

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <https://orca.cardiff.ac.uk/id/eprint/77115/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Groves, Christopher Robert 2015. Logic of choice or logic of care? Uncertainty, technological mediation and responsible innovation. *Nanoethics* 9 (3) , pp. 321-333.

Publishers page: <http://dx.doi.org/10.1007/s11569-015-0238-x>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See <http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



# Logic of Choice or Logic of Care? Uncertainty, Technological Mediation and Responsible Innovation

Christopher Groves

Post review version, accepted by *Nanoethics*, 30/09/15

## Abstract

The regulation of innovation reflects a specific imaginary of the role of governance that makes it external to the field it governs. It is argued that this decision and rule-based view of regulation is insufficient to deal with the inescapable uncertainties that are produced by innovation. In particular, using risk-based knowledge as the basis of regulation fails to deal sufficiently both with the problem that innovation ensures the future will not resemble the past, and with the problem that the social priorities that underlie innovation often remain unquestioned. Recently, rights-based frameworks have been defended as principle-based approaches to innovation governance that address the gaps which trouble an understanding of regulation as based on risk-based decision procedures. An alternative, care-based view of governance is defended, in which institutional and practice change, aimed at the creation of specific institutional ‘virtues’ and rooted in the broad and deep participation of publics in shaping innovation is seen as an appropriate way of making governance internal to innovation.

## Introduction

Responsible research and innovation (RRI) has been proposed as an answer to a perceived crisis in the contract between technoscience and society, one which aims to effect a values-based transformation in how emerging technologies, and innovation as such, is governed. This normative stance has been characterised as ‘taking care of the future’ [46]. From this perspective on the purpose of innovation, better regulation in the face of the uncertain risks and ignorance that come with technological novelty requires not better rules, but will instead require changes to practices, and therefore to the institutions that sustain them and to the social relationships built around them. Regulation must therefore shift modes, leaving behind the assumption that governance is external to the ‘object’ it governs and needs to be exercised from a centralised position built on supposedly disembodied knowledge. It must instead be translated into transformed into ‘softer’ forms of governance re-embedded in social concerns and priorities. This implies a new set of responsible and responsive relationships between technoscientific ‘enactors’ and ‘selectors’ [1], as well as requiring a redistribution of agency to create other selectors from among publics who have perhaps been hitherto excluded from this position.

In this article, I argue that the use of a concept of ‘care’ here is not just adventitious, and nor does it transpose regulatory debates into the realm of ‘values’, of motherhood and apple pie. Drawing on the ethics of care, and some examples of the ways in which care has been employed in science and technology studies (STS), I propose that RRI should be viewed as a practice-based and therefore also virtues- or dispositions-based concept of regulation that acknowledges several often overlooked aspects of the human relationship with technology. Not only does a care-based conception of RRI affirm the more-than-instrumental role of technology in human life, it also recognises the multiplicity of pragmatic, ethical and aesthetic values that inform human responses to technologies. I proceed by examining the crisis in the relationship between technological societies and technoscience, which I

argue is rooted in the institutional and collective experience of *reflexive uncertainty*. This gives rise to a double-bind within the ‘ethical life’ of technological societies (in Hegel’s sense of *Sittlichkeit*, the often complex connection between subjective will and objective normative constraints), a condition in which the institutions, practices and products of technoscience must be relied on yet cannot be fully trusted. I then go on to examine some suggestions made by Daniele Ruggiu [2] and Rene Von Schomberg [3] for resolving this double-bind. I then set out in response to these perspectives a framework for thinking about care as the basis of an ethics and politics of innovation guided by a distinctive conception of responsibility as ‘taking care of the future’.

### **Future imaginaries and regulation**

The standard role assigned to regulation in relation to new technologies reflects a specific social imaginary, a set of largely unquestioned attitudes, beliefs and values that help define its purposes and means [4]. This places regulation in a particular relationship to other forms of organised social action, and especially to economic activity. The imaginary in question reflects a specific way of constructing the relationship between present and future, one which has deep roots in European and Anglo-American cultures. To understand this imaginary requires tracing how it reflects widespread shifts in shared attitudes towards the future that occurred in Europe and North America in the period between c. 1600 and c. 1900, amidst successive waves of uneven technological, social and cultural change. Lucian Hölscher [5] suggests that the condensation point for change in how modernising and industrialising societies constructed the future in representation and practice was the way in which a mechanistic natural science made it possible to see the future as a totality of possible and more or less probable events. He refers to the emerging imaginary as that of the ‘mechanised [*technisiert*] future’. Barbara Adam and I have pointed to a similar development, distinguishing between the future horizons of traditional societies, Western antiquity and pre-Renaissance Europe on the one hand and the ‘abstract futures’ of post-Renaissance science, the ‘open’ futures of the Enlightenment, and the ‘empty’ future of neo-classical economics on the other [6].

This distinction between an implicit understanding of the relationship between past and future characteristic of ancient and medieval Europe and ‘modern’ ones has been characterised as one between the world of the ‘divine corporation’ [7] and a world in which this great chain of being has been broken. In the pre-modern worldview, which endured through the Reformation and up to the Counter-Reformation, the immemorial past of divine revelation is seen as determining the ethical life of the present, with individuals assigned by divine appointment to ‘offices’ that prescribe how they should act and what virtues are necessary to their station. The structure of ethical life is thus at once deontological and virtues-based. The dissolution of this worldview comes with the age of scientific and political revolution in the 17<sup>th</sup> century, which emerged alongside the religious unrest of the Reformation and Counter-Reformation. The result is the emergence of a strongly consequentialist (and eventually broadly preference-consequentialist) strand within the ethical life of societies in which the success of efforts at transforming the world is the main criterion of their praise- or blameworthiness. Here, future outcomes are more important than enacting rules rooted in the past.

At the same time as this valorization of innovation and novelty emerges, nascent social sciences model themselves on natural science. They begin to understand the social future as the product of laws (of, for example, population growth and decline or institutional change) as rigid as those thought to operate in nature. Knowledge of social laws began to be seen in intellectual culture as the only genuine source of freedom, the key leverage point for action undertaken in order to shape the future. Then, from the mid-19<sup>th</sup> century on, constructing the future as an object not only of scientific knowledge but of *management* was made possible by mathematical developments in economics, including cost-benefit analysis and marginalist theory [8]. This fuelled the rise of ‘risk thinking’ [9],

coalescing around knowledge practices such as probability theory, welfare economics-based definitions of risk, and the acceptance of preference-based utilitarianism and consequentialism as the appropriate normative frameworks for public administration, whether in matters of public health, infrastructure planning (such as constructing bridges, roads and dams), social insurance or education.

