Changing Ecologies of Knowledge and Action (CEKA)

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1. The topic and its importance

The familiar landscapes in which science and technology are produced, distributed and used and are accountable to wider society are radically changing. The key features of change involve:

1. *What kind of science is done* - there is an apparently accelerating development of new sciences, technologies and fields of radical application, especially in the biosciences; additive manufacturing and advanced IT;
2. *How science is done* - the continuing radical improvements in the cost-effectiveness of computing are leading to improved analysis across all fields of science, control of increasingly complex processes in additive manufacturing, and in some fields increasing reliance on modelling/simulation & 'big data'. Information science also serves as an epistemic model in new emerging fields of knowledge, in which the nature of physical and organic things are conceived of as code, as informational building blocks, capable in principle of fundamental manipulation and redesign, and thus offering a reductionist vision of a total technology of complete control;
3. *Where science is done* - *s*cience is increasingly being done beyond the conventional settings of university and industrial labs: in garage labs, public labs, and collaborative facilities of various kinds, some local, some international, sharing the opportunities and risks of new technologies and bringing together new combinations of industrial, academic and state partners;
4. *Who does science* - science is increasingly performed not only by career scientists in university, government and industry labs but also performed directly, or commissioned on behalf of, patient groups, environmental campaigners, entrepreneurs, and hobbyists, with individuals sometimes occupying more than one role in parallel;
5. *How science is owned and communicated* – changing approaches to, and uses of, intellectual property regimes and publishing models are developing in the light of a model of open access especially to publicly funded science, and the growth of crowd-funded science;
6. *How science is governed, regulated and socially mediated* - although overall there might seem to be a growing disconnect between hierarchical institutions and distributed practice, closer inspection reveals a rich variety of linkages. These can range from complete autonomy to full value capture by conventional commercial science outlets. Intermediary organisations and networks are playing a developing role in shaping distributed practice through supplying equipment and experimental materials, and brokering deals for new scientific

[1] This paper represents discussions over many months at InSIS, and all my colleagues deserve credit for their multiple inputs. In addition this text draws directly on contributions from Steve Rayner and Jeremy Howells, to whom special thanks are due.

outputs or capacities. In macro-issues of governance and regulation many jurisdictions are still evolving (potentially divergent) approaches;

7. *What different sectors of society expect science to do - s*tates and cities increasingly build political imaginaries around sociotechnical narratives. In parallel to these symbolic uses of science in political attempts to build high-level consensus around broad visions of the future, the pragmatic decisions about particular technologies are often highly contested between different interests and values, suggesting that much science is increasingly post-normal in character.

The background to these developments is a set of broader longer term, and specific and more immediate, changes affecting how science and technology are produced, consumed and perceived.

Longer-term processes of social change

According to Beck (1992), earlier modernity, in which industrial society distributed goods, had, by the late 20th Century given way to a period of reflexive modernity, in which industry's distribution of environmental harms occupied centre stage, and concepts such as sustainability and the precautionary principle were invoked as possible tools to manage risk. Beck also suggested that trust in traditional organisations of governance would be lower in late modernity, leading to greater emphasis on 'subpolitics': involving wider social and individual agency in seeking to manage change.

Consistent with Beck's analysis is the analysis of political socialisation and the influence of changing values over political styles (Inglehart, 1977) and in particular the concept of the 'decline of deference' (Laird, 1989). In reviewing data from the World Value Survey over 25 years, Nevitte (2011) concludes that new orientations towards authority operate across domains and are as consistent and coherent enough to allow a degree of prediction; that they originate within the family; and they are consistently associated with public evaluations of confidence in political institutions and shifts in protest behaviour.

These general social trends may account more for changes in attitudes to science and technology than anything more specific to these domains. Publics became more sceptical and discriminating consumers of all kinds of messages from authority, and given that science's privileged epistemological status was also under challenge, its products were treated the same way. Onora O'Neil (2013) suggests that over the last 20 years the evidence is that the same professions are judged as possessing, or lacking, trustworthiness; and that in practice we are very discriminating in who we judge trustworthy for what purpose. Under this view, trust is essentially a form of delegation, and this would explain Stirling's (2008) observation that participation can substitute for trust - or 'discursive deference' as he puts it - in the governance of science.

Michael Gove's comment during the 2016 EU referendum campaign that "people in this country have had enough of experts" rekindled a debate about "truthiness" - the term coined in 2005 by U.S. satirist Stephen Colbert for knowledge which is accepted because it intuitively 'feels right', even if it untested against evidence or intellectual scrutiny - and wider claims that we are living in a post-truth or post-factual society (Manjoo 2008). In this scenario claims to truth are spread by 'digital wildfires' and support techno-fantasies whose role is to buttress us against economic and political uncertainty. The resultant post-truth society is "not merely one where politicians and media lie -

they have always lied - but one where they don't care whether they tell the truth or not." (Pomerantsev 2016).

