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The Mediation of Hope: Communication Technologies and Inequality in Perspective

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Digital technological innovation is taken by many to signify societal progress and the promise of equitable and sustainable societies. Others link the complex digital system to multiple and persistent inequalities and to a concern that innovations in areas such as artificial intelligence, algorithmic computation, and machine learning and their applications are being introduced in a manner that suggests, at least to some, that humans may lose their authority over the future pathway of digital technologies. Research traditions including economics, the economics of technological innovation, and critical studies of technology and society are discussed as is the predominant focus of digital economy policy. It is suggested that critical interdisciplinary engagements could influence digital economy policy makers to consider alternative digital technology innovation pathways and more proactive policies that could yield a better future.

Keywords: innovation, artificial intelligence, digital economy, employment and skills, inequality, dignity

The New York Times asks "Google Wants Driverless Cars, but Do We?" (Kitman, 2016), and investor confidence seems more likely to provide the answer than public deliberation about the adjustments and accommodations needed to deploy this technology. Driverless cars are one of the possible steps along the technological innovation pathway toward increasing dependence of human beings on automation and the artificial intelligence applications embedded in so-called intelligent machines. The automation of everyday life, whether in the form of the Internet-of-Things or advanced robotics, is depicted, especially in the popular literature, as signifying societal progress, the promise of a better life, and, ultimately, the reduction of social and economic inequality. These outcomes depend on multiple technical and nontechnical factors, and it does not follow that these developments will improve the quality of life overall or contribute to reduced social and economic inequality. Nonetheless, for some, the digital technological innovation pathway is singular, and it is often depicted as being inevitable even if "there will be heartbreak, conflict, and confusion in addition to incredible benefits" (Kelly, 2016, p. 267).

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Investment in the development and use of novel digital applications, including intelligent or social machines and robots, supported by algorithms and machine learning, is expected by many industry leaders to raise income levels and foster movement along a singular pathway through a fourth industrial revolution that "will fundamentally alter the way we live, work, and relate to one another" (Schwab, 2016, para. 1). Introducing measures that could better address social and economic inequality or the potential for a loss of human authority and control over the workings of advanced digital information processing systems is often seen as unnecessary and damaging.[2] This view is echoed in the neoclassical economics and science, technology, and innovation (STI) economics traditions as a result of assumptions employed about the relationship between technological innovation and the economy. For these scholars, hopes for a better future are mediated by a discourse that privileges expectations about benefits from the current digital technological innovation pathway. The value of achieving these expectations sooner rather than later means that policy interventions to mitigate problems should be introduced only with caution and as a response to market developments.

Critical traditions in the social sciences do not make the same assumptions and are therefore able to treat the relationship between technological innovation and society as contingent and conditioned by cultural, social, political, and economic factors. This means that contributors to these traditions typically challenge the inevitability of any particular technological innovation pathway. This, in turn, leads some of them, in the contemporary period of rapid innovation in intelligent machines, to ask whether technological and societal transformations are consistent with human flourishing. For some, this means that people should be able to engage in "a kind of living that is active" (Nussbaum, 2012, p. 342). It also suggests a kind of living in which human needs and values such as altruism, solidarity, and dignity are respected and the sociotechnical environment is consistent with increasing equality and sustainability (Annett, 2016; Calabrese, 2017; Castells & Himanen, 2014).[3] In this article, I examine views from economics and other traditions in the social sciences that are concerned with the relationship between digital technology innovation and societal outcomes. The potential for a productive engagement among researchers working in otherwise parallel traditions is examined with the aim of assessing whether such an engagement can help to focus digital economy policy on measures that could encourage a reorientation of the digital technological innovation pathway. Such a reorientation might encourage consideration of whether the extension of calculative (intelligent) machines throughout society is consistent with an inclusive and more equitable society.

Technological Innovation, the Promise of Adjustment, and Digital Economy Policy

The view that digital technologies will offer solutions to societal problems is a familiar and consistent theme in the academic literature in the economics discipline and in the economics of STI field.[4] Neoclassical economics focuses on the "diffusion" of innovations in the digital technology marketplace

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[2] See Smith and Anderson (2014). Industry leaders report mixed expectations about the benefits and risks of digital technological innovation to 2025.

[3] For example, the *World Happiness Report 2016* and the *World Social Science Report 2016*.

[4] There is a less prominent strand in the STI field associated with institutional political economy and sociology; see, for instance, Lemstra and Melody (2014), Mansell (1996), or Miles (2000).