Government power is thus imagined increasingly as administrative and managerial as well as sovereign [10]. It becomes consolidated by practices of standardisation and quantification employed by centralised states in order to make the nations they rule legible to them [11]. Similar methods evolved for surveying future possibilities and outcomes. This creates a new politics of the future, in which some social actors (governments and their agencies, but also corporations) able to leverage expertise in prediction and foresight are able to plan and act with more strategic consistency, flexibility and speed than others. This effectively colonises the future just as 19<sup>th</sup> century imperial powers colonised vast areas of the globe, thus creating conditions in which less knowledgeable and powerful others will later have to operate and make decisions [12].

Against these developments, the relationship between administrative government and the fields of social activity it covers increasingly takes on the regulatory form described by Lösch, Gammel, and Nordmann [13], that of an external governor of activity. This form reflects a specific legacy of the new ‘mechanised’ imaginary of the future, in which the maximum satisfaction of preferences is privileged as a moral touchstone. In particular, it reflects developments in the nascent science of thermodynamics (that would, in turn, later undergird the development of cybernetics). The governor of a steam engine, or other machine, is a device that acts as one of its subsystems, and registers when a system state variable (such as pressure) is increasing too fast or approaching a dangerous level. It then triggers a mechanism to lower pressure, speed etc. to a safe level. It thus represents a negative feedback mechanism that is added to the engine. Although the relationship between subsystem and main system is one of feedback, this feedback function is limited. The main system provides information to the governor, which acts back upon it at a certain point to keep its operating parameters within certain levels.

In the 19<sup>th</sup> and 20<sup>th</sup> centuries, the dominant imaginary of governance borrows from this construction of risk and uncertainty in engineering. Regulation is positioned in a relationship with social action similar to that between the machine and its governor. However, with an engineered system like a steam engine, its safety parameters have largely been decided in advance, thanks to extensive calculations, experimental testing of materials and assemblies beforehand, and practical experience ‘in the field’. Some tinkering may be necessary in practice with each new machine, but general parameters of safe operation have been established. The situation is quite different, however, with emerging technologies – and even more so when innovation as such becomes the object of governance [14].

### **Reflexive uncertainty and the ‘double bind’**

If a post-‘divine corporation’ world is one that is organised around the idea of an open and improvable collective future, then it is also necessarily one organised around foresight. The need to estimate the consequences of actions in order to determine whether one has acted *ex ante* responsibly is part of a new understanding of future-oriented responsibility that comes with the demise of the divine corporation. Yet at the same time, the complexities that new technologies bring are hard to factor in to foresight, and in many cases impossible. Technological innovations both draw on knowledge and create it, but they also simultaneously produce non-knowledge and ignorance [15, 16]. Re-engineering

nature to add previously non-existent entities to the world creates, as Ian Hacking argues, the problem of side- and interference effects, which arise out of unforeseen interactions between such entities and natural or other engineered systems [17]. As Hacking points out, this creates systems with emergent properties, the behaviour of which cannot be predicted on the basis of existing knowledge. The problem is therefore often that the unpredictable is more of a problem than the predictable. A central feature of a post-‘divine corporation’, improvable world is that the past is often not a reliable guide to the future. Yet we tend to operate, in moral and legal contexts, as if it were.

Consequentialists have tried to respond to such problems related to uncertainty by distinguishing between the use of consequentialist principles (such as the principle of utility) as criteria for deciding in general what makes an action right or wrong, and the employment of such principles as empirical decision procedures. The problem with such a distinction, however, is that the existence or non-existence of particular kinds of uncertainty or ignorance has a specific bearing on whether normative distinctions between different actions established by, say, the principle of utility are stable or not. Saying that we should always act to maximise utility or follow rules that have this effect does not help us in situations where it is unclear what it might mean to maximise utility in terms of future outcomes [18].

The key problem is that to define a subset of future possibilities as risks, determinate probabilities of specific losses or harms, relies on scientific foresight regarding the likely consequences of acting in particular ways. However, this foresight is not contingently, but in certain circumstances (as Hacking shows) necessarily limited. Uncertainty thus becomes reflexive, created in part by what we do and also by the forms of knowledge that make our actions possible. The result is a kind of double-bind. To want to improve the world through the creation of new technical means leads us to look ahead to make our actions justifiable in the present, but the only tools we possess for the task of looking ahead are ones which have been honed to understand the world of the past and present, not a world in which as yet uncreated novel entities exist. Examples such as the use of dichlorodiphenyltrichloroethane (DDT) show how the modelling of suspected risks (what is the probability of exposure to DDT affecting human health?) can miss unknown mechanisms of harm, such as the effects of bioaccumulating DDT on bird populations. If we want to improve things, we must take a gamble – but the moral justifiability of this gamble seems impossible to establish (given reflexive uncertainty) on preference-consequentialist grounds. An unwillingness to full acknowledge this leads us towards what Ulrich Beck calls organised irresponsibility, a kind of institutionalised moral corruption.

This corruption is encouraged by the fact that focusing on the assessment of knowable risks rather than on acknowledging and dealing with deeper uncertainties has strategic political value. It provides a way of justifying policy and constructing reputational capital [19] that both buttresses economic and cultural power and helps maintain valued identities – for individuals and for organisations. Concepts of risk, which render uncertainty determinate and promise that it can be reduced and controlled, perform the symbolic function of demarcating the risky from the unpredictably dangerous [20], domesticating uncertainties surrounding everything from infrastructure projects to health behaviours, and thus allowing them to be governed. This demarcation represents a new moral divide between the pure/responsible and impure/irresponsible [21]. At the same time, the irresponsibility of a tendency to focus on knowable risk is evident. Indeed, a post-‘divine corporation’, innovation focused and technologically-dependent world carries with it an uncertain future that is like a vast and, moreover, constantly changing [22] ocean of which only a small region, shaped by a range of assumptions, can be encapsulated within the sphere of known or knowable risk [23]. Nonetheless, the possession of the institutional capacity to perform due diligence by defining, assessing and then managing risks within a

given bureaucratic and legal framework can assist social actors to create and redistribute uncertainty and risk in ways that benefit them [24]

In such circumstances, which have been described as characterised by a move towards post-normal science [25] or the emergence of a ‘risk society’ [26], the use of quasi-legal instruments such as the precautionary principle has grown amidst a new ethics and politics of uncertainty. Rather than being a tool of top-down governance that takes the form of ‘hard law’, the precautionary principle is chiefly a decision-making tool for the executive [27] that is designed to acknowledge and make actionable the uncertainties which inevitably surround attempts to read off from scientific knowledge definitive conclusions about the legitimacy or otherwise of actions taken in the present. Beyond the executive, it also represents to a lesser extent a shield for those seeking to challenge regulatory decisions which they feel expose them to unacceptable risks [28]. In this way, it represents an administrative brake on innovation while also responding to the condition of post-normality.

