the frequent failure of predicted outcomes to be realised. Finally, as historical precedent indicates, a 'technological fix' can be transitory, as technology should not be endowed with powers it does not and cannot possess (Harvey, 2017).

In contrast to the prevailing tendency to regard technology as an autonomous driver of socioeconomic transformation, this study argues for a deeper understanding by posing the question 'what is shaping automation and its predicted effects?' This question is addressed through adopting a social shaping of technology perspective (SST), a theoretical approach that originated in 1985 with the eponymous reader (Mackenzie & Wajcman, 1985) imbued with Marxist and feminist influences, and whose main aim was to understand technological change as a social process. Accordingly, this study responds to the call for 'new connections' between SST and the sociology of work (Wajcman, 2006) through a novel contribution, a critical analysis of automation and the future of work, building on the work of inter alia Spencer (2018) and Morgan (2019), while engaging theoretically with SST. In challenging the dominant narrative

that assumes AI and robotisation will inevitably and fundamentally reconfigure the world of work and employment, this study concentrates on how profoundly technology is socially shaped.

WHAT SHAPES TECHNOLOGY?

Aside from a common opposition to technological determinism, there is no agreed definition of what constitutes an SST approach (Russell & Williams, 2002), which has been described as a 'broad church' (Williams & Edge, 1996), encapsulating diverse disciplines and intellectual origins. This array of perspectives has given rise to areas of disputation, reflecting epistemological and ontological disagreements. Although there remains no clear SST orthodoxy, an emerging consensus is committed to opening up the black box of technology to social and political analysis by interrogating both the content of technologies and the processes of innovation.

Although SST theorists reject the simple causality of technological determinism, they acknowledge that it contains a partial truth: technology matters (Mackenzie & Wajcman, 1999, p. 3). The metaphor of 'shaping' rather than 'social construction' was intentionally selected to reflect the materiality of technology (Mackenzie & Wajcman, 1999). SST not only critiques technological determinism, but also 'social determinism' (Marx & Smith, 1994), which assumes that the ways in which society uses technology are of sole concern, rather than the technology itself. SST scholars argue that rather than reducing everything to the interplay of social forces, the material power and properties of technical objects deserve attention. Technological things, in themselves have political properties, as they embody particular forms of power and authority as well as 'ways of building order in our world' (Winner, 1985, p. 30). Winner compares technological innovations with regulation or political institutions, as they also influence how people work, communicate and consume over time: to choose a particular kind of technology is to choose a particular form of political life (ibid:31). Although technological determinists maintain that the most optimal technology will triumph, perceptions of what constitutes the 'best' technology often depends on structural positioning, with labour and capital likely to have conflicting accounts of what is technically desirable. For SST scholars, technology is not neutral and the inherent determinism serves an ideological function, obscuring the class interests of those who benefit from technological change (Russell & Williams, 2002; A. Taylor, 2018).

In social science, there has been an 'artificial gulf' (Williams & Edge, 1996, p. 893) between the social and the technical, with the former often perceived as 'external factors' and the latter seen in the form of equipment and tools. SST rests on the proposition that technology and society are mutually constitutive, rather than separate spheres (Mackenzie & Wajcman, 1999). They influence each other interdependently and in multifaceted ways, rather than linearly. This perspective contends that the social shapes the technical and, reciprocally, the technical shapes the social (Mackenzie & Wajcman, 1985), as each evolves in relation to the other. Likewise, technology and work organisation are mutually constitutive, yet many traditional conceptions treat them as separate categories. Technologies are in part prefigured by existing forms of work organisation and embody divisions of labour and expertise, whereas technological change is frequently motivated by the intention to develop and transform work organisation.

The remainder of this study interrogates the debate on how technology is perceived to transform the future of work, engaging with the theoretical framework of SST and its principle

themes, by which technology is shaped—by existing technology, economics, social relations, gender and the state.

Existing technology

When unravelling the processes of technological innovation, SST scholars maintain that existing technology is an important precondition of new technology, providing the foundation on which existing devices and techniques are modified. It has been argued that there is an inevitability to technological innovation, particularly when the component technologies and necessary contextual conditions are in place. The iPhone is an exemplar, launched in 2007 and aggressively marketed as a 'game changer' in the mobile handset market. This smartphone was based on the existing multichannel platform created for the iPod and iTMS in 2003, which consolidated the practice of hardware and software integration into a substantial revenue generator for Apple (Montgomerie & Roscoe, 2013). The iPhone illustrates how existing technology serves as an important precondition as its scope is incrementally extended into new areas, yet that new device is also defined by the installed base of related products. Existing technology has the capacity to constrain given the way it may consolidate earlier achievements, creating path dependency and lock-in, which continues to bear influence (Mackenzie & Wajcman, 1985). Scholarship on the challenges of integrating new technologies with often dated legacy systems (e.g., Light & Wagner, 2006) highlights the problems of multiple system assimilation, potentially heightened as robotics and AI are introduced to augment existing systems.