(David, 2012) and on the competitive dynamics of, for instance, digital platforms and services. However, the complexity of the markets in which companies operate involves many second- and further-order effects that give rise to fundamental uncertainty and cannot therefore be readily anticipated or modeled (Evans & Schmalensee, 2014). The STI economics tradition, in contrast, is concerned with complex factors that give rise to the Schumpeterian creative destruction of incumbent companies by innovative entrepreneurs. In both traditions, innovation is seen "as a highly uncertain process responding to opportunities as they arise" (Fagerberg, Laestadius, & Martin, 2016, p. 20), and the principal aim is to exploit the technological trajectory or pathway that leads to economic gain. In neoclassical and STI economics, it is assumed that innovation and creative destruction are essential features of the processes in the economy that generate economic growth, productivity gains, and improved social welfare.

With respect to policy in the digital economy in the wake of innovation, the position in both traditions is usually to adopt a "wait and see" approach that favors adjustments to disruptive changes in technologies only after they have reached the marketplace and demonstrated their effects.[5] The assumption underlying these approaches is that although disruption is to be expected, the market will deliver ameliorative and compensating effects to this disruption and that the "after effect" of technological change is likely to be positive. Thus, for example, the results of aggregate analysis of indicators of investment and the diffusion of advanced digital technologies indicate that such investment is strongly associated with reductions in economic inequality, evidenced by data showing positive income and growth effects when countries are compared internationally (Pepper & Garrity, 2015).[6] It follows that, because next-generation innovative intelligent technologies may have useful potential, they should be brought to market as rapidly as possible as a result of public and private investment in research and development. The STI economics tradition is more likely than is the neoclassical economics tradition to see a need for policy intervention to smooth the market adjustment process in the face of creative destruction because it pays more attention to multiple economic factors and it is not assumed that adjustment happens spontaneously (Freeman & Louça, 2001).[7] Social justice and equity and the assessment of the quality of life from sociocultural or political perspectives and values are sometimes noted as issues requiring consideration in the STI economics literature, but this research tradition has not traditionally emphasized these issues (Schot & Steinmueller, 2016). Within these economic frameworks, market intervention via government policy is seen as a potential threat to the speed of bringing digital products and services to

[5] For example, although all productivity improving technological change can be expected to create "technological unemployment" (by allowing the same amount of output to be produced using fewer inputs of capital and labor), this first-order effect is moderated or overcome by second-order effects such as a decline in the price (assuming competition) that will increase the quantity demanded and once again stimulate demand for capital and labor inputs (see Vivarelli, 2014). Because the size of second-order "compensatory" effects cannot be anticipated ex ante, it is appropriate to intervene only when they can be demonstrated to be insufficient to overcome the labor-displacing first-order effects.

[6] Based on a global analysis of World Bank data 1990–2010 showing global poverty (measured at U.S.$1.25/day at purchasing power parity) falling in relation to rising digital technology (mobile subscriptions and Internet users) penetration (Pepper & Garrity, 2015).

[7] See Bauer and Latzer (2016) for perspectives associated with the economics discipline.

market, deferring gains that might be achieved to the substantial detriment of consumers and citizens and the competitive position of a country's industries.

The economics-inspired framings of the impacts of disruptive digital technologies and the appropriate policy responses influence the digital economy policy agendas in many countries and regions around the world. However, global evidence of a correspondence between digital technology investment and positive income and economic growth effects is inconsistent with statistical evidence indicating that the diffusion of digital technologies also seems to be associated, albeit not in a consistent or straightforward way, with rising income inequality within countries (Bauer, 2016). The multiple factors contributing to the complex interactions that account for inconsistent results are not fully understood. In addition, however great the contribution of the diffusion of advanced digital technologies within countries to inequality, the evidence of growing income inequality in many wealthy countries has become a high-level policy concern (Organization for Economic Cooperation and Development, 2015). Insofar as the rapid take up of digital networks and services and new potentials for automating jobs are contributing factors, digital economy policy makers are reluctant to intervene in markets as this would risk reducing the rate of investment. Thus, for example, the European Digital Single Market Strategy aims to support and encourage a flourishing digital marketplace, led principally by private investors. The strategy is intended to improve access for consumers and businesses to online goods and services and to create the best conditions for the digital network and services market to flourish, the goal being to maximize the growth potential of the digital economy. Governments are expected to stimulate the growth of the digital economy through public and private investment in research and development in network technologies, machine learning (cognitive systems) and robotics, and new digital systems for the health, security, and other sectors. The challenge of adapting to the digital world that emerges once these technologies reach the marketplace is seen mainly as a matter for business (European Commission, 2016b).

