R&D MANAGEMENT

Open Science and Open Innovation in a socio-political context: knowledge production for societal impact in an age of post-truth populism

Palie Smart[1], Sara Holmes[2], Fiona Lettice[3], Frederick Harry Pitts[1], Jeremy Basil Zwiegelaar[1], Gregory Schwartz[1] and Stephen Evans[4]

[1]Department of Management, School of Economics, Finance and Management, Faculty of Social Sciences and Law, University of Bristol, Bristol, UK. palie.smart@bristol.ac.uk. fh.pitts@bristol.ac.uk. jeremy.zwiegelaar@bristol.ac.uk. gregory.schwartz@bristol.ac.uk
[2]Cranfield School of Management, Cranfield University, Bedfordshire, MK43 0AL, UK. sara.holmes@cranfield.ac.uk
[3]Norwich Business School, UEA, Norwich, NR4 7TJ, UK. Fiona.Lettice@uea.ac.uk
[4]Institute for Manufacturing, Cambridge University, Cambridge, CB3 0FS, UK. se321@cam.ac.uk

This conceptual paper traces the origins and progress of Open Science and proposes its generative coupling to Open Innovation in the contemporary socio-political context; where universities are re-imaging their civic missions in the face of anti-establishment populist politics. This setting is one of changing knowledge production regimes and institutional pressures that create contradictions identifiable through the prism of the series of scientific norms conceptualised by Robert K. Merton. This paper privileges a sociological perspective to proffer scientific knowledge production as a societally embedded process, which is well illustrated by scholarship in the Science and Technology Studies (STS) and Science in Society fields. In doing so, it identifies the co-evolution, co-existence and co-production of Open Science with Open Innovation; and notes how it shares the attributes of other recent diagnoses of changing knowledge production regimes; in particular Mode 2, post-normal science and the Quadruple Helix. It also argues that Open Science can be coupled with Open Innovation to catalyse positive societal change, but that the rise of a populist *post-truth* **era opposed to objectivity, expertise and technocratic political solutions gives the demand for openness and participation a different complexion. Merton's norms provide a useful lens to observe recent shifts in the delivery of science, knowledge and innovation in society towards more inclusive, ethical and sustainable outcomes; and expose the limited reflection on how the appropriation and exploitation of open scientific knowledge encounters industrial R&D and Open Innovation.**

1. Introduction

The public value of science and knowledge production regimes are being re-framed, signalling alternatives in the pursuit of research that hybridises expert and non-expert inputs from broader civil society (Stilgoe et al., 2013; Franzoni and Sauermann, 2014; Perkmann et al., 2015; McNie et al., 2016; Adams et al., 2017; Carayannis et al., 2018; Fini et al., 2018b). As a social movement, it gains momentum in the contemporary socio-political context; in which Higher Education Institutions (HEIs) are re-imaging their civic missions in the face of anti-establishment populist politics. These works discuss how such organising for research is inclusive, democratic and ultimately more impactful in economic and social returns; because of its focus on open participation and sharing in scientific inquiry. This pervading phenomenon has demonstrated repercussions in the exploitation and appropriation of new knowledge that privileges an Open Innovation model (Chesbrough et al., 2006; Holmes and Smart, 2009; Huizingh, 2010; Chesbrough and Di Minin, 2014; Salter et al., 2014, West and Bogers, 2014; West et al., 2014; Fini et al., 2018a). Policymakers in the UK, Europe and the USA, are embracing initiatives to open up the scientific research process under the auspices of Open Science. Projects receiving United Kingdom Research and Innovation (UKRI) or European Commission funding under the Horizon 2020 Programme and Framework Programme 9 (2021–2027) are required to make all of their data and findings freely available. In the United States, federally funded scientific research programmes by agencies that spend more than USD 100m on research and development must ensure their results are freely available 12 months after publication.[1] Opening up the scientific process is not simply about sharing, but increasingly about participation, ensuring new knowledge is co-produced and better able to impact user communities for societal improvement (Chesbrough and Di Minin, 2014; MacIntosh et al., 2017). A recent review of Open Science by Vicente-Sáez and Martínez-Fuentes (2018) concurs with this grand mission and calls for further academic exploration into the relationship between Open Science and Open Innovation. This paper follows Fini et al.'s (2018a) suggestion for more theory-development work to complement empirical analyses of science in society and its commercialisation. Yielding conceptual contributions to the field of management and organisation studies is our aim; as we begin to address our principal research question: 'Is the nature of the relationship between Open Science and Open Innovation conducive to a knowledge production regime for societal improvement?'.

However, contemporary social and political conditions complicate such appeals to openness. Scientific knowledge production is a societally embedded process, as illustrated by scholarship in the Science and Technology Studies (STS) and Science in Society fields. This suggests that society is not an optional extra added into a Quadruple Helix as a component standing alongside industry, governments and other actors (Carayannis et al., 2018), nor the receptacle for an impact separable from the practices of management and knowledge production that those actors engage in. Rather, those actors themselves sit within society, and their impact is always social insofar as the practices they engage in are themselves social in nature (Tsao et al., 2008). It is necessary to locate the Open Science and Open Innovation relationship within what is happening in society at a given time, to properly examine its generative and contradictory coupling. Our discussion takes place in a context of increasing institutional pressures for greater transparency and accountability of publicly funded scientific research programmes and calls for transformative innovation policy (Diercks et al., 2019; Schot and Steinmueller, 2018). Meanwhile, the rise of a populist post-truth style opposed to objectivity, expertise, mediation and technocratic political solutions grants the demand for openness and participation a different complexion. The dangers this poses to scientific inquiry and innovation have been noted by a series of scholars writing in the wake of the national-populist political upheavals of recent years (Fisher, 2017; Long and Blok, 2017; Brown, 2018; Kelly and McGoey, 2018; Nerlich et al., 2018). This paper suggests that, by removing normative constraints, an agenda of openness in a post-truth age may contradictorily throw up barriers to beneficial innovation that compromises the generative link between Open Science and Open Innovation. In the context of the contemporary populist politics of knowledge, this paper seeks to re-frame Open Science in relation to Open Innovation for realising more inclusive, responsible and sustainable outcomes targeting industrial and societal prosperity. Its timeliness is captured by Soete's (2019) comments that there is 'growing evidence that the growth and welfare gains of new technologies and innovation are no longer forthcoming in an automatic "trickle-down" fashion' (in press). National diffusion infrastructures are experiencing growing social and environmental concerns about the negative externalities of unsustainable industrialisation; and research policy is realigning itself to new needs (Lettice et al., 2012; Ciarli and Ràfols, 2019).