The precautionary principle is one of a variety of other normative instruments that are created as part of the efforts of technological societies to cope with reflexive uncertainty, and which are wielded by, as well as shaping the behaviour of, a variety of non-governmental as well as governmental actors. These include codes of conduct, standardisation processes and the standards they create, contracts, funding schemes, economic incentives like subsidies and tax credits, licences and accreditation schemes. There are thus a multitude of regulatory tools and institutions which may be leveraged in creating what are felt to be ‘responsible’ modes of action in the face of deeper uncertainty, with ‘hard’ legislation being only one of these options [29]. Soft regulation moves upstream in the innovation process, shifting away from a command-and-control model that imposes an external ‘governor’ on the products of a still essentially linear innovation process towards a model of continual intelligence gathering [30] that aims to modulate and shape innovation processes by reflexively guiding the implicit assumptions about their proper purposes and what might constitute significant unwanted potential impacts.

If the preference-consequentialist moral framework implicit in the imaginary of regulation as an external governor becomes increasingly problematic in the face of reflexive uncertainty, then we are left with an outstanding question: how to relate to each other the various governance tools that evolve in increasingly technological societies, and thus to make them cohere around explicit ethical and moral considerations. Without such efforts, then the desire to respond to the double-bind laid out above with, for example, a precautionary approach may become problematic. What kinds of potential harm should we be precautionary about? We might want to be precautionary about potential harm to the natural environment, given that it may be serious and irreversible. But some may want to be precautionary about economic harm, as this could also be serious and irreversible [31]. This raises the prospect of value conflicts that afflict governance tools and which cannot be resolved solely with the aid of these tools themselves, insofar as they rely solely on preference-consequentialist frameworks that fail in the face of reflexive uncertainty. We therefore need to reposition the debate on the level of normative ethics, and to consider whether another normative ethical framework other than that of preference-consequentialism can provide an adequate basis for responding to the challenge of reflexive uncertainty.

This repositions the debate on the level of normative ethics, and the extent to which different frameworks in normative ethics can help us deal with reflexive uncertainty. One recent attempt to think further about these issues is provided by Ruggiu [2], who suggests that the relationship between the determinate risks of extant technologies and the uncertainties surrounding emerging technologies is essentially one between two different temporalities of concern, and therefore requires a two-

pronged regulatory approach. On the one hand, innovation creates products which, once they have emerged, require command-and-control regulation that is moulded around relatively tight and short ‘timescapes’ [32] of anticipation, observation and action. On the other hand, innovation as a process requires forms of regulation which are more open-ended and adaptive in order to shape it towards particular ends. Ruggiu suggests that the two forms are related to each other as rules are related to principles. The case of products is one in which the relevant question is whether it falls under exclusions or prohibitions mandated by a regulatory rule (i.e. is  $x$  hazardous to human health?) based on scientific evidence about its characteristics, whereas innovation processes require principles that have to be specified in individual cases through wider ranging processes of reasoning and debate, and which are ultimately anchored in principles commanding wide assent such as human rights. In such cases, there are a variety of uncertainties which may be relevant, such as the decision horizons that properly pertain to a particular process, the nature of significant harm, and so on [33]. It is important to distinguish between the two temporalities in order to ensure that governance is attentive to evidence of emerging risks while also avoids responding to the challenge of reflexive uncertainty by anticipating irreversible and serious hazards everywhere and thus slowing innovation down too much [34].

However, this distinction may be problematic. The uncertainties which surround products may, for example, also be open-ended and attached to processes whose outcomes may remain latent for long periods. New products, as in the case of nanomaterials of various kinds, often therefore open up regulatory gaps [35]. Criticising a risk management framework for nanomaterials produced by the International Risk Governance Council (IRGC) (whose ‘two frames’ approach is mirrored in Ruggiu’s argument), Bijker et al. [36] note that uncertainty, ignorance and social ambiguity may be as relevant to current products as much as they might be to emerging innovation. Trying, for example, to determine whether a particular product falls under a given regulation may require research that comes before or after it goes to market (depending on the sector and relevant regulations), as assessing harm may be extremely difficult without detailed and long-term life-cycle analyses [37]. Further, future products may make such longer-term uncertainties even more relevant for thinking about how risk governance itself may need to evolve. For example, Davies [38] points out that the potential hazards presented by new generations of complex and increasingly active nanomaterials may be synergistically dependent on chemical composition, physical form and environmental context in ways that current approaches to risk assessment and management are ill-equipped to handle.

The difficulty with such solutions does not lie in the difference between the forms of uncertainty pertinent to the regulation of products versus the regulation of innovation. Instead, it persists at the level of normative ethics, and derives from the reliance on preference-consequentialist moral principles and therefore on foresight that is evident in both portions of Ruggiu’s regulatory framework. Nasty surprises may be waiting ahead, even where hitherto well-characterised risks are concerned – for example, if products are used in unforeseen ways or they enter into unexpected interactions with natural or other technological systems. The difficulties with exercising foresight in a way that provides sufficient justification for action are an intrinsic part of the regulation of both extant and emerging technologies. It is thus necessary to provide a normative foundation for regulation that comprehensively addresses these persistent shortcomings, and places the possibility of unpleasant surprises at the forefront of concern, rather than subordinating it to a secondary position.<sup>1</sup>

---

<sup>1</sup> This assumes, of course, that the predicament described above cannot be resolved simply by trying to avoid Hacking’s ‘interference effects’ by renouncing certain forms of technology entirely.