When there is evidence of uneven progress toward the take up and widespread use of advanced digital technologies and services within countries, regions, or cities, it is assumed that lagging areas will catch up as a result of targeted public investment, for example, in high-tech clusters. Relatively small amounts of public funding (compared with private investment) are directed at stimulating investment in broadband network capacity and at enhancing the digital skills base. Research on the factors contributing to digital divides helps to provide an evidence base for policy interventions of this kind aimed at overcoming inequality due to factors such as socioeconomic class, race, gender, or disability (Ragnedda & Muschert, 2013; Robinson et al., 2015; van Dijk, 2013), but the primary goal of digital economy policy is strongly oriented to promoting economic growth and competitiveness.

Notwithstanding uncertainty about the scale of the future disruptive impact of digital technologies on employment, making the workforce "digital ready" through policy initiatives in the education and skills domain is less controversial. A Skills Agenda for Europe for higher education has been introduced, for example, which prioritizes investment in strengthening computer science, nanotechnology, artificial intelligence, and robotics skills, together with team working, creative thinking, and problem-solving skills (European Commission, 2016a). These investments are frequently regarded by policy makers as a sufficient response to evidence of a growing mismatch between the skills of the workforce and employer demand. The timing and the extent of these sorts of policy interventions can be questioned, however, because the hope is that mismatches between the skills of the workforce and demands of employers will be met as a result of market dynamics. The policy discourse tends to confirm this assumption. For instance, a government report on artificial intelligence and robotics states that "*we know* [emphasis added] that gains in productivity and efficiency, new services and jobs, . . . are all on the horizon" (House of Commons, 2016, para. 36). Statements of this kind occur despite disputes among economists about the scale of the impact of technological change on employment and its implications for different categories of workers and their ability to qualify for jobs in the digital economy. For instance, Brynjolfsson and McAfee (2014) argue that the second machine age (of intelligent machines and robots) will boost productivity, but with adverse effects for low- and middle-skilled workers. Autor (2015) disputes their assessment, asking skeptically, "Why are there still so many jobs?" with the implication that advances in digital technologies may not be as disruptive as is sometimes forecast.

Uncertainty about the timing and extent of policy interventions to enhance the skills base, or to address weaknesses in digital literacy more generally, is created partly as a result of the predominant influence of the neoclassical economic analytical tradition in which the competitive equilibrium framework positions technological change principally as a problem of adjustment to a given distribution of benefits. In economics, technological change is taken as synonymous with productivity improvement. Technologically induced unemployment or inequalities are expected to be transitional and temporary effects that will disappear as markets adjust to their new equilibrium. As increasingly sophisticated digital technologies impact the range of work tasks that can be performed by semi- or fully autonomous machines, however, it is difficult to estimate the extent to which wage inequality will be exacerbated and over what timeframe (Atkinson, 2008; Frey & Osborne, 2013). In the STI economics tradition, it is typically more confidently asserted that adjustment policies with respect to employment and skills must be adopted because it is assumed that market dynamics are unlikely to produce a more equitable outcome even in the long term. Thus, for example, Freeman and Soete (1994) depicted digital technologies as "the greatest technological juggernaut that ever rolled" (p. 39), and they signaled the need to introduce policies in response to the disruptive impacts of these technologies on employment several decades ago. Their advice was to introduce policies to adjust to the structural rigidities in the economy that give rise to inequality as a result of technologically induced unemployment, so as to ensure a better distribution of the economic gains from digital technological innovation.

In summary, the dominant orientation of digital economy policy is toward stimulating economic competitiveness based on the premise that, if a country does not achieve a leadership position in emerging fields of technological innovation such as machine learning, big data analytics, artificial intelligence, and their applications, some other country will achieve this. Evidence drawn from mainstream or neoclassical economics and the economics of STI is often used to underpin digital economy policy. The prevailing view is that the rapid commercialization of advanced digital technologies works as "a powerful catalyst and a driver of inclusiveness" (Wyckoff, 2016, para. 13), enabling countries to rise up the global value chain, expanding markets, offering greater choice to consumers, creating employment, and leading to sustained prosperity. The aim of policy is to avoid industry consolidation and the bundling of digital information products in ways that restrict competition or slow the pace of innovation and productivity growth. Research in neoclassical economics or the STI economics tradition rarely questions the directionality of the overall technological pathway and its broader societal consequences. As Soete (2016) indicates, policy informed by these traditions is predicated on the view that the optimal pathway for digital technological innovation is the one selected by the market, that is, as if technological advance is a "force of nature": a self-organizing ecosystem that "creates itself out of itself" (Arthur, 2009, p. 21).