SST analysis goes further, demonstrating that existing technology is not merely a precondition of new technology, but actively shapes its development. The concept of 'technological system', based on Hughes' (1987) studies of large technological systems, is pertinent to current debates on automation, showing that technologies rarely function as separate, isolated devices, but elements of an integrated whole, which encompasses technical artefacts, institutions and the environment, straddling technical, social, economic and political dimensions. The necessity to integrate into wider systems imposes major constraints on the design and development of new technologies. For example, his study of Edison's invention of the light bulb demonstrates how requirements of the electricity generation and distribution system are embedded within the bulb's design. Elements of technological systems continually interact and are vulnerable to systemic changes, so that when the characteristics of one component change (e.g., regulation, labour markets), others may be impacted. Creators of technological systems strive to increase the size of the system and reduce the influence of external elements, which lie beyond their control (Hughes, 1987), hence the desire to eliminate alternative systems. As systems mature, they acquire momentum, as the integration of vested interests, sunk costs and assets facilitate system durability. This powerful path-dependency, which emerges over time, is not necessarily the result of outstanding technical efficiency, but rather the combination of contingent circumstances with institutional interests that favour one technology over another (Mackenzie & Wajcman, 1999, pp. 19–21).

That contemporary technologies are increasingly systemic in character can be seen in the cases of big tech firms. Some of the most highly capitalised enterprises are digital platform firms (Ekbia & Nardi, 2017; Rahman & Thelen, 2019), which have created novel ways to create and capture value, mainly centred on their ability to monetise vast amounts of data as intermediaries controlling multisided market flows. Many of these corporations strive to build

monopoly power and eliminate competitors (Mazzucato, 2018) based on a mode of organising similar to the ways in which utilities function, as they strive to build infrastructural power (Srnicek, 2017; Van Dijk, 2020). This development centres on direct ownership of technology and data extraction, as opposed to labour control, although it becomes an outcome of emergent systems. These large technological systems are producing a networked mode of market dominance leading to the creation of indispensable infrastructures by, and in the interests of, the few.

Uber, whose digital platform is underpinned by AI, offers a telling illustration of how a firm builds what Hughes (1987) would classify as a large technological system. Its growth is depicted as inexorable, its business model a force of 'disruptive innovation', capable of displacing incumbents and transforming transportation (Cohen & Kietzmann, 2014). Uber self-identifies as a technology intermediary, rather than a network transportation firm, whose primary objective is 'advancing mobility with AI' (Uber, 2022). Network effects enable it to scale geometrically, recruiting 'off-the-books' workforces of 'partner drivers'. Comparatively lower fares, subsidised by injections of venture capital, help fuel expansion and remove nascent competitive systems, destroying market alternatives and creating occupational uncertainty for many traditional taxi drivers (Rahman & Thelen, 2019; Reid-Musson & Bartel, 2020). Uber presents money-making opportunities for venture capital based on ability to scale at speed and on long-term prospects for capital growth, rather than immediate profit (Isaac, 2019, pp. 64–72; Uber, 2019, p. 1). As an asset-less company, Uber prioritised investment in 'proprietary marketplace, routing and payments technologies', in order to benefit from functionality at scale with GPS smartphone technology, electronic payments and an algorithmic decision engine (Uber, 2019, p. 8). Data extraction from its 91 million monthly active customers (Uber, 2019) provides the foundation on which other services and products are created. This expanding infrastructure underlines its ambitions to become a global logistics company, embracing autonomous vehicles and branching into food delivery markets in competition with rivals like JustEat (Uber, 2019, p. 26). Although this appears a tale of inexorable growth, Hughes' (1987) research serves as a reminder of how the need for wider system integration imposes constraints and exposes vulnerabilities. In the case of Uber, regulatory constrictions, such as the landmark UK Supreme Court ruling on worker status, are beginning to encroach, leading some to question the viability of its economic future (Venkataramakrishnan & Croft, 2021).

Economics

Economic shaping is one of the most salient features of SST (Williams & Edge, 1996), because technological reasoning and economic reasoning are assumed to be inseparable (Mackenzie & Wajcman, 1999). Economics drives the fetishistic belief in technical fixes and has led to the widespread conviction that technology can solve problems of crisis capitalism (Harvey, 2017). The impact of the 2008 financial crisis and 'Great Recession' (Roberts, 2016) enhanced the lure of automation and the implicit causality that it will foster long-term economic growth, satisfying capital's desire for perpetual accumulation (Mazzucato, 2018; Rosenberg, 1976). Comparisons are made with the Industrial Revolution, which mainstream economists view as capitalism's historical triumph spearheaded by mechanisation, when, in reality, economic expansion depended not so much on technology, but on the mobilisation of labour on an unprecedented scale, the physical adaptability of the workforce, extensification of work and new forms of work discipline (Samuel, 1977). In today's macro-economic context, intensified

competition and weak productivity levels threaten individual capitals. In search of a solution, machines are resurrected as the answer to the productivity puzzle, notwithstanding compelling evidence that technology per se does not inevitably determine capitalist growth.