## Normative foundations for regulation: from rights to care

### *Rights as normative anchor points*

The need to examine the principles and/or values on which regulatory regimes are erected is a direct response to the fact that innovation means the past is no longer a reliable guide to the future, and that preference-consequentialism is therefore a problematic normative theory. Although reliable and adaptable forms of risk assessment within mandatory regulatory frameworks are still essential for product safety, the problem of novelty discussed in the previous section means that such approaches to risk need to take their place within a broader approach to living with reflexive uncertainty as such. The regulatory problems which are issued in by innovation are not just epistemological problems of limited information or knowledge, as the classic statement of the problem of novelty in the Collingridge dilemma would have it [40]. The problems created by innovation are an outgrowth of human finitude [23, 39], a condition that modernity believed it had outgrown, believing instead that all barriers to human progress could be overcome through technology. Rather than believing uncertainty and ignorance can necessarily be reduced to knowable risk, and thus transformed into objects that can be managed or governed, it is necessary to find other ways to live with them. The idea that the relationship between regulation and its object is essentially that between a ‘governor’ and the machine it governs is an obstacle to achieving this.

A different normative ethical framework, one which recognises the inescapability of reflexive uncertainty, together with its ethical and moral significance, is thus required. Ruggiu [2] argues that human rights provide such a framework, particularly within the EU context. These can serve as principles which both guide risk-focused regulation in the present and are adequate to shape future-oriented ‘soft’ regulation (as represented by the frameworks discussed in this issue by Jahnel, for example). This approach is mirrored by Rene von Schomberg in his discussion of RRI as a values-based framework for the regulation of innovation, in which the rights affirmed in Article 3 of the Treaty of Europe are put forward as ‘normative anchor points’ for regulation [3]. Rights serve as a bulwark in the face of uncertainty, recognising the weakness of preference-consequentialist principles (such as the principle of utility) as moral guidelines in the face of great uncertainty. In this way, the legitimacy of decisions may be built on principles which already command assent because they are enshrined in legislation enacted by a democratically-representative body.

But normative frameworks of the kind pointed to by Ruggiu and von Schomberg are insufficient to replace the preference-consequentialist framework that is part of the imaginary of governance we have surveyed above. The question raised by the collective experience of reflexive uncertainty and its accompanying ethical double-bind is no longer one concerning the effect of the outcomes of action on preferences, is instead the age-old philosophical question, ‘how should we live?’ Ruggiu and von Schomberg respond to this challenge by articulating values-led frameworks for regulation. Under these frameworks, the social priorities that motivate innovation will be examined, with the goal of redirecting it towards priorities that are enshrined in collective agreements. If we cannot know all the risks associated that may be associated with nanomedicine or the genetic modification of insects, then at least we can perhaps come to an agreement on whether it is worth living with the uncertainties that surround them in the interests of a morally and politically acceptable or even desirable social goal – such as curing cancer or wiping out malaria. Human rights frameworks, whether international or not, may not be sufficient guides here, however.

First, rights gain traction as principles for deciding what kinds of outcomes are morally relevant, and to what extent they are morally permissible or not (for example: would enforcing a new immigration law infringe against the right under the European Convention on Human Rights to a family life?). But



in relation to innovation, uncertainty extends to whether particular directions for innovation might actually have negative consequences for human rights or not [41]. The problem of reflexive uncertainty surfaces again. Second, what counts as responsible in some national or international contexts may entail a very different balance between social priorities and rights to that which may be seen as socially legitimate in other jurisdictions, reflecting differences in developmental needs as well as cultural distinctions, as has been argued in relation to differences between the EU and BRICS nations, for example [42]. This point is reflected in Schomberg's defence of a specifically 'European' view of responsible research and innovation that recalls John Rawls' theoretical anchoring of political philosophy in the traditions of a 'people' [43]. Third, the balance between competing priorities that become enshrined in rights (such as, in the European context, economic growth versus sustainability), might look very different from an intergenerational and longer-term future-oriented perspective than from a shorter term one.

If we need to foreground some normative ethical framework other than either preference consequentialism or a rights-based approach to answer the question 'how should we live', then where should we look for it? In the rest of this paper, I suggest that these should be provided by an approach that focuses not primarily on outcomes, but on individual and institutional dispositions and virtues via which certain outcomes are more likely to be reached. This represents, I suggest, a development of an approach based on the ethics of care.

### ***From 'logic of choice' to 'logic of care'***

The idea that a virtues-based ethical perspective is a more appropriate response to a situation of great uncertainty or ignorance is not new [18]. Recently, an argument for a virtues-based approach to uncertainty and ignorance has been made by advocates of a proactionary principle. From this point of view, adaptive, risk-based regulation and an affirmation of the contribution of innovation not just to material progress but also, through participation in it, to the meaningfulness of human lives more generally [44, 45]. But such a gung-ho affirmation of risk itself presupposes that one values risk-taking for its intrinsic value. As was pointed out above, however, the power to innovate and commercialise innovations is also a power to create, redistribute and impose risks and uncertainties. Responding to the 'how should we live' question with the answer 'riskily!' is to ignore the other question to which the experience of reflexive uncertainty gives rise, as to how we collectively decide *which* risks and uncertainties are worth bearing.

A perspective on the governance of technology that views it as 'taking care of the future' [46] necessitates a different approach. On the one hand, it has to recognise the centrality of human need to any ethical framework. It can thus draw here on the ethics of care, in which it is typically proposed that one should act in ways that elicit, recognise and provide for needs attentively and respectfully. Meeting needs requires certain virtues: attentiveness, respect for the otherness of the cared-for other, and so on [47]. But there is arguably more to care than this. Care also recognises that attachment relationships are a central element in what it means to be human, because attachment is the foundation of how humans, as vulnerable creatures, domesticate an uncertain future to a degree through sociality [48]. The emphasis of the ethics of care on particular relationships, then, reflects a particular interpretation of what a good life consists in, namely connectedness [49]. One consequence of the centrality of connectedness to human life is that the needs of individuals (and groups) are therefore not 'encountered' by people as generic ('I need 2000 calories a day to survive) but as singularized within a complex context of connectedness that is biographically and historically shaped ('I must spend Passover dinner with my family, it's the most important evening of the year') [50]. Perspectives

that view needs, capabilities or other ingredients of human flourishing as generic or ‘given’ therefore fail to address questions of ‘how they are constructed and reproduced’ [51] within social groupings. Needs, rather than being easily universally definable, are always constructed in the process of meeting them in ways that are emotionally and symbolically constitutive of individual and group identities (as with the Passover meal, or kosher and halal food, for example). Care for the needs of others is not care for generic humanity, but care for a particular and singular other who is also a member of a variety of groups with their own particular histories (and who remains in part unknowable in his/her singularity). As care is a practical matter of *techne*, it also relies on technological support. Technologies therefore play a vital role, not only as tools but as mediators of how needs are defined or met. Technologies are not simply means for fulfilling pre-defined needs, then. They help to construction and singularize what needs mean. Technologies shape what caring for needs means, and what the consequences of constructing needs in particular ways may be for our sense of who we are.