Asymmetrical Power and Technological Innovation

The preceding section emphasized policy responses informed by, or following from, influential strands in the neoclassical economics and STI economics literatures on technological innovation. *Ex ante* policies are not excluded, but the emphasis is on *ex post* policies aimed at influencing company strategies once innovative technologies have reached the market and without acknowledging the directionality of technological innovation and its broad societal impacts. It is important, however, to consider directionality insofar as the dialectic at work in the construction of the sociotechnical environment is always infused with actual or potential conflicts between what is technologically feasible and individual and collectively expressed preferences (Mansell & Silverstone, 1996), as well as sustainability considerations. When these diverge, there may be a basis for compromise and there may be multiple technological innovation pathways or directions that could be pursued. Achieving a different direction after substantial investment has been made in a particular pathway through research and development spending and, as a result of commercialization, by relying on ex post policy changes is likely to be very difficult given the public and private commitments that have been made.

Other academic traditions are much more likely to consider the directionality of digital technological innovation, alternative pathways, and the broader societal consequences of asymmetrical power relations. Over the past 25 or 30 years, research drawing on sociology, anthropology, philosophy, and other disciplines has inspired investigations of the relationships between society and technological innovation, sometimes working closely with computer scientists. This work has been conducted largely in parallel with those working in or near the neoclassical economics discipline and the STI economics field. This research provides insight into the multiple ways in which digital technological innovation is shaped by combinations of cultural, social, political, and economic factors. Researchers acknowledge that "technology is an instrument of power" (Hecht & Allen, 2001, p. 1), as, for example, in research inspired by Thomas Hughes, which has shown how, historically, various actors have made a difference to technological design decisions. In what is designated as the Social Construction of Technology Systems (SCOTS) tradition,[8] the focus is on specific technologies or large technical systems, and empirical work examines the technical and nontechnical aspects of the innovation process by seeking to understand the motivations and actions of individuals, "relevant social groups," "system builders," or actors and "actants" (Bijker, Hughes, & Pinch, 2012).

Research in this tradition demonstrates the scope for interpretive flexibility with regard to the design, deployment, and use of technology. It does so using mainly qualitative research methods that are not commonly found in the economist's and or economics of STI scholar's toolbox. It has shown that technology designs (hardware, software, network architectures) may become embedded in a more or less

[8] The SCOTS tradition is associated with the work of Wiebe Bijker, Michel Callon, Thomas Hughes, Trevor Pinch, and Steve Woolgar, among others (see Bijker et al., 2012), and a variety of other labels may be used.

stable configuration over time, but that this process is never fully complete. In this tradition, the technological innovation process and the emergence of new technical architectures do not occur in an uncontested knowledge space (Selin, 2007; van Schewick, 2016). Strands of this work have been taken up in fields such as human–computer interaction (HCI) research, especially as HCI researchers increasingly seek to link micro- and macro-level analysis of the technological innovation process, in contemporary studies of the materiality of technology and in the emerging fields of platform and infrastructure studies, as well as in subfields of information systems or science (Gillespie, Boczkowski, & Foot, 2014; Orlikowski & Scott, 2008; Plantin, Lagoze, Edwards, & Sandvig, 2016). Work in these areas demonstrates the malleability of digital technological systems, and it may employ implicit or explicit theories of power relationships.

Contributors to these traditions have tended to eschew normative positions or addressing policy directly (Hecht & Allen, 2001). This is said to be changing, however, as scholars grapple in the contemporary period with the design of future digital technologies and with the ethical implications they are raising for individuals and society.[9] In the context of debates about the contemporary digital technological innovation pathway with its emphasis on the creation of intelligent machines, for example, questions are being asked about the capacity of humans to control the digital system and about the governance arrangements needed to ensure that algorithms and data are managed in a way that is consistent with the values of social justice and inclusion (Kallinikos & Constantiou, 2015). Scholars such as Zuboff (2015) express concern about the directionality of innovation and suggest that the computerization of everyday life is encouraging configurations of asymmetrical power that present risks to citizens as a result of "a new kind of automaticity" (p. 82).

This scholarship is influencing digital technology designers, business managers and strategists, and, in some cases, government policy. When it does influence policy, it has the potential to operate to counter, or moderate, the race to innovation along the contemporary digital technological innovation pathway that is typical of digital economy policy, as discussed. It provides an evidence base that can serve to challenge policy makers who are often inclined to take the design and consequences of a given technological innovation pathway as unproblematic or inevitable. Often using micro-level methods, research in these traditions consistently challenges the idea of a neutral scientific or technological innovation pathway leading in any straightforward way to the progressive improvement of the human condition. An example of digital economy policy that benefits from research into the flexibility or malleability of technology design is the efforts made to enact privacy and data protection policies. In the European Union, the latest iteration in policy designed to protect individuals' personal data is the General Data Protection Regulation, which emphasizes "data protection by design" and "data protection by default" (European Commission, 2016c). This regulation encourages the adoption of technical design features and architectures aimed at making it easier for consumers and citizens to protect their personal data. When