This paper draws together the threads of ongoing debates about the nature of knowledge production regimes within the sociology of science, technological and institutional spheres. The context is an age of openness in which the Open Science and Open Innovation co-productive relationship can be a generative force for good, in light of global societal challenges. In addition, this work adds to the changing lexicon of how scientific inquiry, its appropriation and innovation is metamorphosing, and discusses this phenomenon with reference to Merton's scientific norms; that provide a much needed moral purpose and agency for the future of science and R&D management.

2. Open Science, Open Innovation and societal challenges

The advent of Open Science is generally argued to stem from the increased availability of knowledge and scientific findings made possible by Oldenburg's 17th Century launch of the *Philosophical Transactions of the Royal Society* – the original European Open Science endeavour. New journals and periodicals followed in its wake, heralding a new era from the previously dominant ethos of secrecy that surrounded attempts to unlock scientific puzzles (David, 2004). Partha and David (1994) use the term Open Science to distinguish it from the 'closed science' era which had preceded it, with discoveries often shared only with wealthy patrons supporting a scientist in their work (David, 1998; 2004; Nielsen, 2012).

The movement to share scientific knowledge through the then nascent medium of print in the 1660s resonates today in Open Source Software development, Open Innovation approaches, innovation intermediaries, living-labs, crowdsourcing (Mortara, 2010; Bucheler and Sieg, 2011; Franzoni and Sauermann, 2014; Colombo et al., 2015) and the calls for open access to scholarly research and the ethos of science as a public good (Willinsky, 2005, 2009; Nielsen, 2012). In 2010, the first Open Science Summit was held, in Berkeley, California, to discuss the role of science in the 21st century and the wide-ranging implications of making all research freely available to anybody to use and reuse as they see fit (Delfanti, 2010).

The debate about Open Science is taking place in the context of discussions about the evolving nature of scientific knowledge production regimes. The end of the 20th century saw the emergence of other descriptive and prescriptive theories of how the creation of scientific knowledge is changing. Mode 2 knowledge production (Gibbons et al., 1994; Gibbons, 2000) is arguably the best known of these approaches, suggesting that scientific discovery is moving outside of the walls of universities, becoming transdisciplinary and heterogeneous. This has been happening in alliance with R&D intensive organisations such as Proctor & Gamble, Toyota, General Electric and Apple for some decades. Ziman (2000) refers to this as 'post-academic science' and also notes that science is becoming transdisciplinary, public funding is increasingly scarce, scientific results are focused on knowledge utility in society and science is becoming industrialised as academics forge closer links with industry. The strain on funding for scientific endeavour has led to what Slaughter and Leslie (1997, 2001) and Slaughter et al. (2004) term Academic Capitalism as universities embark increasingly on commercially-focused activity and have to compete in the external-funding market, whilst safeguarding their intellectual property, professional autonomy and independence. This is reified in the Triple Helix Model, which theorises how innovation results from the relationship between universities, industry and government (Leydesdorff et al., 2017), and its further development into the Quadruple Helix, which adds civil society to include forces like culture and media (Colapinto and Porlezza, 2012).

From a more prescriptive stance, Funtowicz and Ravetz (1991, 1993) and Benessia et al. (2016) argue for a new approach to scientific inquiry relating to complex public policy issues. Termed 'post-normal science', it can be applied in situations where 'facts are uncertain, values in dispute, stakes high and decisions urgent'. (Funtowicz and Ravetz, 1991, p. 138). The concept is certainly pertinent to the Global Challenges (as described by the United Nations Sustainable Development Goals) and call for higher levels of openness and sharing in researcher and user communities (Chataway et al., 2014; OECD, 2015; Pansera and Owen, 2017). Vicente-Sáez and Martínez-Fuentes (2018, p. 428) state '*Intergovernmental organisations across the world such as the European Commission, the European Parliament, the European Council, the Organisation for Economic Cooperation and Development (OECD), the United Nations, and the World Bank recognize the importance of Open Science to address the big societal challenges that humanity faces in the 21st century*'. There is little doubt as to the contemporary relevance of claims that science can improve the health, wealth and well-being of society in light of today's UN global challenges and OECD projections of the global economy (Fini et al., 2018a). Following the recent IPCC Report 'Global Warming of 1.5°C' and 30 years since Brundtland et al. (1987), the UK Department of Business, Energy and Industrial Strategy (BEIS) again indicate the importance of science for an inclusive and sustainable industrial strategy'. Vicente-Sáez and Martínez-Fuentes (2018, p. 435) suggest that 'Open Science is transparent and accessible knowledge may stimulate business strategies, actions, and practices, in other words, new ways of collaboration that help to breakdown walls between Open Science and Open Innovation'.

However, the broader socio-political context becomes acute when the onslaught of digitalisation, networked e-infrastructure, artificial intelligence, platforms, big data analytics and algorithmic computing impact the way scientists are able to create knowledge. Coupled with institutional and public pressures regarding the relevance of science to society and structural changes and opening access to this knowledge for industrial R&D and the wider societal audiences; the world of scientific inquiry is in flux. But for all those who see the present popularisation and opening up of science as a much-needed epistemic democratisation, hand-in-hand with a populist rejection of expertise, others see in such populism 'authoritarian implications of a wholesale destruction of scientific norms and institutions' (Kelly and McGoey, 2018, pp. 6–7). Evolving scientific paradigms, in this way, might play into some of the fears expressed by scholars about how science relates to the rise of a populist 'politics of openness', behind which may lurk 'metaphorical dragons or monsters' (Nerlich et al., 2018, p. 3). The democratisation at the heart of post-normal science, which 'purport[s] to bring science, society and publics closer together through processes of openness, access and transparency' may have a negative as well as a positive side (Nerlich et al., 2018, p. 4).

3. The need for a sociological perspective

The dangers are illuminated by a perspective on scientific production that situates science as part of society, rather than standing apart from it. It is argued that approaches such as the Quadruple Helix include society or civil society within existing models as an afterthought, in a way that Roth et al. (2018, p. 5) describe as desultory. It may be better to conceptualise scientific production and the universities, industry R&D, and government that produce such knowledge, not as standing alongside society as separable forces but rather as themselves embedded from the beginning in society itself. Recent scholarship addresses this by suggesting the substitution of the Quadruple Helix for the systems theory of Niklas Luhmann, which better captures the complexity by which science is located within and not independent of society (Colapinto and Porlezza, 2012). Other scholars have pointed to how mainstream market- and technology-oriented explanations of innovation miss the role played in the latter by the actions and structures of the political state (Pfotenhauer and Juhl, 2017; Fini et al., 2018a). By locating the constitution of the production of scientific knowledge in social and political phenomena, attention is drawn to its conditioning by and relationship to foregoing political trends. In this paper, we highlight the possible problematic affinities between the populist suspicion of expertise that pervades the movements driving political developments like President Trump and Brexit with demands for openness in the sphere of scientific participation and communication, and the contested forms of truth and post-truth this can generate (Kelly and McGoey, 2018). This context is one in which, as Brown puts it (2018, pp. 169-170):

> [t]he recent increase of xenophobic right-wing populism in both Europe and the United States lends new urgency to…questions regarding the publicity and legitimacy of expert knowledge. What aspects of science should be made public and to whom? Will public scrutiny of expertise increase or decrease its legitimacy?