2. Understanding and managing change

Individually some of these new features are at an early stage of development and are small scale. In combination they can be seen as a new ecology of institutions, practices, norms and cultures which are reshaping science, innovation and society in ways that either are, or have the strong potential to be, highly disruptive of the social and economic order with which they are co-produced. A central research mission for InSIS and its consortium partners over the next decade will be to:

- analyse how these changes are redistributing social risks and opportunities, and creating new individual and collective identities;

- in parallel, throw light on some of the governance issues, which are thrown up at a variety of scales and in a variety of contexts, and review the possible means by which they may be tackled, with benefits accentuated, and harms reduced.

Our research will focus on:

- **Citizen science**, which is a rapidly growing phenomenon. This may be enormously productive as an experience for its participants and in terms of the data and analysis produced. However, it is also prone to idealisation as a democratisation of access to science. Such a view tends to elide the way in which it effectively increases the efficiency of existing organisations by allowing volunteer citizen labour to substitute for the work of scientists or bureaucrats. Who sets the agenda is unchallenged. By contrast, our research will examine only that part of the citizen science spectrum, which involves co-produced and proactive, citizen-led science;

- **DIY (do-it-yourself) science**, in which citizens directly participate in scientific practice;

- **Open science and innovation.** We will analyse and assess a whole range of newly emerging forms and patterns of institutional collaboration of innovation centred on the 'open' sharing of knowledge;

- **Quality and expertise in the new ecology of science.** Many of the problems attributed to quality and which lie behind the sometimes claimed 'quality crisis in science ' are mismatches in information and assumptions between multiplying contexts of science production and use: it is an epiphenomenon of the wider changes in scientific production and use described here. As Sarewitz (2015) points out, 'quality assurance will increasingly become a matter for political interpretation', requiring more openness from scientists on how political convictions may sway the assessment of scientific evidence; issues which are of course particularly pertinent in the formulation and use of science advice.

In developing this agenda, InSIS will build on research projects on new issues of technology governance (Bioproperty and Climate Geoengineering programmes), on the ways of countering distributional inequality associated with sociotechnical change (the ResIST project) and the ways in which social, spatial, economic, environmental and

technological factors are brought together in urban design and development (Future of Cities programme). This experience will be added to strong interests and experience in different forms of expertise, and in their uses in science advice, and critical perspectives on public participation (particularly in relation to deliberative mapping) in science and technology and on the Responsible Research and Innovation movement. The project's work on open innovation systems and new roles for the university will benefit from the association of Jeremy Howells, visiting professorial fellow at Kellogg College [and Will Hutton/colleagues in SBS?].

3. Research sites: emerging organisational forms

Our work will initially focus on five research settings:

- Smart cities. With rapid urbanisation, city regions are increasingly sites of experimentation where social, spatial, economic, environmental and technology policies come together in integrated imaginaries of development. Our research programme will select a number of contrasting cases of cities and city regions to examine how policies towards knowledge production and use relate to decentralised knowledge production, new patterns of institutional collaboration, and local specialisation in knowledge production and use. The selection of the city regions will be a key methodological step in the research, since the aim would be to choose cities which already embody many of the other research targets, but which offer potentially divergent approaches to governance and regulation.

- Emerging institutional forms and networks involved in the production, distribution and appropriation of knowledge at a variety of scales. The research will identify, track and analyse a variety of novel institutional forms in which knowledge is being produced, appropriated and used in collaborations, ranging from local fablabs, DIY-bio labs and makers spaces to international risk-sharing consortia involving combinations of industrial, academic and state partners. Other than exceptional cases showing unique features of interest, most cases will be selected from the city regions selected above. We will also study the influences of the local and international networks, professional and commercial, helping to shape scientific practice, suggest approaches to regulatory issues, or broker deals for new scientific outputs or capacities in our chosen cases.

Open science and innovation is a special case of new institutional forms. Its origins lie in the increasing complexity of technology, and the need for firms to integrate a variety of strands of knowledge in developing new products and processes. This first led firms - and later public agencies and enterprises seeking to increase the commercial returns from their research - to move away from the traditional vertically integrated model of R&D provision in-house, towards more innovative and forms of knowledge management involving networks of collaborating organisations (Chesbrough 2003 & 2013). A second, more radical strand has focused on democratising and opening up science and innovation on free or reciprocal models of cooperation and sharing, for example in relation to infrastructure (the EU's Open AIRE). The primary examples are open-source software, the Creative Commons (CC) and Knowledge Commons movements, and the issue of knowledge disclosure and the 'copyleft' intellectual property initiative. Of particular interest is the cross-fertilisation of these two strands as open science and innovation concepts widened to encompass more novel and effective techniques to organise and manage groups or networks or companies and public organisations in a

particular locale (city; see above) or sector (software or bioscience/pharmaceuticals) and how this may be supported through intermediaries (Howells, 2017).

- Social/consumer movements for popular control of knowledge and action. Historically, citizen science/DIY science has been profoundly influenced by its linkage to social action/social movements, especially in citizens acquiring scientific, legal and political knowledge attempts to counter local environmental threats (Gibbs 2010, Brown et al, 2011). Recently local communities have become more pro-active in seeking to identify and manage local environmental risks, including the loss of local environmental services, and public health challenges, emergency and disaster responses. Finally patient organisations and various public and private sector initiatives are seeking to put patients at the centre of medical and pharmaceutical provision. The research will analyse selected initiatives exemplifying key issues.