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[9] Consideration of alternative futures and ethics is not new. Norbert Weiner's early concern with "the human use of human beings" was echoed in social informatics research, by Computer Professionals for Social Responsibility members, and in the 1980s, by Donna Haraway, Sherry Turkle, Shoshanna Zuboff, and many other scholars who cannot be cited here. All of these scholars signaled similar concerns and some sought to build bridges between instrumental and critical research traditions (see also Mansell, 2012).

the legislation is implemented, companies will be required to ensure that the operations of existing and future electronic services meet the standards mandated for personal data protection. This legislation updates previous legislation and, in this sense, it can be regarded as an ex post response to the technological capabilities for data mining, processing, and analyzing personally identifying data that have been commercialized in the marketplace. With the passage time, if it is effective, it will have an impact on the future designs and operations of online digital services, and it could then be regarded as a precautionary or ex ante policy response.

A key component of this legislation is the individual's right to an explanation of how decisions resulting from algorithmic processes have been made, and doubts have been expressed about the feasibility of implementation. If these doubts are confirmed, this may prove to be because technological innovation has exceeded the capacity of this "disclosure" approach to regulation to be effective and the legislative process will have produced "toothless" legislation (Wachter, Mittelstadt, & Floridi, 2016). Alternatives will be needed to moderate digital platform company strategy and the operational designs of their services within the framework of the existing technological pathway. In other instances, policy initiatives may lead to architectural changes in digital platform-based services such as filters to protect children, changes in the way aggregation platforms such as Facebook moderate content, or measures to track online trolls and bullies, but these changes commonly occur after the technologies have been released in the marketplace. It is in this sense that they can be regarded as ex post, that is, undertaken in response to the assumption of a singular technological trajectory.

Alternative Digital Technological Innovation Futures

The discourse around technological inevitability and adaptation to mitigate risk and to secure industrial economic competitiveness that is so prominent in the popular press and in digital economy policy is deeply entrenched. It performs as a dominant social imaginary (Mansell, 2012; Taylor, 2004), making it difficult, but not impossible, for policy makers, and indeed, some scholars, to imagine alternative digital technology innovation pathways and how they might be achieved. For many digital economy policy makers, their hopes for the future as a result of following the current pathway are accompanied by the caveat that "no one is certain where this transformation leads or ends, but it is fast moving and all-encompassing" (House of Lords, 2015, p. 8). Their hopes also are moderated by what computer scientists and hardware and software developers offer by way of encouraging expectations for improving the safety and reliability of digital technology systems,[10] but the innovation pathway itself is rarely called into question. This is despite the fact that in the critical literature, for instance, in the field of media and communication studies, it is understood that "mediated connection and interconnection define the dominant infrastructure for the conduct of social, political and economic life across the globe" (Silverstone, 2007, p. 26). This dominant role suggests the need to evaluate whether the directionality of mediated connection is consistent with achieving desired social and economic outcomes.

[10] See transcript of evidence in support of the House of Commons (2016) report on robots and artificial intelligence (http://tinyurl.com/zd2639s).

Advances in artificial intelligence research and its applications in the commercial market have triggered a recent round of consultations aimed at considering the need for new policy measures, potentially before the applications reach the market. For example, in the United Kingdom, the House of Commons Science and Technology Committee has noted that "it is vital that careful scrutiny of the ethical, legal and societal dimensions of artificially intelligent systems begins now" (House of Commons, 2016, para. 71). To this end, a Commission on Artificial Intelligence has been established to consider the principles that should govern the application of artificial intelligence techniques to help ensure that they are socially beneficial. Although it remains to be seen what the commission's recommendations will be, the precedents discussed suggest that ex ante policy interventions will be avoided. In Europe, consultation is underway in the European Parliament to consider, among other things, whether robots should be treated as "electronic persons" with rights and duties and liability for damage. An ethical framework has been proposed for discussion, guided by the principles of "beneficence, non-maleficence and autonomy" and by a consideration of matters of dignity, freedoms, equality, solidarity, justice and citizens' rights as required by the European Union Charter of Fundamental Rights (European Parliament, 2016b). The Obama Administration's National Science and Technology Council strategic initiative and its related interdisciplinary and multiactor workshops[11] on the future of artificial intelligence have yielded the observation that discussions about future expectations have not been common in the past or conducted in a systematic way (National Science and Technology Council, 2016). Crawford and Whittaker's (2016) summary of one of the workshops emphasizes that it is essential to consider how it can be ensured that the digital technology systems that are in the experimental stage will not be harmful when they enter the market.