Annemarie Mol [52] has explored this role of technology at length, examining the ways in which everyday technologies such as diabetes monitors are intermediaries in the achievement of care, and how, as such intermediaries, they change what it means to care successfully by altering our conceptions of need and so ‘interfere with their own ends’. Someone with diabetes, for example, can now measure their insulin levels much more frequently now that small portable monitors are readily available. This has changed what health professionals understand by successful treatment of the condition [52, p. 49]. Care therefore has to be conceived as a narrative process. The changing meaning of earlier actions and decisions over time helps participants understand what to do later on. As we have seen, what it means to care successfully also changes over time. Engaging in care therefore requires agents should be alive to the inherent uncertainties that surround acting, and not least to the final unknowability of others who are cared for, in their singularity. Part of recognising the otherness of others is the acknowledgement of the irreducibility of their perspective on the world, which is expressed in their activities of sense-making and in action. It is this otherness of others that demands from the ‘carer’ the cultivation of particular virtues, which prevent them from acting too hastily or paternalistically. Further, the otherness of the other lies in its share both of the future and of the future’s unpredictability. This share, a singular future in which there is always something to be settled, something ‘outstanding’ for the subject, means that care is always ‘about’ the future, an insight which connects the ethics of care to Heidegger’s account of *Dasein* as the being for which the world is an ‘issue’ [53].

At work in this approach is a temporality different from that evident in what Ruggiu identifies as the short term focus of command and control regulation, or that manifest in the imaginary-driven, scenario-using approach that focuses on the longer term. Mol identifies this temporality as a ‘logic of care’ rather than one of ‘choice’. Instead of trying to collect, condense and process information so as to arrive at a punctual decision, the logic of care identifies the temporal context of action as an open-ended and evolving narrative, one in which sense-making is recursive in nature. What emerges from out of the future enables us to revise our understanding of the past, and our changing understanding of the past enables us to act in the present to realise or prepare for particular futures. But the emphasis is not on controlling the future, but identifying from within narratives of care the needs of the cared-for, including the ways in which s/he is best able to exercise agency, from their position, in making sense of and influencing their own future. As participants in the construction and reproduction of needs and thus of socially-recognised ends, technologies play a role in shaping and reshaping the recursive narratives of care Mol describes.

### ***Towards a new ‘culture of innovation’***

A care perspective such as that outlined here therefore leads us to think again about the role and meaning of governance. It aligns itself with recent calls for the governance of innovation to move upstream [54], to a point before visions and research congeal into products, so as to help shape the priorities which in turn influence the course of innovation through expectations and other factors. At the same time, the temporal logic of care requires that governance mechanisms should be such so as to accompany innovation through distinct stages and at different levels – identifying and defining social priorities, but also influencing design as well as shaping risk identification, assessment and management. The reflexivity towards priorities and guiding values which was the goal of upstream engagement would be developed further by this approach, and made part of a continual process of social learning. At the same time, the ‘engagement’ here would need, as advocates of upstream engagement have argued, to be designed to involve a wide range of stakeholders in deliberation. The goal of deliberative engagement here would be twofold.

On the one hand, it would seek to ensure that better anticipation of impacts of innovation is made possible, with a view to anticipating or building resilience against impacts that may occur in either the nearer or the more distant future. On the other, it would also have to embody the sensitivity of care to the particularity of needs, going beyond the appeal to rights and acknowledging how needs are historically (and technologically) constructed. Opening up innovation and its implicit priorities to wider scrutiny and deliberation would facilitate this by bringing a spectrum of perspectives to bear on research, development, design and commercialisation. A care perspective would view the governance of innovation as a way of re-embedding technoscience within society, of making it more responsive to a range of pragmatic, ethical and aesthetic values, rather than as a transcendent oversight mechanism structured by risk thinking. In particular, it would refuse

*to separate needs from the people who are their subjects and takes as its starting-point the idea that people themselves (can) have knowledge about their own subjectivity; in principle they are competent to express who they are and what they need. It takes seriously people’s stories about what they need to live well.*  
[55, p. 60]

Rather than making *rules* or *principles* the basis of regulatory decisions, then, a care perspective looks to create *institutions* and *practices* to create a new bond between science and society. Rather than being a contract, in which each party agrees to restrict themselves to particular actions only according to specific rules or principles (whether command-and-control rules or principles such as human rights), this bond would be more of a solidaristic form of cooperation, through which the interdependence of society and innovation in defining ends and creating means is recognised. This bond would be dependent on the inculcation of particular durable mutual expectations on the part of each side. Such expectations could only be created and sustained if it is possible for actors on either side, ‘enactors’ or ‘selectors’ in Garud and Ahlstrom’s [1] terminology to demonstrate particular and contrasting virtues.

For example, Stilgoe, Owen, and Macnaghten [46] discuss four ‘innovators’ virtues’ which might be considered candidates to serve as the basis of this new bond: anticipation, inclusion, reflexivity and responsiveness. These represent respectively the capacity to develop better and more adaptive foresight to spot instances where uncertain hazards may be expected, the ability to open up reflection on both the limits of foresight and the purposes for which innovation is undertaken, the capacity to

open up innovation processes to active engagement with other stakeholders (including publics) and the ability to respond to (if necessary, with changed plans) to what is learned through such engagement. One could also add ‘humility’, understood as a capacity to reflect upon both the limitations of one’s capacities to achieve ends with the aid of technology, and upon the dangers of actually achieving one’s intended ends through technical means [56]. What the virtues of a ‘selector’, imagined as a technological citizen, might be, are quite distinct. By ‘technological citizen’ [57] is not intended a subject who fits the categories of ‘informed’, or ‘pro-technology’ as has been imagined by successive waves of deficit-model based public education programmes [58, 59]. On the contrary, it refers to citizens who are able to create communities of interest (and with them, new social identities) around specific complexes of problems and potential technological, but also social and institutional, innovations [60].