Economists diverge in their predictions concerning the impact of automation on workforces. While most early studies predicted cataclysmic job loss (e.g., Frey & Osborne, 2017), these prognoses have been contested. Autor (2015) rejoinder insists that while some jobs will disappear, new ones will emerge. Acemoglu and Restrepo (2019), meanwhile, maintain that tasks within jobs may be automated as opposed to entire job categories. What unites these disjointed and contending narratives is that they are premised on hypotheticals. Problematically, what purports to be reliable forecasting is bolstered by the apparent authority of quantification (Morgan, 2019), which, in asserting the certainty of a mapped-out future, acts teleologically as prescription for change.

Aside from the inescapable problematic of forecasting the future, a theoretical difficulty must be acknowledged as a central contradiction of capitalism cannot be resolved by the utilisation of robots (Roberts, 2016). Underpinning arguments in this study are essential propositions drawn from Marxist analysis. Technology of all kinds, the 'new, new technologies' (Howcroft & Taylor, 2014), whether AI, automation, machine learning, platforms or robotic process automation (RPA) are all products of previous labour and, thus, to use Marx's term from Capital Volume 1 are 'dead labour'. Space constraints prohibit a full theoretical exposition of this central element in Marxist analysis (see Choonara, 2017, pp. 27–31 for an effective summary). Essentially, dead labour is animated by living labour and contributes to the final value of commodity. Marx identified a central contradiction as lying in the organic composition of capital, the ratio between constant capital, representing all means of production, machinery and raw materials (dead labour), and variable capital or human living labour.

Clearly, any increase in the 'ocial productivity of labour' instigated by the introduction of new technology (congealed dead labour) to the production process promises a fuller realisation of the potential of capitalist production, through cheapening costs, increasing productivity and, ordinarily, labour shedding. The drive to improve efficiency leads to the expulsion of living labour from the production process relative to dead labour. If living labour is the source of surplus value, a central Marxist proposition, then technological innovation and increasing utilisation undermine the very source of valorisation, human labour. For Marx (1991), this is the basis of what he declared to be 'the most important law of modern political economy', namely 'the law of the tendency of the rate of profit to fall'.

Roberts (2015) provides concrete contemporary examples. Industrial robotics have the potential to change manufacturing by increasing precision and productivity without incurring higher costs, and the much-heralded 'Internet of Things' offers possibilities for connecting machines and equipment to each other and to common networks, allowing manufacturing facilities to be fully monitored and operated remotely. New technology may replace labour but over time, a capital-bias or labour shedding means less new value is created (as labour is the only form of value) relative to the cost of invested capital. Moreover, whatever cheapening costs and productivity gains leading to high prices and profits may benefit the innovating individual firm in the short-term, when others emulate or innovate further, that advantage is lost as competition forces prices down generally. So, for example, if one banking corporation leads in implementing RPA it gains only temporarily as others then follow and perhaps even surpass it in technological innovation that ultimately contributes to falling profits rates. Thus, robots and automation, although offering short-term increases in productivity cannot transcend the contradictions of capital accumulation.

SST contests the dominant assumptions of neoclassical economics, whereby firms are believed to choose the technology most appropriate for accumulation (Mackenzie & Wajcman, 1999). This apparent simplicity is confounded by the limited progress made by mainstream economics in analysing technological change, which neglects contingency, the concrete conditions under which capital considers technological potential in the context of capital accumulation, the circuits of capital and, specifically, the imperatives of cost reduction and profit maximisation. Hence, we see firms' preoccupation with expected return on investment, even when the automation of jobs and tasks is feasible. Research suggests that robotics can deliver large returns, with repayment periods of 2–18 months, yet robots have not been adopted as widely as anticipated (Graetz & Michaels, 2018). Only 10% of US companies that could benefit from robots, have opted to capitalise (Frey & Osborne, 2017). Similar limitation is discernible in the worldwide shipments of industrial robotics, having grown by a mere 1% in 2017–2018 (IFR, 2019). Although such modest global exchange might be a manifestation of 'slowbalisation', declining volumes of international trade, investment and technology (The Economist, 2019), the trend simply underscores the significance of macro-economic factors constraining the inexorable march of technological adoption as the dominant narrative avers.

SST maintains that labour costs are vital to economic decision-making, as they provide the justification for investment in new technology (Mackenzie & Wajcman, 1999). The decision of whether or not to automate work is based ultimately on cost comparisons between human labour and machines, by which capital outlay associated with automation must fall sufficiently relative to labour for investment to occur. Yet, with technological innovation, outcomes simply cannot be known in advance, so future costs and profits are guesstimates. Uncertainty leads firms to seek yields from rent-seeking activities that promise immediate returns, such as the intensification of labour or reconfiguration of the labour process, rather than necessarily longer-term investment (Cushen & Thompson, 2016). In the giant e-commerce warehouses, robots might be expensive compared to human labour which, crucially, remains extraordinarily cheap (Briken & Taylor, 2018). Consistent with other countries, a decade-long decline in real wages in the UK (TUC, 2018) is identified as significantly contributing to modest technology adoption (Lloyd & Payne, 2019).