In each of these examples in this subfield of digital ecosystem innovation, forums are being created for an interdisciplinary and critically informed debate, and the issue of ex ante intervention in the form of regulation is at least being considered. This may help to foster the design and deployment of artificial intelligence-inspired applications in which decisions are not made principally by global players such as Google, Facebook, and Amazon (and potentially other global players with headquarters in other parts of the world). Instead, they may be the result of collaborations among policy makers, academic and industry experts, and citizens with a view to guiding the technological innovation pathway so that it does not harm the disadvantaged and is consistent with the best interests of humanity (Hall, Hendler, & Staab, 2016), a hope that is articulated by leading computers scientists and social scientists.

Critical Interdisciplinary Engagement on Digital Technological Innovation

Evidence is accumulating with regard to the links between social and economic inequality and employment challenges and about the frequently claimed erosion of the capacity of humans to exercise control over their digital environment, especially as the current digital technological innovation pathway yields an intelligent decision-making apparatus in which automated decisions are increasingly unaccountable (Couldry & Powell, 2014; Turow, 2011). Kitchin (2017) calls for the use of research methods such as genealogies of code, autoethnographies of coding practices, interviews with coding teams, and examinations of the tasks that algorithms perform together with reverse engineering of

[11] Workshop presentations are available (http://tinyurl.com/z23uwpy).

algorithm computations to understand the implications of their further development. These methods also could be applied in the analysis of other facets of the digital ecosystem, and Kitchin suggests that examinations of the "full socio-technical assemblage" are needed, including "analysis of the reasons for subjecting the system to the logic of computation in the first place" (p. 25).

To undertake a "full" analysis, or more broadly, an analysis of the directionality of the emerging digital technology system and its consequences, arguably researchers would need to examine the structural or macro-level market and other institutional developments. This suggests that some of the approaches offered by economic analysis can be helpful. Despite its assumption regarding the inevitability of a singular pathway, the STI economics tradition can bring evidence to bear on dysfunctionality associated with adjustment processes involving employment losses and income disparities or identify evidence of the detrimental impacts of market power. The tools of economic analysis, including simulations, can also be used to ask questions about how outcomes might be different and about what would need to change. Such tools can be applied on a macro or aggregate scale or at a micro or firm level. The methods employed in economic analysis are quantitative and, as a result, they are less helpful in identifying and characterizing the processes that might enable alternatives to be pursued or achieved through changes in regulations or incentives when asymmetrical power relations are involved.

A further reason for turning to STI economics is with regard to the analysis of inequality associated with digital technological innovation. Here, a key question is whether the assumed "natural" trajectory of change is consistent with aspirations to preserve human autonomy––and, as some argue, human flourishing. Digital economy policy is particularly influenced by those who draw on economic analysis to support their views about whether ex post and/or ex ante policy interventions are justified. This is especially so in competition policy considerations of market failure and multisided digital platform dynamics and in discussions about the potentially discriminatory roles of platform leaders and gatekeepers (Evans & Schmallensee, 2014; Gawer, 2009; Mansell, 2015). Models and research results derived from neoclassical and STI economics traditions are regularly cited directly or indirectly via consultancy reports on the digital economy and in digital economy policy documentation. They are also often relied on in legal arguments about the need for regulatory intervention. Policy makers concerned with the dynamics of the economy and the trajectory for digital innovation do not often turn to the results of research in the SCOTS and other critical research areas, despite the fact that there is much they could learn from them.

Working toward an interdisciplinary research agenda that embraces some strands of economic analysis alongside other critical traditions in the social sciences is also likely to be helpful insofar as critical strands of research in economics acknowledge that market power matters. Market power can provide companies operating in oligopolistic markets with the ability to disproportionately influence market outcomes and result in technological progress that is not aligned with the broader interests of society (Atkinson, 2015). In response to the existing pathway of digital technological innovation and contemporary evidence of increasing job insecurity, and even if the timing and scale of the future impacts are uncertain, some economists are proposing policies aimed at addressing technologically induced inequality. Their proposals are attaining a higher profile in policy forums than has been the case in earlier periods of digital technology innovation, not the least because of problems created by financial crises and social unrest. These policies include progressive income and wealth taxation to address growing income inequality at the national level and wage subsidies or conditional or unconditional basic income guarantees for those who find they cannot participate in the labor force because they lack the skills or because their jobs have been automated (Berger & Frey, 2016; Piketty, 2014).[12] Thus, economists working within the critical economics framework are explicitly acknowledging that "technological progress is not a force of nature but reflects social and economic decisions" (Atkinson, 2015, p. 3) taken by specific actors.