At a time when the relationship between politics, society and knowledge production is characterised by the substitution of norms of expertise, objectivity and disinterestedness with national or popular sentiment, it is an instructive exercise to return to the conceptualisation of scientific norms offered by the sociologist Robert K Merton, whose now classic work in the Sociology of Science continues to ignite debates about the scientific community and its increasing interfaces, porosity and openness (Macfarlane and Cheng, 2008; Bucchi, 2014; Trench and Bucchi, 2014; Fini et al., 2018a). In his seminal work outlining the four institutional norms of science – communism, universalism, disinterestedness and organised scepticism – Merton (1973, pp. 268–269) states that 'the ethos of science is that affectively toned complex of values and norms which is held to be binding on the man of science'. These norms represent moral standards for scientists as social agents that should ultimately manifest in positive change in society through an appropriate knowledge production regime. Therefore, the following sections draw on the Sociology of Science and consider each norm and its relevance to the openness discussion in a post-truth age of populism.

C*ommunism* notes that the findings of science are 'a product of social collaboration and are assigned to the community' (Merton, 1973, p. 279) and that individual researchers eschew their intellectual property rights in favour of recognition and esteem for their ideas. **U***niversalism* holds that scientific endeavour and discovery should not be evaluated or influenced by race, gender, politics or class. The norm of **D***istinterestedness* focuses on the role the scientific body plays in ensuring robust research: 'Involving as it does the verifiability of results, scientific research is under the exacting scrutiny of fellow experts. Otherwise put, the activities of scientists are subject to rigorous policing, to a degree perhaps unparalleled in any other field of activity'. (Merton, 1973, p. 276). Finally, **O***rganised* **S***cepticism* is both a methodological and institutional mandate which holds that the scientific community should robustly scrutinize ideas and be mindful that their discoveries may cause controversy with other institutions. These norms are collectively known by the acronym **CUDOS.**

Polanyi, in his classic 1962 paper, paints a vivid picture of the men of science as explorers, striving 'towards hidden reality for the sake of intellectual satisfaction' (2000, p. 19). While these may be theoretical ideals, subsequent scholars considering the ethos of science have argued that for the field to advance, research must be laid open to scrutiny by the republic of science (David, 1998), and scientists should be free in the pursuit of knowledge for its own sake (Nelson, 2003) without imperatives forced upon them by perceived popular, commercial or state interests. Dasgupta and David (1994) argue that the norms of openness, where scientists waive their intellectual property rights in return for recognition and esteem, play a critical part in maintaining the efficacy of modern science and that traditionally society has benefited enormously by the separation of industry and academia, and, *inter alia*, that of the state and society. However, this separation is contested by the new political claims made against expertise and in favour of a politically charged openness, which appeals to an unmediated transparency and identification of power and decision making with the popular will, wherein the '*majority* of the people' are taken 'as standing for the *entire* people' (Brown, 2018, p. 174).

In light of these wider societal and political trends, recent discussion on the state of science has argued that the Mertonian ideals are under attack from other quarters, with a succession of authors (e.g. Etzkowitz, 1998; Ziman, 2000; Nelson, 2003; Etzkowitz and Ranga, 2015; Breznitz and Etzkowitz, 2017) noting the shift towards commercial enterprise in academia and the increasing encroachment of patenting on the scientific commons. They identify the US Congress passing of the Patent and Trademark Law Amendments (Bayh-Dole) Act of 1980 which encourages universities to take out patents on their research where they were able to do so. With regard to the Mertonian norms, Ziman (2000) argues that the acronym **PLACE** is replacing **CUDOS**. Science, Ziman argues, is producing '***P****roprietary* knowledge that is not necessarily made public. It is focused on ***L****ocal* technical problems rather than on general understanding. Industrial researchers act under managerial ***A****uthority* rather than as individuals. Their research is **C***ommissioned* to achieve practical goals rather than undertaken in the pursuit of knowledge. They are employed as ***E****xpert* problem solvers, rather than for their personal creativity'. (Ziman, 2000, p. 78–79). In a similar vein, Etzkowitz (1998) notes that there is an increasing participation by academics in entrepreneurial activities and the failure to define this participation as deviant suggests that the capitalisation of knowledge (David and Hall, 2006; Sampat, 2006; Fabrizio and Di Minin, 2008; Baldini, 2009; Larsen, 2011; Mark et al., 2014; Maskus et al., 2019) is beginning to take precedent over the Mertonian norm of disinterestedness. Privatisation attempts on the scientific commons have met opposition from commentators. Nelson (2003) notes that much of current scientific research is oriented towards providing solutions to practical problems, making it financially valuable, and argues that new efforts must be applied to keep scientific knowledge open and accessible to all. David (1998, 2004) observes that the institutions and norms governing Open Science are fragile and very vulnerable to the withdrawal of public protection and public patronage.

If changes in the institutional dimension are threatening to erode the scientific commons, then the development of networked technology is arguably pushing it in the opposite direction and offering the opportunity of greater openness. Technology enables more diverse involvement in the scientific endeavour and a growing number of research activities incorporating people outside the traditional republic of science bears witness to this. This prospectus has brought to bear new critical claims about the status of scientific openness in contemporary society. A series of scholars identify not the threat that over-commercialisation poses to openness, but rather the threat that the increasingly double-edged character of openness itself poses to science in an age of populist assaults on expertise, mediation, technical solutions and notions of objective truth. Demands for openness are seen not to introduce new pathways to appropriation and exploitation, but rather create a contradiction in the channels between Open Science and Open Innovation in the name of socially positive outcomes that address the global challenges of our time.