Much hype surrounding the future of work is based on assumptions that technology obviates the need for labour and will radically transform labour markets. Rather than being preoccupied with prediction, it is worth exploring extant research that considers the consequences of new technologies on labour markets. Lost amidst forecasts of a post-work future is a 'rather large elephant in the room' in that pre-Covid, countries were experiencing comparatively low unemployment rates (Fleming, 2019), as opposed to a labour displacing technological boom (Thompson, 2019). The size of US and UK labour forces hit historic highs of 164.6 million in February 2020 (USBLS, 2020) and 32.98 million in November 2019 (ONS, 2020), respectively. Further, analysis of occupational trends (Spencer & Slater, 2020; Thompson, 2019, pp. 304–306) reinforces scepticism regarding the medium-term impact of automation. One longitudinal study examining the impact of automation on US occupations concludes that computer use is not associated with a reduction in overall employment (Bessen, 2016), notwithstanding variable job loss for specific occupations. Digitalisation has negatively affected those in low-skilled, low-wage jobs and led to job losses (Graetz & Michaels, 2018), while creating net gains in well-paid jobs, implying a redistribution of labour across occupations and associated growth in wage inequality.

A related presumption, whether Utopian or dystopian in intent, is that repetitive routinized, tasks will be displaced by automated processes (Holtgrewe, 2014), shedding the economic costs associated with low-cost labour. European research investigating computerisation's effects (1995–2015) demonstrates that Information and Communication Technology's (ICTs) have tended to replace routine tasks, while complementing (or not affecting) creative and social tasks (Lewney et al., 2019). Of the remaining tasks and occupations, digitalisation has led to significant increases in repetitiveness and standardisation, usually by recourse to online or automated processes, which sit alongside lower-paid, lower-quality jobs. Rather than technology liberating workers from 'grunt work', automation poses a far greater threat to the quality than the quantity of work (Spencer, 2018), as deskilling weakens the power deriving from nonreplicable skills (Harvey, 2017). Mass computerisation has coincided with the 'ravages of neoliberal capitalism' (Upchurch, 2018, p. 208) and an impressive body of UK research (e.g., Green, 2006; McGovern et al., 2007) convincingly demonstrates that computer-led technological change, intertwined with organisational change, have led not to job displacement but work intensification. Disciplinary performance management systems (P. Taylor, 2013), imbricated by digital metrics, were exacerbated by economic crisis that did not produce catastrophic job loss. Thus, the relationship between computers and humans is not determined by technological capabilities, but by the priorities and strategies of organisations that own and operate them. The obligation for workers to commit ever-greater effort, 'having to meet tight deadlines, operate at high speeds or just generally work intensively' (Green et al., 2018) remain dominating imperatives.

The evidential void beneath grand theorising is revealed when 'actually existing capital, technology and labour' (Thompson, 2019), in which automated technologies exist, is examined. Call/contact centres are a pertinent example, particularly because of the centrality of ICTs to its architecture. More than two decades ago, consultants' predictions (Taylor & Bain, 2003, p. 1) that automation, the rise of the internet and self-service would decimate employment, were widely accepted. Although global expansion of employment (P. Taylor, 2015) confounded this baleful determinism, AI and machine learning have resuscitated job-displacement prophecies. Yet, despite great interest in AI and promised but often unrealised investment, 'the proportion of telephony self-service remains stubbornly low (5%), despite expectations of its future use' (Contact Babel, 2020, p. 43). Two-thirds of customer contact still requires live voice communication, with 28% involving agent interaction (email, web chat, SMS, post). 'Significant inhibitors', not least cost, thwart the implementation of Automatic Speech Recognition. Chatbots that simulate conversation, the most obvious manifestation of AI, do not obviate agency, but 'for the foreseeable future...will work alongside human colleagues' (op cit: 84).

Although much of the automation debate among economists' centres on whether the rate of displacement exceeds the rate of replacement—which remains speculative—less attention is paid to how diffusion of new technologies inevitably opens a Pandora's Box of externalities and unintended consequences (Orlikowski & Robey, 1991). As capabilities expand and more powerful digital tools become available, increasing volumes of work occur rather than obsolescence (Willcocks, 2019). Technology has the tendency to add to the quantity of work, evident in the dramatic expansion of digital data, and the growth in auditing, regulation and bureaucracy, and in unanticipated effects such as cybersecurity, data storage and privacy concerns. The ways that new technologies create additional labour demands becomes apparent in ostensibly automated systems, which rely on adjunct, deliberately concealed, human labour in order to function. Gray and Suri (2019) neatly capture the concept of 'ghost work' to describe how on-demand labour forms a shadow, poorly paid workforce, which is employed on a

piecework basis to intervene to repair glitches that automated tools are unable to solve, ensuring that mobile phone apps, websites and AI applications work effectively. The performance of such labour 'make(s) the internet seem smart'.