In the STI economics tradition, Freeman (1992) earlier emphasized the need to assess the broad societal consequences of technological change and, potentially, to slow or alter the direction of technological change using ex ante policies.[13] Scholars working in this tradition are starting to reengage with a broader range of societal issues and questioning the assumption that a faster pace of technological innovation and largely ex post adjustments to the disruptive forces of creative destruction are necessarily good for society. Soete (2016) asks, for example, "Could it be that innovation is not always good for you?" (p. 14). He suggests that "destructive creation" may be becoming the norm in some areas of the economy, and he emphasizes the need to investigate how the digital technology innovation pathway is related to financial and employment crises and why the benefits of technological innovation are available to "the few at the expense of the many" (p. 14). Extending the range of concerns conventionally addressed within the STI economics framework, Mazzucato and Perez (2015) call for a proactive (and ex ante) policy agenda to guide the digital technological innovation pathway, insisting on the need for an informed citizenry to collaborate with academics and with policy makers in selecting a technological pathway that is most likely to secure equitable outcomes and sustainability as envisaged by the United Nations' (2015) 2030 Sustainable Development Goals.

There are other indications of new efforts to foster collaborative research among scholars working in the STI economics tradition and in some branches of the SCOTS tradition. Schot and Steinmueller (2016), for example, observe that the STI economics field over the past 50 years has been largely instrumental and that there is a need to focus research on the directionality of technological innovation and its broad societal consequences. In addition to their concern with research and development, the structural characteristics of digital technology markets (and in other fields, e.g., energy) and the need for ex post policies, they call for a new framing of policy issues that would emphasize the inclusion of civil society in participatory approaches to the choices about which technologies should be brought to the market. Their explicit aim is to address the broad social purposes of technological innovation and to acknowledge that there are always multiple potential directions for technological transformation. They argue that this kind of engagement could help to foster "the creation of negotiation spaces or market niches for alternative technologies to become established, capture imaginations and win constituencies among actors that would otherwise be excluded" (Schot & Steinmueller, 2016, p. 17) from policy formulation and implementation. In addition to bridges that are being built across these research traditions, there is engagement between HCI and political economy scholars. For example, Ekbia and

[12] These policies are controversial; see European Parliament (2016a) for information about trials.

[13] Scholars working in the STI economics tradition such as Charles Edquist, Chris Freeman, Bengt-Åke Lundvall, Richard Nelson, Carlota Perez, and others have stressed the importance of research aimed at analyzing the institutional contexts of innovation, mainly, the institutions engaged in research and development and in innovation and learning.

Nardi (2016) call for a closer link between microethnographic approaches and the approaches familiar to non-neoclassical economists, political economy of communication scholars, and critical sociologists, anthropologists, and geographers.[14]

These efforts work to problematize the contemporary digital technological innovation pathway by introducing critical theories of power and the way power relations influence technological innovation at all levels. They could provide a more robust basis upon which policy makers can assess whether digital technology systems are being designed in the laboratory and commercialized in the marketplace in ways that are consistent with broad societal goals. On occasion, this could yield ex ante policy responses. Assuming that these collaborative ambitions materialize and produce results, the insights of this work can be introduced to digital economy policy makers by scholars who participate as advisors or who work as activists for, or with, civil society organizations and, indeed, as consultants to industry.

In summary, the dominant imaginary in many policy discussions concerned with the prospects for the competitiveness of the digital economy is of a digital technological environment that beneficially augments human–machine, machine–machine, and human–human relationships, albeit with risks that can be managed. Insofar as it is informed by evidence from the social sciences, this comes principally from neoclassical economics or the STI economics tradition. The result is that it gives relatively little attention to cultural and social values such as altruism or how best to ensure that digital technological advances foster solidarity and human dignity or flourishing. Digital economy policy is mostly characterized as transitional, with the aim of responding to a disruptive period in which there is a mismatch between the skills and other resources required to participate productively within the evolving digital economy as it progresses along a pathway toward the greater use of computational and artificial intelligence systems. Views about the timing of the introduction of technological solutions to the market and the capacity to design in societal values differ among experts, but, nonetheless, it is hoped that solutions to harms and safety risks will be found by technology developers and/or effectively mandated by ex post legislation.