4. Societal actors and participatory knowledge (co)production

In some ways, developments in the opening out of science to new participant groups can be seen as an early precursor of new political demands for unmediated and non-expert openness. The concept of citizen science, where individuals with no specific scientific training or background contribute to scientific R&D runs counter to the perceived view that science is progressed by comments and criticism from 'competent' investigators. Citizen science is not new, and indeed Darwin and Newton can be regarded as amateurs, but technological advances in gathering and sharing information have enabled far more people to participate in science (Silvertown, 2009; Nielsen, 2012; Lane, et al., 2014; Follett and Strezov, 2015). The Internet is characterised by horizontal diffusion with open protocols and tools designed for collaboration (Delfanti, 2010). Policy guidelines for scientific funding which seek to bring science closer to society make citizen involvement in science more attractive for professional scientists (Silvertown, 2009). Counter to Mertonian norms that scientists eschew Intellectual Property Rights (IPR) in favour of recognition and esteem, citizen scientists appear to be involved simply for the enjoyment of discovery and making meaningful contributions to science for its own sake; similar to those in the Open Source Software community (Stodden, 2010). Delfanti (2010) argues that citizen science, where individuals collect data for organised scientific projects such as collecting wildlife data, is giving way to a new context for scientific inquiry in which non-scientists organise themselves outside the traditional academic space to produce knowledge. Levy and Germonprez (2016) add granularity to the concept by identifying citizen science characteristics, and an associated definition, that can be applied to the technology field. The rise of citizen science, epitomised by the activities of garage biologists, provides another challenge to the institutional processes of knowledge production regimes.

Figure 1 below provides a schematic of the involvement of interested non-specialists in scientific discovery. Traditional science involves academics contributing to research conducted by their peers. Citizen science refers to non-specialists contributing to academic–led projects; whilst garage biology is an example of science started and pursued by people working outside the science mainstream. Finally, the online encyclopaedia, the Wiki model, is an example of managing a knowledge bank which is created by non-scientists and to which scientists (as well as non-specialists) now contribute.

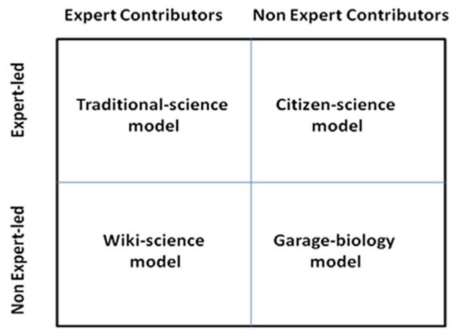

Figure 1. Typology of expert and non-specialist research types. [Colour figure can be viewed at wileyonlinelibrary.com]

As science embraces new networked technologies, the traditional concept of Open Science, as conceived in the tradition of Merton, is evolving. This has been driven in no small part by the hacker ethic (Weber, 2004; Gehring, 2006) and proponents of Open Source Software development; which we discuss in section five. Indeed, this hacker ethic feeds into the new and superficially anti-authority politics of openness in other spheres of social life.

4.1. *E-science in service to society*

As the process of scientific discovery begins to embrace the opportunities offered by networked computing, a plurality of terms has been used to discuss the way research in the Internet age is conceived, conducted and disseminated (Jankowski, 2007; Schroeder, 2007). In the United Kingdom, the term e-science is favoured (Hey and Trefethen, 2003), whereas in the United States, e-research is typically called 'cyberinfrastructure'. This followed the Atkins report of 2003, commissioned by the National Science Foundation (NSF), which contained a vision of how science would be revolutionised through networked computing. Europe usually favours 'e-infrastructure' (Schroeder, 2007; Barjak et al., 2009) or 'e-research' (Jankowski, 2007; Lyon, 2016) as constructs to describe the digital age of science. The USA, UK and EU have all created central offices to promote and co-ordinate e-science efforts[2] based on visions of the benefits to research projects and, ultimately, to society.

Meyer and Schroeder (2009, p. 247) define e-research as 'the use of digital tools and data for the distributed and collaborative production of knowledge'. Watson and Floridi (2018) have shown how the use of technology platforms, using crowdsourced participation for what is known as citizen scientists, is beneficial as part of knowledge co-production. In this context, professionals and volunteers use digital technologies to exchange knowledge and ideas in virtual labs to improve research outcomes. Nentwich's (2005, p. 2) definition of cyberscience also focuses on the process of scientific discovery. Cyberscience is '*all scholarly and scientific research activities in the virtual space generated by the networked computers and by advanced information and communication technologies in general*'. The opportunities for knowledge production from technological advancement fosters collaboration not only within disciplines, but across them, as e-science inevitably involves computer scientists as well as discipline-specific researchers (Schroder, 2008; Watson and Floridi, 2018). Drawing on the work of Shinn and Joerges (2002), Schroder (2008) applies their concept of research technologies to e-science. Research technologies (Shinn and Joerges, 2002) are instruments which are developed outside particular disciplines and then re-embedded in multiple local contexts, spreading a shared language. These research technologies focus on concrete practices, rather than abstractions, which, in the case of e-science, are focused on manipulating data across networks using shared characteristics in the way data are classified, stored, manipulated and distributed (Schroder, 2008). Sharing and using all of the knowledge available in relevant datasets is key to addressing important scientific issues (Bisol et al., 2014). The European Commission (2016) has backed research focused on sharing knowledge. It has developed processes to ensure that research is shared earlier in the process to allow for transparency of scientific communication (European Commission, 2015). Authors such as Schroeder (2007), and Fry et al. (2009), discuss the implications of the Open Science ethos on e-science initiatives. Schroeder (2007) notes that the move towards openness in e-research does not just come from national policy initiatives or academic movements, but from the unstoppable movement towards online research which requires large-scale computing and open protocols. Zamfir (2015) contends that the rise of e-science (together with e-education and e-business) has created a new paradigm of meta-instruction for learning. More recent examples of the use of e-science have enabled collaborative and inclusive research (Bisol et al., 2014), facilitated by technology, for crowdsourced approaches to data collection. In this paradigm shift, there is an open exchange between researchers and the general public using social media to collect data (Aleksic et al., 2015; Grand et al., 2016). For example, the sightings of rare birds or species are communicated, and data collection protocols are explained in social media exchanges. The technology enables interactions between researchers and the public (Morzy, 2015), providing enhanced data collection and novel analytical tools/initiatives which were limited prior to these e-science initiatives.

5. The rise of an age of openness

Scientific, management and technology journals publishing about the changing nature of R&D, show an increase in the use of the 'open' prefix relating to the production and diffusion of knowledge. This age of openness links closely to Merton's (1973) norms of communism and universalism which promote an inclusive knowledge production regime and collective ownership of its outcomes, denying appropriation by producers. The central tenet of the open movement is the waiving of property rights and the emergence of copyleft (as opposed to copyright) licences, which enshrine the open nature of knowledge and data and are essential to the movement. Open institutions are essentially concerned with decentralising knowledge production and its distribution as a collective good by making it accessible for the development and adoption of educational products/services to wider audiences (Deng, 2011; Hampton et al., 2015). The resultant open knowledge can be defined as '*any content, information or data that people are free to use, re-use and redistribute – without any legal, technological or social restriction*' (http://okfn.org/about/vision-and-values accessed 17 March 2018).