Technology, economics and social relations

SST challenges the belief that economic calculations are universal, arguing that they are peculiar to, and the result of, particular forms of social relations (Mackenzie & Wajcman, 1985; Noble, 1985). Economic considerations remain a mechanism of social shaping, as cost is not universal, but is mutable and affected by the ways in which society is organised. These variable considerations are unable to impose a single logic on technological innovation, which is made manifest in distinct social and institutional circumstances and settings (Russell & Williams, 2002). Consequently, innovation is historically contingent and the ways in which technology is shaped by economic considerations differ (Ekbia & Nardi, 2017).

SST scholars argue that social relations affect technological change through the ways in which they shape the framework of market calculation (Mackenzie & Wajcman, 1985). In contradistinction to simplistic assumptions that jobs characterised by routine cognitive or manual processes can be substituted by robots, capital's willingness to invest in labour-saving technology reflects the ways society is organised. It follows that technology adoption may be more constrained in industries dependant on cheap labour where supply is abundant. Compare, for example, the rapid uptake of robotisation in auto manufacturing with limited technology adoption in garment manufacture. According to the International Federation of Robotics (2019), the automotive industry is the largest user of industrial robots, an industry with relatively high-paid, male-dominated, unionised labour. In contrast, textile work, traditionally carried out by women who sew for low wages, either as migrants in Western countries or in the global South, such as Cambodia and Vietnam, is largely bypassed by technological innovation (ILO, 2016). Aversion to automation exists when the labour force is low-cost and nonunionised. As Marx observed, technology can only be understood in the context of the totality of relations that constitute a capitalist social formation: there is no prime mover (Harvey, 2017).

Understanding the process of accumulation requires appreciating capital's attempts to control and shape the labour process, rather than inducing the fantasy that the worker is 'a mere appendage of the circulation of capital' (Harvey, 2003, p. 12). Capital faces the perennial problem of overcoming labour indeterminacy, which is particularly taxing when the labour process is akin to an 'art form' and reliant on skills, craft and tacit knowledge (Braverman, 1974). Hence, the system-wide impulse to deskill, fragment and routinise, preferably under the domination of machines: 'capitalism has a technology that cannot abide mysteries' (Harvey, 2017, p. 118). Moreover, capital commissions new technology not only to minimise labour costs, but also to reduce dependency on human labour and to divide and disorganise (Cockburn, 1985; Wajcman, 2011). History abounds with instances where technologies were implemented regardless of immediate cost and profit concerns, since the key objective was to diminish labour autonomy and enhance managerial control. Consider Winner's (1985) example of 19th century mechanisation in Chicago, where McCormick's reaper manufacturing introduced expensive pneumatic moulding machines, coinciding with an offensive against the plant's workforce and the National Union of Iron Molders. New machinery, operated by lower-skilled workers, produced inferior castings at higher cost and

was eventually abandoned. Yet, from the perspective of capital, the process of deskilling had achieved the intended objective of union destruction.

As Noble (1977, 1984) points out, technological choices can only be analysed by attending to the conflictual relations of production within which automation takes place. A contemporary example concerns the Fight for $15 movement in the US, a union-backed initiative, which led to closures of McDonalds outlets as fast-food workers struck for a liveable wage (Ashby, 2017). Given the primacy of economic relations, the assumption is that low-cost labour in sectors such as hospitality and care work, is relatively immune to automation. However, as this dispute shows, the response of fast-food corporations was to claim that higher pay would bankrupt the sector and cause automation and job cuts. Indeed, McDonalds implemented a rollout of touchscreen self-service kiosks, shedding some frontline workers (A. Taylor, 2018). These cases illustrate the conflict within labour–capital relations, as the social relations of production lead to the adoption of particular forms of automation, aimed at suppressing collective worker action (Harvey, 2017). Technologies of production emerge as a result of class relations: 'behind the technology that affects social relations lie the very same social relations' (Noble, 1985, p. 109).

Gender

SST scholars remind us that technologies are not neutral, but 'crystallisations of society' (Wajcman, 2018, p. 4), which bear the imprint of the social context from which they derive and thus reinforce inequalities and forms of discrimination. Some early approaches of SST, which examined technology design and development, focused on the male 'heroic' actors who dominated these processes, neglecting women's role in the production and consumption of technologies (Wajcman, 2000). Feminist researchers, such as Cockburn (1985), raised questions concerning how the gendered nature of society influences technology development and how the gendered divisions of labour in the production and consumption of technology are also reflected in the form of technologies. Explaining the influence of broader social structures—which results in some groups being excluded or marginalised—enables a better understanding of the mutual shaping of gender and technology.