- The evolving (curatorial/civic) university. How might conventional sources of knowledge relate to these new initiatives? Hutton (2012) envisages a new role for the university which would see itself as a promoter of open knowledge in the public interest rather than proprietary knowledge to be spun-off or sold. Healey (2017 forthcoming) coins the term 'curatorial university' for this pathway in contrast to the 'entrepreneurial university' of Triple Helix and other linear-model innovation theories (see http://triplehelix.stanford.edu/3helix_concept). Others have stressed the need for a new civic university, which would redress the balance between its support for commercial innovation and wider social innovation delivered through social enterprises and the non-profit sector, strengthening trends already in place (Universities UK 2012). The project would examine how a university with such a curatorial/civic approach to knowledge might work, the paths by which it might develop and the policy incentives that might be required to facilitate such development. In particular it would consider how the curatorial university might have a special role in housing and nurturing small-scale, decentralised research production, both commercial and non-commercial, and how through such a role it might help to allay concerns about quality and safety.

4. Key theoretical perspectives and their insights

The project will draw on four main strands of theory:

- Models and modes of governance, knowledge and action and the locus of social control in different stages of/forms of new knowledge production and distribution. In particular we would draw on recent advances made by science and technology studies (STS) scholars in understanding the co-production of knowledge and social order and the always socially situated ways in which innovation and governance pathways are appraised (Jasanoff, 2006; Stirling, 2008). In turn, we would look to advance appraisal techniques that build-in diversity and reflexivity from the outset to engender more socially robust knowledge and decision-making (Nowotny et al., 2001; Bellamy, 2016). In particular, we would seek to develop deliberative mapping: a multi-criteria option appraisal process that brings experts, stakeholders and publics together in a symmetrical appraisal of, in our case, alternative policy pathways for governing the changing landscape of science (Burgess et al., 2007; Bellamy et al., 2016). We will draw on the notion of Post-Normal Science (Ravetz & Funtowicz, 2015), particularly for its current discussion of the challenges of maintaining scientific quality under current conditions of research production.

- The meanings and insights of an ecological perspective on knowledge production and

consumption. Can we better understand the relationship between curiosity- and problem- oriented science and how far might we consider these forms as proxies for the issue of expert/democratic control, which innovations such as DIY science may take further? What are limits of self-regulation of the science system and the markers of it? How does new decentralised science production relate to the whole? What are the meanings of ecological niches in this context (as regulatory niches to seek competitive advantage?). Redundancy in science production and the extent to which we can assess ex-post and ex-ante the costs and benefits of 'marginal' or 'useless' scientific production. Implications for Science, Technology and Innovation Indicators: the development from single attribute indicators, through relational indicators, to ecological indicators (what would these look like?) Some of these issues were covered in the OECD 'Blue Sky' Conference on "Towards the Next Generation of Data and Indicators in STI', 19-21 September 2016, Ghent.

- Cultural Theory (Douglas 1970, Thompson et al. 1990) provides a systematic lens through which to view public and expert perceptions and discourses about science, technology, and society. Cultural Theory focuses attention on the co-occurrence and social distribution of preferences for establish trust, distributing liability and obtaining consent (the TLC factors) with specific forms of social and institutional organization (Rayner 1995). It enables us to trace how competing voices in science, technology and policy disputes attribute blame and demand accountability (Thompson & Rayner 1998, Ney 2012) and their preferences for different kinds of policy instruments (Rayner 1991). It is also the basis for the theory of "clumsy institutions" as ways to manage intractable or "wicked" problems (Rittel & Webber 1973) characterised by "contradictory certitudes" (Verweij & Thompson 2006).

- Innovation theory. Innovation has a fundamental role to play in economic and social change. Its beneficial associations with growth and development are well understood and recognised; less well understood is the 'creative destruction' (Schumpeter 1942) of other parts of the economy and society that follow in consequence. These shifts in growth *and* decline in products, services, markets and production are all played out at both an economic and social level and between and within city regions and national states. The rise of open science and innovation, and other aspects of decentralised knowledge production, represents a potentially major paradigm shift in terms of how science and innovation is structured and organised and who benefits and where.

5. Potential policy benefits

The research conducted under CEKA will help us understand the development of new decentralised and citizen-centred knowledge production in relation to the whole system by which knowledge is produced, validated and utilised. In particular it will help us assess:

- whether and in what respects this new production is disruptive, and what new patterns of innovation may be emerging;
- whether and how new modes of doing science affects the balance between the traditional prime governmental target of knowledge in support of economic development, on the one hand, and broad social equity in enjoying the fruits of new knowledge (United Nations 2012), and democratic accountability/approval for the uses of science, on the other;

- policy mechanisms currently being used in the governance and regulation of these new sites and processes for performing S&T at various scales, with particular attention to issues of safety and quality control;
- future S&T policy pathways, including possible new priorities for the university by which the new knowledge production might be supported and encouraged.

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