As has been argued by a variety of writers on the ethics of care and its political extension [47, 55, 61, 62], the introduction of care to the public sphere is not intended to create a new ‘organic’ political realm, or remodel public life on the model of the private sphere, but to reconstitute the public sphere by transforming institutions and practices in ways that recognise more adequately the interconnectedness and interdependence of citizens and institutions. Indeed, what is implied by such an ethics and politics of care is a revision of how we understand citizenship. Such a revision would recognise citizens as technological [57] and ecological [63], alongside the inescapably embodied, connected and vulnerable nature of ethical and political subjectivity [64]. This means that enactors and publics alike are composed of individuals who are relational and interdependent, but that their relationship vis-à-vis one another is asymmetrical, rather than being formally equal and reciprocal as in classical accounts of the relationships between citizens that are constitutive of a social contract. Re-imagining institutions to bind new relationships between science and society needs to begin from this insight to re-visit initiatives like the ‘science shops’ movement, started in the Netherlands in the 1970s [65], as a way of developing responsive [46] innovation, shaped by problems identified by publics. The outward-facing scientific specialists involved in developing these new institutions need to be open to the agency of potential publics, and the capacity of active communities to form around needs and interests [60].

Elsewhere [66], I have discussed an example of how the ‘soft’ governance of innovation can shape legitimacy by recognising this asymmetrical interdependence, along with specific vulnerabilities that arise from interconnectedness and the ways in which technologies mediate purposes and identity. Here, soft governance means values-led corporate social responsibility. During an earlier study [67], an interview was conducted with a small technology company that focused on developing technologies (nanosensors designed to detect volatile organic compounds [VOCs]) using nanomaterials (carbon nanotubes) purchased from an upstream supplier. The role of N in the value chain was identified in interview as ‘like an R&D consultancy’, with the core of business being product development intended to ‘inspire’ their partners elsewhere in the value system – consumer product manufacturers, in the main – to create new applications for nanosensors. A central focus of N’s work was determining which applications would ‘meet a critical customer need’, which required understanding end-user needs. N’s engagement with potential end-users, such as asthma sufferers, takes place in focus groups, intended to establish whether ‘they need the technology’, establishing that it ‘would add tremendous value to their quality of life’. But this value, N suggested, would be derived not by meeting a need defined technically and abstracted from the experience of users.

Such an abstract definition might identify a user need as, for example, maintaining health by avoiding or mitigating asthma attacks. A nanosensor could then be used to detect biomarkers such as the presence of volatile organic compounds in breath to spot, early on, signs of impending attacks. But

focus groups of potential users defined the ‘compliance of actually using those devices’ as a major consideration. Some researchers have suggested that compliance with health monitoring may be compromised by resentment at the dependence on artefacts, and the confirmation of a dependent identity, one is thereby forced into [67]. Drawing on focus group data, N decided to incorporate nanosensors in devices like mobile phones, which are not only convenient and increasingly ubiquitous, but are also associated with independence and autonomy. In this way, the purpose of the sensor was redefined through consultation with potential users, bringing to light the ways in which using sensors relate to (and may reinforce) aspects of identity that individuals evaluate negatively. By changing product design, these concerns relating to a specific identity, and to the kinds of agency associated with that identity, could be successfully resolved.

Here, uncertainties surround innovation as a process, rather than being attached to a specific object (the nanosensor) as such, in abstraction. The focus of these uncertainties is on the meaning of a technical artefact designed as a solution to a particular problem. Products based on nanosensors of the type produced by N may be classed as a medical device and therefore subjected to specific risk-management regulations in different jurisdictions. They may also be subject to end-of-life disposal regulations (such as the Waste Electrical and Electronic Equipment Directive in the European Union), due to their being included in electronic devices. Debates around the adequacy of these regulations as ways of avoiding or mitigating risks may be necessary. But the case study points to how deeper uncertainties can surround the value and social meaning of products already in existence, even where issues relating to risk (e.g. relating to medical device use or environmental pollution) may have already been well-defined.

The uncertainties addressed by what N described as a values-led form of voluntary governance concerned the nature of the specific problem devices using nanosensors were designed to address. Without establishing a relationship between the company and potential end-users in which the specific needs and vulnerabilities of a group who experience themselves as possessing a certain identity (‘asthma sufferers’), the nature of the problem would remain defined unreflexively from an abstracted, ‘expert’ perspective. By developing such a relationship, the company demonstrated a form of care for the particularities of needs and the singularity of subjects, one that avoided overstepping the mark by defining needs without reference to the self-understanding of asthma sufferers. Instead, it took seriously ‘their stories about what it is to live well’, in Sevenhuijsen’s words, and made space for their own agency in defining their needs.

As Callon, Lascoumes, and Barth [60] note, the key problem of democracy is how minorities will be represented in public life. If technological innovation is, to borrow Shelley’s description of poets, an ‘unacknowledged legislator’ of the world, re-shaping the ways of life of groups and individuals globally, then it is about more than how preferences, expressed in consumption decisions, can be fulfilled. Through participation in scientific research and technological innovation, loose assemblages of subjects, from sufferers of ‘orphan’ neuromuscular diseases to those living near hazardous infrastructure can gain identities, agency, and recognition in public life. In relation to such efforts to create agency, technoscience can play a valuable mediating role, helping to take care of agency just as the effective participation of ‘minorities’ in creating and shaping innovation processes can take care of the capacities of technoscience.

## Conclusion

The dominant imaginary that has helped to shape the regulation of technology, as we have seen, has positioned governance externally to the practices and artefacts which it regulates, with the result that regulation always lags behind the activities of technoscience. In trying to remedy this temporal lag, governance has to depend on frameworks (such as standard approaches to risk assessment and management) which tend to ensure that it holds its vision fixed firmly on the past in trying to anticipate the future, and is thus always fighting the last war again, even when the processes of innovation it is attempting to regulate decisively change the terrain. It has been argued in this paper that the field of uncertainty which surrounds innovation should be understood, first and foremost, through the normative uncertainties which are the legacy of preference-consequentialism as applied to social and technological innovation. These force us to reconsider the normative ethical assumptions implicit in how we understand innovation and regulation together.