Questions concerning inequalities rarely feature in debates on the future of work (Howcroft & Rubery, 2019), which reflect a limited meaningful engagement with gender. The exceptions consist largely of estimates of job losses for female and male employees from automation, which mirror variant predictions of wider job losses, only this time accounting for gender differences. For example, the Ghosh (2015) maintains that automation will heavily disrupt certain job families, with the largest share of female employees, such as office and administrative roles, being affected. Conversely, a PwC (2018) forecasts that automation will impact more male jobs (35%) than female jobs (26%). If the process of technological change is integral to the renegotiation of unequal power relations, plans for automation built on current models of working are likely to exacerbate unequal social relations, given the segregated nature of the current workforce (Rubery, 2015).

Technical expertise has long been associated with masculinity (Cockburn, 1985; Wajcman, 1991) and research on gender and technology has largely been directed to the systematic exclusion of women from science, technology and engineering occupations. Although diversity is of representational concern, this extends to how technology and its design mirrors the world of those who create them and is embedded with processes and scripts that aim to enforce

intended patterns of use (Winner, 1985). Consequently, the material representation of technical systems reflects the enduring segregation of under-represented groups in technology occupations. This leads Yarger et al. (2020, p. 3) to pose the question: 'If diverse people across racial, ethnic, gender, sexual identities and socioeconomic backgrounds are absent from the information technology workforce that is designing and developing AI systems, how well will the software foster inclusion and equity?' The ICT sector represents an area of absolute growth in the UK (Spencer & Slater 2020; Thompson, 2019), yet female participation is declining and women tend to be concentrated in lower-paid jobs (WISE, 2017). Work practices likened to frat house cultures and labelled 'Brotopia' (Chang, 2018), prompt many women and people of colour to exit hostile environments shortly after appointment, creating a revolving door of employees. This dynamic is evident in numerous discrimination and sexual harassment cases in Silicon Valley, such as the \$10 m class action payment from Uber, compensating 285 women and 135 men of colour for financial and emotional harm (Isaac, 2019).

The original focus of SST research on gender can be extended to include intersectional inequalities. One relevant area attracting attention is AI bias and the 'hunt for scientific fairness' (Powles & Nissenbaum, 2018) as opaque mathematical models are applied to various aspects of our lives, reinforcing discrimination and augmenting inequalities. An emerging literature examines recruitment practices and highlights 'dataset bias', as people from diverse cultural backgrounds are systematically disadvantaged, thereby ensuring no disruption to the homogeneity of workplaces and workforces (Yarger et al., 2020). Consequently, critical research questions the value of workforce analytics and emphasises the potential damage to employee interests (Angrave et al., 2016). Ethical concerns with bias in HR practices extend to algorithmic modelling generally, as applied in various domains, such as finance, health and platform work. Yet, computerised decision-making, built on existing data—which itself mirrors inequalities—is partial and codifies deep-seated biases. Such systems reflect ideology that is simply 'camouflaged with technology' (O'Neill, 2016, p. 25). Benjamin (2019) dubs these systems a 'New Jim Code', reproducing existing inequalities, despite perceptions that they are more progressive than erstwhile discriminatory systems. Problematically, much of this debate is premised on how best to fix AI and reduce or remove embedded inequalities, since technology is deemed perfectible, as opposed to resisting automation or considering alternatives (Powles & Nissenbaum, 2018), given the social biases implicated in the technologies.

Economics, social relations and the state

Early SST research focussed on the industrial-military complex and how it had shaped contemporary society, particularly during the post-1945 period of high spending on military technology (Mackenzie & Wajcman, 1985). Technological innovation is beset with uncertainty (Russell & Williams, 2002) and, so, historically, the state, rather than the private sector, has played a prominent role in financing and supporting technological innovation. Indeed, many state-funded military technologies were later commercialised by tech companies such as IBM, AT&T and Texas Instruments (Mazzucato, 2018), and several ubiquitous technologies derive from publicly funded infrastructures and technologies (e.g., World Wide Web development at CERN, smartphone technology, GPS). Platform firms have reaped benefits from core technologies financed by the US Department of Defense (Block & Keller 2011) and Silicon Valley, originating as a technology cluster for military purposes, is the heartland of US tech

giants (Klepper, 2010). The US government has contributed additional support to venture capital financing through tax relief policies and programmes for loans, expertise and assistance to technology-oriented firms (Wonglimpiyarat, 2006). The role of the state is largely limited to providing required resources to accelerate innovation and remove obstacles, promoting the smooth adaptation of society to technological change.

In the United States, the combination of state investment and its support of venture capital has financed a technological infrastructure on which much of the success of tech firms' has depended. The resulting dominance of the 'big five' tech companies (Alphabet-Google, Amazon, Facebook, Apple, Microsoft) leverage significant economic and social power (Peck & Phillips, 2021; Srnicek, 2017). Their model of technological and financial success serves as blueprint for other forms of technological innovation. This reverence is reflected in the financing of technology startups, which has increased substantially since 2010 (McNeil, 2016) as venture capital incentivises scaling at speed, supporting unproven firms with rapid growth potential (Langley & Leyshon 2017), enabling new ventures to quickly dominate the technology landscape. Compared with dotcoms, financial interests supporting platforms focus on the longer-term pursuit of winner-takes-all returns (Rahman & Thelen, 2019), displaying tolerance for an unprofitable present in the hope of future market domination.