Among the commonly used terms underpinned by the open ethos are *Open Source Software,* concerned with the process by which computer source code is created, modified and used; *open access*, concerned specifically with the unhindered availability of knowledge, particularly scholarly publications; *open content*, a broad term concerning both the creation and dissemination of informational or artistic material in any form; *Open Science*, an umbrella term for the way scientific research is conducted, disseminated and evaluated in a networked world; and finally, *open data*, which generally relates to the publishing and dissemination of non-textual information, e.g. mathematical statistics and scientific results. Other terms also in use, such as *open research*, or *open notebook science,* are synonymous with those listed here. The adoption of an Open Science model has been more rapid in medicine and natural sciences than in the social sciences and humanities (Giordani et al., 2018). Figure 2 shows the growth in the use of these terms in the literature.

5.1. The case of Open Source Software

The Open Source Initiative (OSI) is celebrating its 20th Anniversary in 2018. Arguably, one of the most

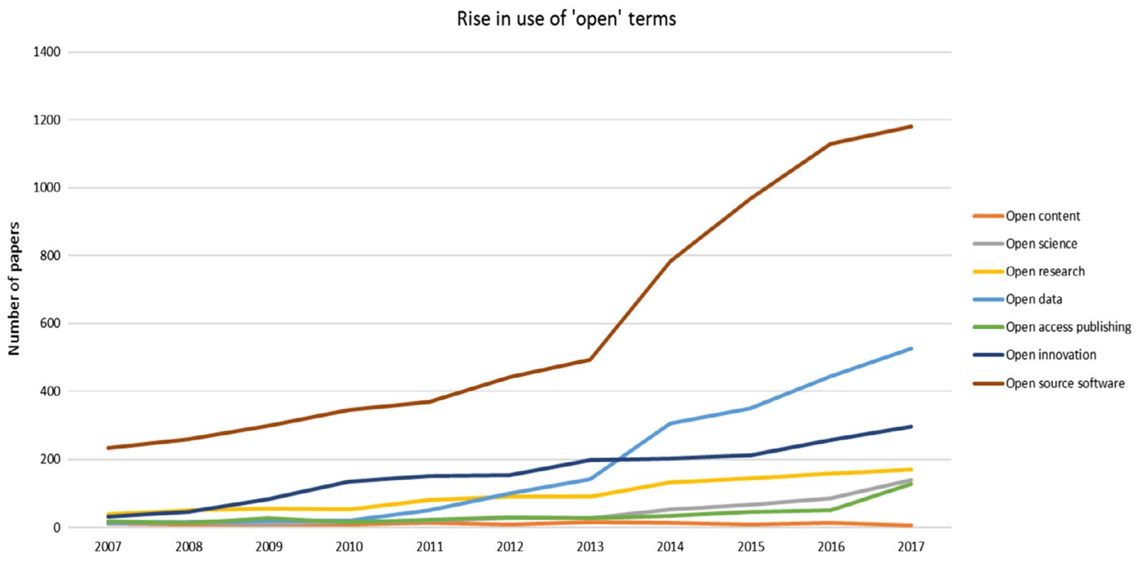

Figure 2. Use of 'open' terms (Scopus, March 2018). [Colour figure can be viewed at wileyonlinelibrary.com]

practised conceptualisations within the open paradigm is Open Source Software (OSS). As Weber (2004) observes, OSS has gone furthest in addressing some of the legal and business-related issues, specifically through the development of licencing arrangements which keep the software in the public domain.

Early contributors noted that individuals were motivated to participate in open source projects for both intrinsic reasons such as the sense of enjoyment it produced and the sense of altruism generated (von Krogh and von Hippel, 2003; Roberts et al., 2006; Schilling, 2012) and extrinsic reasons, such as the reputation enhancement of being involved and the private use of the software developed (Hars and Ou, 2002; Hertel et al., 2003; Azmi and Alavi, 2013). Weber (2004) included reputation and ego-building and a sense of community and identity, which resonated closely with Levy's (1984) research with MIT programmers in the 1960s. Weber emphasises the artistic and intellectual pleasure and notes a political dimension, that of fighting an enemy, i.e. dominant software corporations, such as Microsoft and IBM. As Weber (2004) notes, these motivations are distinct from the norms of academic scientific research, from which this community arose and to which it still has strong ties.

With regard to the innovation and governance processes, von Hippel and von Krogh (2003) state that OSS development represents a unique combination of private and collective aspects of innovation and knowledge. The source code used is freely available public knowledge (Wolkovich et al., 2012), but the learning and expertise developed is privately held, intangible knowledge. Grand et al. (2004, p. 592) observe that OSS development represents '*an unusual collaborative effort where skill and adherence to a philosophy are entry qualifications to a community where developers work together beyond firm, sector and national boundaries to co-create a public good*'. However, Host and Orucevic-Alagic (2011) note that some participants do try to commercialise from their involvement in open source projects, often with limited success.

The relative maturity of the Open Source Software development field has led authors and commentators (e.g. von Krogh and von Hippel, 2006; Stodden, 2010; Nielsen, 2012; Heron et al., 2013) to suggest that the ethos and organisation of OSS has relevance to other areas of economic and social activity, particularly scientific research. The open movement could be argued to have set in place a wider social ethos of openness and the removal of constraints and validations upon knowledge; a distorted resemblance of which today pervades the political sphere. This might also be traced to the imperatives upon researchers to make their findings, data and outputs available, often in the name of greater accountability to a public that, as recent events have shown, is summoned up to different ends across the political spectrum. We consider these issues in the following section.

5.1.1. Open Access, Open Content and Open Data

The move from academic print publishing to predominantly electronic publications is proclaimed to be the second discontinuous shift in scientific publishing (Solomon and Bjork, 2012; Schmidt, et al., 2016). The Budapest Open Access Initiative in 2002 is described as a milestone in the open movement, given its major role in developing digital repositories for storing research (Garcia-Penalvo et al., 2010).

The term open access (OA) has been defined as enabling content to be free to read and free to reuse (Piwowar et al., 2018). Other scholars have suggested different interpretations of OA that include that content is free to read online, free of charge and available digitally online (Willinsky, 2003; Matsubayashi et al., 2009; Laakso et al., 2011). With the movement towards OA arrangements seemingly unstoppable (Bernius, 2010; Laakso et al., 2011, Bisol et al., 2014; Czarnitzki et al., 2015), authors are considering the subsequent impacts on motivational and behavioural issues; including citation success (Lawrence, 2001; Eysenbach, 2006; Davis, 2009; Kim, 2010; McCabe and Snyder, 2014; Piwowar et al., 2018). However, Gaule and Maystre (2011) caution that a citation is not a proxy for wider dissemination as it fails to capture the invisible readers who do not contribute to scientific debate but may access papers, particularly in medicine. Whilst it may be difficult to quantify the wider dissemination of OA articles, Bernius (2010) argues that OA generates a positive impact by accelerating the scientific knowledge production process. This is notwithstanding a call for further empirical studies in this burgeoning field (Davis, 2009; Lyons and Booth, 2011; Grand et al., 2016; Lyons, 2016). This includes research into the take-up of OA scientific papers by other areas of society, specifically business and policymakers (European Commission, 2016; Vicente-Sáez and Martínez-Fuentes, 2018) to evaluate whether OA publishing can deliver the promised societal benefits. Whilst open access is important, there is also a need to consider how content and data can be made accessible (e.g. free OA Digital Object Identifier (DOI) service) to advance the Open Science movement (Piwowar et al., 2018).