This is not to minimize the efforts of critical scholars who engage with policy making for the digital economy and their impacts, but to characterize the view that is most frequently displayed in the discourse of digital economy policy. Nor is the intention to minimize the challenges of governing the digital environment. Both ex ante and ex post policy making are costly, time consuming, and highly politicized. Even small shifts in policy favoring broader societal interests (beyond the prospects for economic growth and productivity gains and the fortunes of monopolistic companies) can be hard fought and difficult to achieve when set against a political economy that favors the interests of the large digital platform companies and hardware, software, and component equipment suppliers.

The suggestion here is not that there is a lack of vision of alternative technological pathways within branches of critical academic scholarship. Scholars working in the political economy tradition such as McChesney and Nichols (2016) argue, for example, that the current digital technological innovation pathway will lead to “the mass genocidal elimination of much of the world’s surplus and disposable population” (p. 264) if steps are not taken to change the prevailing pathway. Benkler (2016) provides

[14] Citing, for example, Mosco (2009) and Piketty (2014).

insight into policy and legal contests over standards, architectures, and regulations that, when they are won by companies whose principal interest is in attaining market dominance, work against the potential for fostering alternatives to the commercial market such as collaborative sharing in online relationships. Other examples include Lovink (2016), who sets out a vision of an alternative pathway using "collective awareness platforms" to resist unequal power structures. Mason (2015), a journalist who draws on political economy and complexity theory, envisages the adaptive spontaneity of computational digital technologies, which he suggests will yield a more equitable form of capitalism. These scholars foresee a technological innovation pathway that favors open networks, commons-based production, a reasonable standard of transparency, and a capacity for human authority and control over the digital ecology, consistent with increasing social and economic equality and sustainability, but this is not the dominant vision embraced by digital economy policy makers.

Conclusion

With contemporary research evidence yielding forecasts, albeit controversially, of imminent job losses, the end of work as we know it, and in the wake of high-profile discussions about the societal risks associated with the automation of daily life and the economy, there are opportunities to influence the directionality of the digital technological innovation pathway, potentially, through proactive ex ante, as well as ex post, policies. The emerging interdisciplinary research base could help to reshape the mainstream of digital economy policy making. The combination of research in the critical social science traditions, including economics (evolutionary economists working in the STI field and critical economists concerned with inequality), could yield improved insight into the conditions that produce inequality and evaluations of the risk of a potential loss of human authority over augmented intelligence embedded in networks and services. This could help to demonstrate to policy makers charged with promoting the digital economy that there is more scope for alternative technological futures than they normally allow for. This could lead to discussions about what measures are needed to achieve a different pathway. Even if advances in machine learning and algorithmic technique increasingly tend to "rule out, [and] render invisible, other potential futures" (Amoore, 2011, p. 38), alternative digital technological innovation policies could start to have greater traction, even if the main focus of policy makers remains on competition and on the rate of economic growth.

If the conventional evidence base for digital economy policy is combined with the critical analysis of the economy-wide and institutional as well as the micro-level features of the digital technological innovation pathway, the results could help to moderate the propagation of increasingly less transparent algorithms and difficult-to-control artificial intelligence applications. The suggestion is not that intelligent machines should never be brought to market, but that it is crucial to broaden the debate in digital economy policy circles. This seems more likely to happen if researchers are better able to translate disparate theoretically and methodologically grounded findings across critical and mainstream or instrumental research traditions. This is clearly challenging, but there are signs that efforts are being made within the critical research domains. Those critical researchers who do engage in policy making forums concerned with digital economy policy regularly encounter mainstream economic arguments and are usually adept at challenging them. A more comprehensive evidence base has the potential to destabilize received wisdom and to provoke new ex ante policy measures where they are needed. Some readers may argue that in the contemporary phase of capitalism it is not reasonable to hope that the major (or minor) players in the commercial digital industry will alter course toward computational systems that meet desired standards of protection, consistent with citizen rights and a more equitable and sustainable future, except at the margins. If, however, "destructive creation" is shown to be the most likely outcome of the current technological innovation pathway, then digital economy policy relying mainly on ex post adaptive policy responses could start to be coupled with the greater use of ex ante policy measures.

The critical traditions of research on digital technological innovation considered in this article tell us that asymmetrical power relations that may appear to be locked in to a particular pathway are, in fact, contingent and subject to alteration. Engaging in narratives about possible futures, building on insights from formerly parallel scholarly traditions, including some branches of economics, may help to encourage the mediation of hope for a better future in a way that leads to proactive ex ante policy responses that mobilize and reorient investment along a different pathway. In the context of debates about the future of artificial intelligence and the digital ecology and its implications for individuals and society, this could help to moderate the prevailing imaginary and practice of technological innovation policy in the digital ecology, that is, the view that it is "too soon to set down sector-wide regulations for this nascent field" (House of Commons, 2016, para. 71).

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