The rapid ascendancy of oligopolistic technology corporations has enabled them to lay the foundations for the development of AI and robotics and to set research agendas. This is problematic as monopolisation constrains further innovation, leading to mergers and acquisitions of smaller rival firms as big tech expand their capabilities or suppress competition (McNeil, 2016), foreclosing alternative development paths. Contra Mason (2015) big tech expertise, widely held to be the exemplar of entrepreneurial innovation, has not led to the creation of horizontal networks, but to the concentration of capital and centralisation of power (Peck & Phillips, 2021; Thompson, 2019). As the state presence diminishes, the control of digital infrastructure and central information gateways by technology firms solidifies their power base and extends their economic power, which, Van Dijk (2020) argues, supersedes that of some nation states. The capacity for tech giants to dwarf the financial clout of the state can be illustrated by the United Kingdom. The influential narrative that automation will generate economic growth has prompted government initiatives targeting technology investment, pledging £950 million on an AI Sector Deal (DBEIS, 2019). Yet, the scale of state provision pales into insignificance when contrasted with that of a handful of tech giants: in 2018 alone, Alphabet, Amazon, Apple and Facebook spent $1.7 billion on AI, whereas the four biggest Chinese tech firms spent $12.8 billion (Chowdhury, 2018).

The state also potentially plays an important role in technology regulation. Growing discontent with platforms has led to a 'techlash', as disinformation, tax evasion, antitrust security leaks, privacy scandals and an undermining of employment law is seen to compromise wider social values. The power of platform firms is largely 'hidden from view' (Rahman & Thelen, 2019), which poses difficulties to those wishing to challenge it. They resist regulation, claiming to be 'disruptors' breaking new ground as evasion of supranational, national and regional regulation is eased by the patchwork of siloed frameworks, which have limited scope and reach (Van Dijk, 2020). In Western countries, despite certain advances, the failure of the state to intervene effectively has brought no systemic change. The escalation of 'permissionless innovation' (Langlois & Elmer, 2019) may be partly explained by difficulties in grasping the nature of infrastructural power, which compound weaknesses of legal frameworks. It may also stem from the dominating narrative of technological determinism, which limits the scope of public policy to predicting and monitoring technological advancement along a presumed

inevitable trajectory. Given the fiscal consequences of the 2008 Financial Crisis and the Covid-19 pandemic, state investment in technological innovation is likely to shrink, thereby augmenting the power base of big tech firms. Given their opacity, lack of accountability and regulatory arbitrage, the future looks far removed from any supposed tech-Utopia.

CONCLUSION: DÉJÀ VU ALL OVER AGAIN

This study intervenes in the future of work debate, offering a corrective to resurgent and dominant technological determinism by considering 'what is shaping automation and its predicted effects?' Adopting the theoretical framing of SST illuminates the tensions within the debate by revealing the nuances of technological development, which challenges the dominant meta-narrative that assumes the capacity of new technology to transform cannot be contested and is independent of human actors. Seductive, but methodologically flawed, quantitative projections of automation's job displacement effects, which have dictated the parameters of the debate, are ill-equipped to reveal indeterminacies and contradiction, to explore the significance of contingency and context and to provide a basis for concrete socio-political investigation.

Applying the SST framework helps to elucidate the paradoxes surrounding the future of work debate and problematise predictions. Our examination of 'actually existing capital, technology and labour' (Thompson, 2019) reveals countertendencies, which seriously under-mine the unsubstantiated claims that automation will inevitably bring labour displacement, deliver productivity gains and liberate labour from routinized work, ultimately progressing to the endpoint of technological singularity as humans are replaced by robots. The working out of capitalism's contradictions delivers unforgiving judgements on the theorisation of abstract technological possibilities. Several years have now elapsed since the spate of influential publications portending automation and system-wide job loss (Brynjolfsson & McAfee, 2014; Ford, 2015; Frey & Osborne's [2013] first iteration; Mason, 2015; Srnicek & Williams, 2015; Susskind & Susskind, 2015). It is legitimate to ask at what point should these millennial accounts be declared unrealised? Already, would be our answer, not merely on theoretical or historical grounds, but also on the basis of elementary empirical evidence indicating the nonappearance of cataclysmic effects.