Having first gained traction within the education community, e.g. OpenCourseWare from MIT, open content is now being applied in the cultural sphere, where distributed individuals or groups create and refine content, the most notable examples being Wikipedia or YouTube. Chelitois (2009) discusses open content initiatives in the light of Open Source Software development and IPR, and argues there is a distinction to be drawn between the production of functional goods, like software, and cultural goods, like art and music. Drawing on the principles of OSS, open content is covered by various licences, for example, the Free Art Licence and the Open Music Licence. One licence, namely the Creative Commons, is starting to dominate the arena of open content (Cheliotis, 2009).

The governance and regulation of open content sites has received growing attention with authors (Viegas et al., 2007; Forte et al., 2009; Altonen and Lanzara, 2010; Hullova et al., 2019). Ostrom's (1990) principles of collective self-governance encompass participative decision making, transparency, allowing for mutual monitoring, graduated sanctions against transgressors and conflict-resolution mechanisms. Ostrom's (1990) model of collective self-governance was originally applied to natural resource communities, but appears to match the regulatory framework that has emerged on Wiki-sites (Schroeder and Wagner, 2012).

Open Data have gained traction through national government initiatives towards greater transparency with the release of data sets relating to policy initiatives and publicly funded projects. In a knowledge production context, open data can be regarded as one of the building blocks of Open Science (Bisol et al., 2014; Robertson et al., 2014). The findings in science publications rest on supporting information, which in disciplines such as bio-science is freely available, but in other areas is aggregated by publishers and resold, thus limiting the accessibility and dissemination of the research communication. Scientists and open data advocates such as Murray-Rust (2008) argue that such data belong to the knowledge commons and that restrictions on re-use create an anti-commons. Murray-Rust (2008) calls for full open notebook science which would enable research data to be freely available before it is embedded in a published paper which might not be covered by open access arrangements. Rapid disclosure and discovery of new knowledge made available earlier in the research process is one of the key aims for open data advocates (Hampton et al., 2015; European Commission, 2016). Such a development has the potential to radically alter the way Open Science is conducted and further exploited in an Open Innovation milieu. There have been concerns from some quarters that the Creative Commons erodes boundaries and constraints on the use and understanding of intellectual output in such a way as to compromise the standards and rights of ownership characterising ideas and knowledge production (see e.g. Lyon, 2016; Curry, 2018).

6. Open Science and Open Innovation: a generative coupling

Working through its contradictions to support the generative coupling between Open Science and Open Innovation, it might be suggested that normative structures are necessary to govern the creation of positive societal impacts from scientific knowledge production regimes. This is a process of co-evolution, co-existence and co-production. In 2012, 350 years after Oldbenburg introduced scientific papers to speed up the discovery process, the Royal Society published its report '*Science as an open enterprise: open data for Open Science*', making a series of recommendations on how institutions and scientists can ensure the Open Science (re)evolution delivers its social mission potential.

With implications that Open Science, as an ideal, represents a whole new way of producing knowledge (Deng, 2011; Nielsen, 2012; Peters and Roberts, 2012; Friesike et al., 2015; Morzy, 2015; Lyon, 2016; Arza and Fressoli, 2017; Jomier, 2017), authors have also been considering the challenges to, and limitations of, that ideal along some of the socio-political axes discussed above. A key issue is that of a data deluge (Hey and Trefethen, 2003; Hilbert and López, 2011; Hilbert, 2016). With so much data available, openness in scientific research is limited by attention space, that is, who is paying attention and what are they paying attention to (Beer, 2018)? Schroeder (2007) contends that the success of openness will depend on generating and sustaining the largest possible user or attention base. According to Meyer and Schroeder (2009), the challenge of a data deluge is more pressing in some fields than others. Their study found that e-research had more impact in computer sciences, medicine and mathematics and will have to find structures and processes to manage ever-increasing levels of data. A related problem is that of knowledge de-contextualisation (Mohamed, 2007) as tacit knowledge is lost as its codified counterpart is prepared for externalisation.

Another key issue raised, highly relevant to the contemporary populist politics of knowledge, is that of quality assurance. Hemlin and Rasmussen (2006) suggest that a move from a product focus of quality control to a process focus of quality monitoring is required in the networked world of diffused knowledge production. Quality monitoring would entail continuous (rather than episodic) evaluation by data users and lay people as well as traditional scientific peers. Given the wider set of quality evaluators, knowledge is assessed in terms of its societal as well as scientific value. The rise of big data, artificial intelligence and future quantum computing provides impetus for new platforms for the coproduction of knowledge, yet also raises concerns about how data is being generated and transformed for greater value and utility (Beer, 2018). The power of immense volumes of data is in an ability to re-combine elements to reveal patterns, understanding and future predications of societal challenges, such as modelling climate change and the occurrence of catastrophic events. Whilst the data and its analyses act as a pro-social force; significant concerns about personal data consent and digital exclusion in society, the independence of the scientific process and the objectivity of knowledge from pressures towards popularisation and politicisation remain (Hilbert, 2016).

6.1. The socio-politics of openness in knowledge production regimes

Open Science described by the National Academies of Sciences, Engineering, and Medicine (NASEM) 2018 Report entitled 'Open Science by Design' suggests that the continuing advances in information technologies enable global research enterprise collaborations with multiple stakeholders to create a new Open Science ecosystem. Characteristic examples of this mode of science would include the research project Galaxy Zoo, where amateur astronomers volunteered and assisted in the classification of galaxies. The appropriation and exploitation model here is one of Open Innovation, with disparate, networked participants able to contribute to scientific endeavour for broader societal impact, as demonstrated by The Training Partnership UK in the public and private education sectors. Therefore, this paper argues for an extension of the NASEM Open Science ecosystem in which Open Science is coupled with Open Innovation in a generative link.