It was argued that the precautionary principle, understood as an administrative apparatus, is insufficient, being too indeterminate in its application. Rights, it was further suggested (following Groves [41]) are insufficient to counter problems associated with the dominant regulatory imaginary and introduce new forms of uncertainty (relating to cross-cultural and intergenerational dimensions). Care as a normative framework was put forward as an alternative which can address these problems. Instead of offering Ruggiu's choice between rules (for risks) and principles (for uncertainties), care demands the creation of institutions and practices that exhibit particular virtues, and which maximise the promotion of agency among publics to shape the social priorities which guide innovation, as well as to articulate the specific needs and vulnerabilities which they experience (thus allowing citizens to enter the public sphere and take on new public identities). Rather than seeking to re-tool regulation in order to reduce uncertainty for citizens imagined as consumers, a care-based perspective begins from an understanding of citizens as relational (technology-using, ecological, embodied) and moves to propose ways of re-making the cultures in which innovation is pursued to create new forms of solidarity mediated by technological artefacts [68]. As such, it is a recommendation that we learn, collectively but (given our asymmetric relationships to other actors) variously, to turn innovation processes into ways of realising solidarity in the face of inevitable uncertainties.

## Acknowledgements

Research referred to in the text was funded by the UK Department of Environment, Food and Rural Affairs (Grant No. CB0417).

## References

1. Garud, Raghu, and David Ahlstrom. 1997. "Technology assessment: a socio-cognitive perspective." *Journal of Engineering and Technology Management* no. 14 (1):25-48.
2. Ruggiu, Daniele. 2013. "Temporal Perspectives of the Nanotechnological Challenge to Regulation: How Human Rights Can Contribute to the Present and Future of Nanotechnologies." *NanoEthics* no. 7 (3):201-215.
3. Von Schomberg, René. 2011. *Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields, Research and Innovation Policy*. Brussels: European Commission.
4. Taylor, Charles. 2004. *Modern social imaginaries*: Duke University Press.
5. Hölscher, Lucian. 1999. *Die Entdeckung der Zukunft*. Frankfurt a. M.: Fischer.
6. Adam, Barbara, and Christopher Groves. 2007. *Future Matters: Action, Knowledge, Ethics, Supplements to the Study of Time*. Leiden: Brill.

7. Schneewind, J. B. . 1984. "The Divine Corporation and the history of ethics." In *Philosophy in history: essays on the historiography of philosophy*, edited by R. Rorty, 173-192. Cambridge: Cambridge University Press.
8. Porter, Theodore M. 1995. *Trust in numbers: the pursuit of objectivity in science and public life*. Princeton: Princeton University Press.
9. Rose, Nikolas. 1999. *The powers of freedom: reframing political thought*. Cambridge: Cambridge University Press.
10. Macintyre, Alisdair. 1981. *After virtue: a study in moral theory*. London: Duckworth.
11. Scott, James C. 1998. *Seeing like a state: how certain schemes to improve the human condition have failed*. New Haven: Yale University Press.
12. Groves, Christopher. 2013. "Horizons of Care: From Future Imaginaries to Responsible Research and Innovation." In *Shaping Emerging Technologies: Governance, Innovation, Discourse*, edited by Kornelia Konrad, Christopher Coenen, Anne Dijkstra, Colin Milburn and Harro van Lente, 185-202. Berlin: IOS Press/AKA.
13. Lösch, Andreas, S. Gammel, and A. Nordmann. 2009. "Observe-Probe-Regulate: Embedding Nanotechnological Developments in Society." In *Jenseits von Regulierung: Zum politischen Umgang mit Nanotechnologie*, edited by A. Lösch, S. Gammel and A. Nordmann, 3-15. Heidelberg: AKA Verlag.
14. Felt, Ulrike, and B. Wynne. 2007. Taking European knowledge society seriously. In *Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate-General for Research, European Commission*. Luxembourg: Office for Official Publications of the European Communities.
15. Schummer, J. 2001. "Ethics of Chemical Synthesis." *Hylé* no. 7 (2):103-124.
16. Gross, M. (2007). "The unknown in process - Dynamic connections of ignorance, non-knowledge and related concepts." *Current Sociology* 55: 742-759.
17. Hacking, Ian. 1986. "Culpable Ignorance of Interference Effects." In *Values at Risk*, edited by Douglas MacLean, 136-54. Totowa NJ: Rowman and Allanheld.
18. Jamieson, Dale. 2007. "When Utilitarians Should Be Virtue Theorists." *Utilitas* no. 19 (02):160-183
19. Power, Michael. 2004. *The risk management of everything: rethinking the politics of uncertainty*. London: Demos.
20. Crawford, Robert. 2004. "Risk Ritual and the Management of Control and Anxiety in Medical Culture." *Health*: no. 8 (4):505-528.
21. Douglas, Mary. 1966. *Purity and danger : an analysis of concepts of pollution and taboo*. London: Routledge & Kegan Paul.
22. Orléan, André. 2010. *The Impossible Evaluation of Risk, Prisme 18*. Paris: Cournot Centre for Economic Studies.
23. Groves, Christopher. 2009. "Nanotechnology, Contingency and Finitude." *Nanoethics* no. 3 (1):1-16.
24. Vail, John. 1999. "Insecure times: conceptualizing insecurity and security." In *Insecure times: living with insecurity in contemporary society*, edited by John Vail, Jane Wheelock and Michael Hill, 1-22. London: Routledge.
25. Ravetz, Jerry. 2004. "The post-normal science of precaution." *Futures* no. 36 (3):347-357.
26. Beck, Ulrich. 1992. *Risk society : towards a new modernity, Theory, culture and society*. London: Sage Publications.
27. Boehmer-Christiansen, Sonja. 1994. "The precautionary principle in Germany—enabling government." In *Interpreting the precautionary principle*, edited by T. O'Riordan and James Cameron, 31-61. London: Earthscan.
28. Raffensperger, Carolyn, and Joel J. A. Tickner. 1999. *Protecting Public Health and the Environment: Implementing The Precautionary Principle*. Washington, DC: Island Press.
29. Hodge, Graeme A., Andrew D. Maynard, and Diana M. Bowman. 2014. "Nanotechnology: Rhetoric, risk and regulation." *Science and Public Policy* no. 41 (1):1-14.
30. Royal Commission on Environmental Pollution. 2008. *Novel materials in the environment: the case of nanotechnology*. Norwich: The Stationery Office.