Problematically, depicting workplace transformation as determined by 'technological imperative' denies any possibility of choice. Technological reasoning may be compelling and what counts as technological superiority may appear beyond challenge, but SST demonstrates that there is nothing inevitable about the process in which technologies evolve. Technological development includes choices, with potentially differing outcomes and implications for particular social groups with contrasting interests. Choice is not infinitely elastic, though, and the 'technology baby should not be ejected with the determinist bathwater' (Beirne & Ramsay, 1992, p. 5). Nonetheless, automated technologies do not arrive as a deus ex machina, but are outcomes of hitherto, socially shaped development, the oligopolistic structure of big tech and even the intrinsic rigidities of the technologies. SST research shows how technologies both reflect and shape prevailing patterns of power, serving an ideological function in the form of a 'fetish fog' (Harvey, 2017), which mystifies sociotechnical change and which works to the advantage of capital and the elites, and to the detriment of workers. Future of work debates exercise an important ideological influence, undermining challenges to the manifold ways in which digitalisation intensifies work, as incremental change creeps upon us, distracting from the acute problems workers currently face (P. Taylor, 2019). AI is being profoundly shaped by

the big tech players who are seeking to maximise their share of the global market, yet the future of AI remains open. SST's compelling emphasis on the recurring tensions between structure and agency, constraint and choice, and intent and outcome provide an enduring counterpoint to the new technological determinism. Reminders that 'capitalists do not always get their way' (Mackenzie & Wajcman, 1985, p. 71), can help loosen the grip of technological determinism, encourage contestation in the present and indicate alternatives. Concrete, rather than speculative, work futures will likely see existing inequalities of income and opportunity enhanced (Howcroft & Rubery, 2019; Spencer & Slater, 2020) and require challenge and resistance, rather than delay in anticipation of 'big bang' automation.

Accounts of automated futures suffer from a lacuna of agency, eschewing the mediating effects of possible variation in government policy, employers' strategic choice and worker response. They neglect that technological implementation emerges through complex processes, and that it is impossible to predict future uses of emerging technologies, which may well take pathways unanticipated by its originators. The absence of agency is conspicuous in 'left' accounts of Mason (2015) and Bastani (2019). Technological determinism in their theses leads, not to cataclysm, but to tech Utopia, for Bastani 'fully automated luxury communism'. Problematically, these accounts, which claim capitalism is being transcended by massive expansion in automated technology, presume that a singularity endpoint will ensue. For Mason, the crowdsourcing sharing economy, exemplified by Wikipedia and open-source software, notwithstanding the fact that these are exceptional cases, prefiguratively establishes the foundations of postcapitalist society. Space prohibits extensive critique (Choonara, 2017; Graham-Leigh, 2019), particularly of flawed readings of Marx and classical political economy. To imagine that the class that owns the technology and whose purposes it serves, nor the capitalist state, will voluntarily surrender power and interest to a collective commons is plain fantasy. It is not unreasonable to have expected these accounts to have paid attention to how labour and its organisation might resist automation's effects. Yet, there is no praxis regarding work and the labour process. Wajcman's (2006, p. 777) reminder is salutary: 'To say that technology is socially shaped...is to stress that politics and negotiation are key processes through which technical possibilities are, or are not, put into practice'. Contestation is to be encouraged since alternatives remain possible and technological development and adoption can be steered according to different goals. Passively waiting for automated technology to deliver forecloses intervention in the contested terrain of implementation emphasised by SST.

Within the sociology of work, aside from recent interest in the gig economy, technological phenomena in general have been under-researched. Although labour process scholars recognise the complexity of technology on work and skills, they have nevertheless generally neglected examination of the development and content of technology. Given the increasing embeddedness of digitalisation in everyday work practices, rigorous theorising, which extends beyond examining the effects of technology on work, is vital. As digitalisation becomes systematically important (Srnicek, 2017), it deserves more than superficial attention and SST offers a fruitful framework for understanding the processes of sociotechnical change informed by diverse perspectives. One of its strengths is the broad evidence base, which offers a contextualised, empirical understanding of technology development and adoption in situ. More workplace studies, such as research conducted by Lloyd and Payne (2021), are needed, which consider how tools, artefacts and technologies are implicated in work practices. A shift in focus from singular technologies to sociotechnical networks or systems, will be increasingly necessary for understanding the challenges facing work and employment.

This study was drafted when Covid-19's devastating impacts on work and employment were becoming apparent. That the destruction of 500 million jobs and the loss of the livelihood of 1.5 billion people in the informal economy (ILO, 2020) resulted from the severe acute respiratory syndrome coronavirus 2 virus, and not the consequence of automation, is a dreadful irony in the context of future of work debates that portend either catastrophism or utopianism consequent on disappearing jobs. Technological determinism excludes a priori not only the intervention of externalities, the unpredictable implementation and unintended outcomes in respect of the technologies themselves, but also 'exogenous' crises including the devastation of Covid-19. Two particular UK cases, prompted by the Covid-19 crisis, illuminate the limitations of automation discourse. First, pharmaceutical transnational Roche's new 'Amazon-style' automated distribution and logistics centre (Griffin, 2020) encountered 'unforeseen issues' severely disrupting the supply of Covid-19 PCR and antibody test kits, with serious medical consequences. Second, major problems developed in the test-and-trace system when tests could not be automatically linked to the app as expected, which left 60,000 potentially infected individuals unconnected (Iacobucci, 2020). Rather than human-free labour processes delivering seamless solutions, the problematic nature of automation, from intention to implementation and to outcome, is evident, a salutary reminder of the chimera of tech Utopia.

CONFLICTS OF INTEREST
The authors declare no conflicts of interest.

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