Open Science and Open Innovation symbolise inclusivity, diversity and social responsibility; albeit carrying contradictions specific to the current social and political conjuncture. The earlier Open Science model (Oldenburg 17th) was inhibited by the limits and constraints upon participation and reception, leading to a relatively closed innovation model. However, it might be the case that the new Open Science paradigm forecloses innovation, owing to a lack of limits and constraints and specifically standards that act to qualify and validate knowledge and make it meaningful, useful and socially impactful for end users. Here, it might be useful to think of recent applications of Alisdair MacIntyre's understanding of virtue in organisational life as consisting in a dialectic between practices and their inhibition by institutions (Moore, 2012), which features abundantly in the Open Source Software (OSS) scholarship (von Krogh, 2003). In spite of the store set by openness in this area of scientific activity, OSS would be nothing without the capacity of institutions to constrain open practices and the motivations of the actors involved within reasonable and useful limits (von Krogh et al., 2012). Innovation can only follow from practice should the institutional channels be in place. Similarly, as recent critics of openness remind us, '[s]cience cannot function without some monopolisation of expertise', and hence democratic discussion infringes upon specialised knowledge (Turner, 2003, quoted in Nerlich et al., 2018, p. 5). This risk is especially acute in a post-truth age where populism demands the stripping away of layers of mediation and deliberation between the public and technocratic or expert elites that can help sift what is objective or practical from what is not. Applied to scientific knowledge production, this de-institutionalisation of science may short circuit the generative link between Open Science and Open Innovation.

Thus, the question now is, how far in this developing social and political context, can the theoretical ideal of an Open Science and Open Innovation link be fulfilled? This paper suggests that the development of Open Source Software (Stodden, 2010; Athey and Ellison, 2014) may give some clues as to how it may advance. For example, Nielsen (2012) compares the potential of new Open Science to the knowledge created by open source projects. In the open source community, code is modified almost continuously, leading to the proposition that the Open Science–Open Innovation coupling could benefit from the same quick-fire improvements, but is held back currently by the academic publication, citation and IPR constraints which slow down academic discovery, appropriation and full exploitation for societal gains.

Whilst Open Science shares attributes (i.e. heterogeneity, transdisciplinary, reflexivity) with Mode 2, post-normal science, and Triple, Quadruple and Quintuple Helix models (Carayannis et al., 2018), it offers an alternative to the future of knowledge production that runs counter to the privatisation-centred models of Academic Capitalism (Slaughter and Leslie, 1997, 2001) and post-academic science (Ziman, 2000). Such models articulate the declining degree to which the higher education sector is beholden to the public good, and the inclining degree to which it is obliged to the global extra academic market pressures. Ziman (2001, 2003) argues about the social dimension of science and the social responsibility of scientists. However, this takes on a new complexion in the present social and political state of affairs, characterised by populist upheaval and a reconfiguration of the relationship between the people, the state, knowledge and expertise. Although some academics continue to express criticism about the potential for university science commercialisation to generate meaningful value (Davis et al., 2011), there appears to be no obvious down turn in the momentum that has gathered for its expansion into the future (Lockett et al., 2013).

This paper proffers that modern day knowledge production regimes continue to be governed by an ethos that embodies Merton's norms; but they are subject to changing institutional forces demanding greater public accountability and responsiveness to societal needs in the face of declining public funding. Such changes are being met with varying degrees of porosity or openness in the scientific R&D process, with an ever-expanding range of stakeholders to ensure appropriation, exploitation and innovation. However, this must happen in such a way as to resist the pressures to debase the knowledge production through the rejection of disinterestedness and expertise; so will mean preserving Mertonian ideals. The latter will be especially important if Open Science and downstream Open Innovation practices are to deliver societal improvements; in light of the inherent contradictions in Mode 2, post-normal and post-academic science knowledge production regimes, exacerbated by the contemporary politics of knowledge.

6.2. Merton's norms, moral purpose and agency for innovation

In the 21st century, as science adapts to networked technologies, the concept of Open Science as conceived in the tradition of Merton is evolving. The populist politics of openness resonates in 'policy initiatives to "open up" science in response to perceived legitimacy crises in research and innovation systems and in the relationship between science and policymaking' (Nerlich et al., 2018, p. 3). This legitimacy crisis not only owes in part to the decline of Mertonian norms, but may incubate much worse if unexplored, posing the question as to whether a return to Merton offers a renewed moral purpose and agency for future science and innovation endeavours; in a world with pressing global challenges. Bucchi (2015, p. 233) questions Mertonian 'values and norms in science in the light of relevant organisational changes that have marked science in recent decades, as well as the resilience of the concept of "scientific community" to those changes'. In response, Sztompka (2007, p. 211) suggests that 'in this period of "post-academic science", Mertonian norms lose some of their binding moral power, and the decay of trust in science is the predictable result'. But it might also be said that the Mertonian norms, insofar as that the scientific discovery process is, in theory, accessible to everyone with an Internet-enabled device, warrant a review. Therefore, we comment on Merton's four institutional norms and the theoretical implications on Open Science practice, as an antecedent to Open Innovation with moral ambitions.

Merton's norm of universalism, where ideas are evaluated without prejudice against their proponent is consistent with the opportunity Open Science affords to ordinary people to become involved in scientific discovery, but also guards against the capacity for sectional interests to propose politicised or popularised competing notions of truth such as conspiracy theories or quack forms of science. With such boundaries in force, increasing levels of participation in science may be a neutralising counter to the Matthew effect (Merton, 1968,1988) where established scientists often get credit for work which can equally, or more readily, be given to lesser known researchers (or non-experts) raising important questions about the meritocratic process. Similarly, Open Science is in accord with the norm of communism, where scientific knowledge is a product of social collaboration that is shared by society. The use of Creative Commons licences to ensure IPR remains in the public domain is a tangible expression of this norm, and it is the presence of such institutionalised terms of engagement that mediate shared collaboration and make it scientifically meaningful and useful to stakeholders. The key threat in this context remains state policy in science, academic funding and the impact agenda. While new Open Science strengthens the collaboration and sharing ethos, and states and funding councils have moved to embrace these as vehicles for promoting the social utility of science, the institutional environment that defines state policy has not challenged (and in fact may be increasing) the involvement of commercial bodies in science. Thus, the celebration of citizen scientists may be premature, as corporations and entrepreneurs, in their role as civil society and citizenry, are enabled to play a significant role. Unless existing in isolation from Merton's other norms, universalism may prove to be a less discernible Trojan horse for (corporate) particularism.