31. Holbrook, J. Britt, and Adam Briggie. 2013. "Knowing and acting: The precautionary and proactionary principles in relation to policy making." *Social Epistemology Review and Reply Collective* no. 2 (5):15-37.
32. Adam, Barbara. 1998. *Timescapes of modernity: the environment and invisible hazards*. London: Routledge.
33. Hansson, S. O. 1996. "Decision Making Under Great Uncertainty." *Philosophy of the Social Sciences* 26:369-386.
34. Maynard, Andrew D. 2014. "A decade of uncertainty." *Nat Nano* no. 9 (3):159-160.
35. Frater, Lori, Elen Stokes, Robert Lee, and Taiwo Oriola. 2006. An overview of the framework of current regulation affecting the development and marketing of nanomaterials. Cardiff: BRASS.
36. Bijker, W. E., I. D. de Beaufort, A. van den Berg, P. J. A. Borm, W. J. G. Oyen, G. T. Robillard, and H. F. G. van Dijk. 2007. "A response to 'Nanotechnology and the need for risk governance' O. Renn & M. C. Roco, 2006. *J. Nanoparticle Research* 8(2): 153-191."
37. Maynard, Andrew, R. J. Aitken, T. Butz, and V. Colvin. 2006. "Safe handling of nanotechnology." *Nature* no. 444:267-9.
38. Davies, J Clarence. 2009. *Oversight of next generation nanotechnology*. Washington, DC: Project on Emerging Nanotechnologies.
39. Arendt, Hannah. 1998. *The human condition*. Chicago: Chicago University Press.
40. Collingridge, David. 1980. *The social control of technology*. New York: St Martins Press.
41. Groves, Christopher. 2009. "Future ethics: risk, care and non-reciprocal responsibility." *Journal of Global Ethics* no. 5 (1):17-31.
42. Macnaghten, P., R. Owen, J. Stilgoe, B. Wynne, A. Azevedo, A. de Campos, J. Chilvers, R. Dagnino, G. di Giulio, E. Frow, B. Garvey, Christopher Groves, S. Hartley, M. Knobel, E. Kobayashi, M. Lehtonen, J. Lezaun, L. Mello, M. Monteiro, J. Pamplona da Costa, C. Rigolin, B. Rondani, M. Staykova, R. Taddei, C. Till, D. Tyfield, S. Wilford, and L. Velho. 2014. "Responsible innovation across borders: tensions, paradoxes and possibilities." *Journal of Responsible Innovation* no. 1 (2):191-199.
43. Rawls, John. 1995. "Political Liberalism: Reply to Habermas." *The Journal of Philosophy* no. 92 (3):132-180.
44. Fuller, Steve. 2012. "Precautionary and Proactionary as the New Right and the New Left of the Twenty-First Century Ideological Spectrum." *international Journal of Politics, Culture and Society* no. 25 (4):157-214.
45. More, Max. 2012. *The Proactionary Principle*. Extropy Institute 2005 [retrieved 7 June 2012]. Available from <http://www.extropy.org/proactionaryprinciple.htm>.
46. Stilgoe, Jack, Richard Owen, and Phil Macnaghten. 2013. "Developing a framework for responsible innovation." *Research Policy* no. 42 (9):1568-1580.
47. Engster, Daniel. 2007. *The heart of justice: care ethics and political theory*. Oxford: Oxford University Press.
48. Groves, Christopher. 2011. "The Political Imaginary of Care: Generic versus Singular Futures." *Journal of International Political Theory* no. 7 (2):165-189.
49. Groenhout, R.E. 2004. *Connected Lives: Human Nature and an Ethics of Care*. Lanham, MD: Rowman & Littlefield.
50. Marris, Peter. 1996. *The politics of uncertainty: attachment in private and public life*. London; New York: Routledge.
51. Shove, Elizabeth. 2004. "Efficiency and Consumption: Technology and Practice." *Energy & Environment* no. 15 (6):1053-1065.
52. Mol, Annemarie. 2008. *The logic of care : health and the problem of patient choice*. London ; New York: Routledge.
53. Heidegger, Martin. 1998. *Being and time*. Oxford: Blackwell.
54. Wilsdon, J., and R. Willis. 2004. *See-through science: why public engagement needs to move upstream*. London: Demos.
55. Sevenhuijsen, Selma. 1998. *Citizenship and the Ethics of Care: Feminist Considerations on Justice, Morality and Politics*. London: Routledge.
56. Grinbaum, Alexei, and Christopher Groves. 2013. "What is 'responsible' about responsible innovation? Understanding the ethical issues." In *Responsible Innovation: Managing the*



- Responsible Emergence of Science and Innovation in Society*, edited by John Beasant, Maggy Heintz and Richard Owen. Chichester: Wiley.
57. Winner, Langdon. 1992. "Citizen virtues in a technological order." *Inquiry* no. 35 (3-4):341-361
  58. Kearnes, M., and B. Wynne. 2007. "On nanotechnology and ambivalence: the politics of enthusiasm." *Nanoethics* no. 1:131-142.
  59. Groves, Christopher. 2011. "Public engagement and nanotechnology in the UK: restoring trust or building robustness?" *Science and Public Policy* no. 38 (10):783-793.
  60. Callon, M., Pierre Lascoumes, and Y. Barth. 2009. *Acting in an Uncertain World*. Cambridge, MA: MIT Press.
  61. Robinson, Fiona. 1999. *Globalizing care: ethics, feminist theory, and international relations*. Oxford: Westview Press.
  62. Tronto, Joan C. 1993. *Moral boundaries: a political argument for an ethic of care*. New York: Routledge.
  63. Latta, P. Alex. 2007. "Locating democratic politics in ecological citizenship." *Environmental Politics* 16 (3):377-393.
  64. Gabrielson, Teena, and Katelyn Parady. 2010. "Corporeal citizenship: rethinking green citizenship through the body." *Environmental Politics* no. 19 (3):374-391.
  65. Leydesdorff, L. and J. Ward. 2005. "Science shops: a kaleidoscope of science–society collaborations in Europe." *Public Understanding of Science* 14(4): 353-372.
  66. Groves, Christopher. 2015. "Care and technoscience: re-embedding the futures of innovation." In *Embedding New Technologies into Society*, edited by Diana Bowman, Arie Rip and Elen Stokes. forthcoming.
  67. Groves, Christopher, Lori Frater, Robert Lee, and Elen Stokes. 2011. "Is There Room at the Bottom for CSR? Corporate Social Responsibility and Nanotechnology in the UK." *Journal of Business Ethics* no. 101 (4):525-552.
  68. Smelser, Neil J. 1998. "The Rational and the Ambivalent in the Social Sciences: 1997 Presidential Address." *American Sociological Review* 63 (1):1-16
  69. Groves, Christopher. 2014. *Care, Uncertainty and Intergenerational Ethics*. London: Palgrave