By contrast, the norm of disinterestedness, where the scientific body exerts peer pressure on scientists to ensure their work is rigorous and robust is subject to challenge under Open Science; as scientific discovery may be conducted outside traditional academic institutional structures with open innovators. This runs the risk of removing the forms of deliberation and mediation that validate scientific knowledge and expertise and invite claims of competing particularistic truths and a 'radical pluralisation of the forms of legitimacy' (Rosanvallon, 2011, quoted in Brown, 2018, p. 175). The norm of organised scepticism suggests that the scientific community is the guardian of scientific findings that may (or may not) cause controversy with other institutional bodies. This too is under pressure in the new Open Science regime from fragmentation of the discovery process and its extension into non-traditional settings, with the potential compromises this invites with foregoing social and political trends around the status of knowledge, truth and expertise.

Merton's norms, whilst applicable to the traditional science model which envisaged science as a profession, cannot be applied as easily to the Open Science which embraces non-expert lay-people as well as professionals; hence, there is tension between the norms of communism and universalism, and disinterestedness and organised scepticism. Yet, the roots of this tension and the ostensible incompatibility of the Mertonian paradigm and Open Science do not stem from intrinsic contradictions between them. The emplacement of the new Open Science practices within the existing institutional environment that gives primacy to the privatisation of science causes tension and particularly the privatisation of funding, the private appropriation of the fruits of science in the form of property, and the hedging of collectively produced knowledge behind paywalls of various kinds. Nevertheless, cognisance of these norms is imperative to develop openness in knowledge production regimes, whilst protecting it against what recent scholarship has termed a 'monstrous' populist 'politics of openness' (Nerlich et al., 2018).

7. Concluding remarks

In response to our principle research question, 'Is the nature of the relationship between Open Science and Open Innovation conducive to a knowledge production regime for societal improvement?', this paper offers some concluding remarks. As Willinsky (2005) notes, the convergence of open approaches to intellectual property represents a common commitment to the public good, and universities remain the primary force in sustaining this open knowledge economy, which extends well beyond their sphere (see also McNie et al., 2016; Rau et al., 2018). Indeed, the contemporary socio-political context in which Higher Education Institutions (HEIs) are re-imaging their civic missions in the face of anti-establishment populist politics; provides added momentum.

Such conditions can help foster the generative link between Open Science and Open Innovation, as long as some sense is kept of Mertonian norms to mediate openness in the link. With institutional agencies increasingly persuaded by the social benefits of such a configuration, and a growing body of scientists pushing the open ideals, the trend towards greater openness and exploitation in the research process seems inevitable. This has implications for individual scientists, their institutions and the higher education sector and their non-academic (e.g. enterprise) partners in the way research is designed, conducted, appropriated, used and evaluated as a public and private good. Universities must develop their policies and infrastructure to support open research initiatives;

research councils must set in their requirements for funding new research streams and co-ordinating open approaches in collaboration with public, private and third sectors; and governments must provide guidance in terms of future research policymaking.

New Open Science is still maturing and more empirical studies on its impact, such as those by Schroder (2008), Woelfle et al. (2011) and Meyer and Schroeder (2015), are needed. There are many areas to be explored, including, for example, the behavioural aspects of working in an Open Science–Open Innovation environment for experts and non-expert partners; the economic and institutional effects of the recombinant knowledge production regime; contributions to an inclusive and sustainable economy and the challenges of handling intellectual property rights.

More widely, the development of a generative link between open approaches to science and innovation adds to the ongoing debate about the changing nature of knowledge production regimes, within a socio-political context. For example, there are implications for the debate about research relevance and research impact (see, for example, Starkey and Madan, 2001; Van de Ven and Johnson, 2006; Kieser and Leiner, 2009; Bresnen and Burrell, 2013; Perkman and West, 2014; Bager, 2018; Hamet and Michel, 2018; Narasimhan, 2018) in the field of management and organisation studies. The open model advocates collaboration between academia, industry/business, government, civic communities and the media and is an important antecedent for innovation that is mission-led for societal improvement. This paper adds the caveat that this also requires awareness of the potential pitfalls of openness in a populist age and the need to maintain norms that militate against them.

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Notes

1. https://obamawhitehouse.archives.gov/sites/default/files/micarosites/ostp/ostp_public_access_memo_2013.pdf
2. For a greater discussion on this point see Schroeder and Fry (2012).

Palie Smart is a professor and holds a chair in professor of operations management (innovation) at the School of Economics, Finance and Management, Faculty of Social Sciences & Law, University of Bristol. In 2017, she became an appointed member of the UK Government's Innovation Caucus to provide thought leadership to Innovate UK, Economic and Social Research Council (ESRC) and Department of Business, Energy and Industrial Strategy. Palie Smart is the corresponding author.

Sara Holmes is a visiting fellow of the Doughty Centre for Corporate Responsibility at Cranfield School of Management where she has focused on cross-sector partnerships and their role in driving innovation. Her current research interests are responsible innovation and societal impact measurement frameworks.

Fiona Lettice is a professor and holds a chair in Innovation Management at Norwich Business School, University of East Anglia (UEA), UK. She is also Pro Vice-Chancellor (Research and Innovation). Her research interests include: innovation management and new product development, buyer-supplier relationships, diversity management and knowledge exchange. She has worked across many sectors, but some sectors such as the tech sector, automotive, law and financial services have featured more strongly in her research.

Frederick Harry Pitts is a Lecturer in Management at the University of Bristol, where he also leads the Faculty Research Group for Perspectives on Work and co-edits the Bristol University Press online magazine Futures of Work. He is the author of Critiquing Capitalism Today: New Ways to Read Marx (Palgrave 2017) and co-author of Corbynism: A Critical Approach (Emerald 2018).

Jeremy Basil Zwiegelaar, PhD, is a Teaching Associate in Operations and Management Science group at University of Bristol, Department of Management, UK. His research interests include entrepreneurship focusing on new ventures, new venture performance and in operations science, business intelligence as it affects decision making in business contexts. He has other areas which focus on the use and measurement of data, big data and wider effects of these on society and people in different roles such as education, organisations, new ventures and tourism businesses. He is an ad hoc reviewer of academic journals and conferences papers. In addition, he is a member of several professional entrepreneurship and management bodies.

Gregory Schwartz research has looked at the effects of the transformations in global political economy on the nature of work, labour relations, labour

subjectivity and forms of organisation, management and organisation in Central and Eastern Europe. He is especially interested in the place of labour within European integration, the problem of 'labour regimes', the relationship between capital, the state and class, the links between labour migration and the gendered political economy of social reproduction.

Stephen Evans is a Director of Research in Industrial Sustainability at Cambridge University. He leads research that broadly seek to deliver knowledge concerning sustainable change at scale, including programmes in sustainable business model innovation, system transformation, the limits of efficiency and sustainable policy making in developing countries. He has over 30 years of academic experience which includes working collaboratively with leading industrial and academic institutions from around the globe. He has been Specialist Adviser to the House of Lords Science and Technology Committee and is a serial clean-tech start-up founder.

