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Leading with ethics, aiming for policy: new opportunities for philosophy of science

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Abstract The goal of this paper is to articulate and advocate for an enhanced role for philosophers of science in the domain of science policy as well as within the science curriculum. I argue that philosophy of science as a field can learn from the successes as well as the mistakes of bioethics and begin to develop a new model that includes robust contributions to the science classroom, research collaborations with scientists, and a role for public philosophy through involvement in science policy development. Through an analysis of two case studies, I illustrate how philosophers of science can make effective and productive contributions to science education as well as to interdisciplinary scientific research, and argue for the essential role of philosophers of science in the realm of science policy.

Keywords Science policy · Research ethics · Science education · Climate change · Bioethics

Case One: U.S. universities are debating how to respond to the recently passed America Creating Opportunities to Meaningfully Provide Excellence in Technology, Education, and Science Act (America COMPETES Act). This Congressional directive requires that "each institution that applies for financial assistance from the Foundation [the National Science Foundation (NSF)] for science and engineering research or education describe in its grant proposal a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers participating in the proposed research plan" (United States Congress 2007, Sect. 7009).

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Case Two: As scientific evidence mounts, providing a better understanding of the nature and impact of anthropocentric climate change, the global community is facing a complex set of decisions regarding how to respond. While we are already seeing unavoidable impacts and are likely to experience far more in the not too distant future, decisions nations and communities make about energy and life-style choices in the next few years will have an impact on the severity of future harms. The Kyoto Protocol, the international environmental treaty designed to stabilize greenhouse gas concentrations at a level that would prevent "dangerous anthropogenic interference with the climate system," expires in 2012 (United Nations 1992, Article 2). The fifteenth Conference of the Parties of the United Nations Framework Convention on Climate Change, which occurred in Copenhagen in December 2009, led to the Copenhagen Accord, which endorses continuation of the Kyoto Protocol, but is not a legally binding document. As a result negotiations are continuing throughout 2010 in the hopes of securing a legally binding international climate agreement at COP 16 in Mexico.

In this essay I argue that philosophers of science are missing important opportunities to contribute to essential dialogues and make a positive impact on our communities. From our own institutions to national and international policy, the insights of philosophers of science have the potential to make vital contributions to many important and essential realms of science, from pedagogy to international policy. Although I focus in this essay on two specific case studies, these are intended to be illustrative of the value of enlarging the scope of our work and developing a more robust appreciation of the usefulness of the role philosophers of science can play if we embrace a richer conception of the nature and role of philosophy of science.

In the first section of the essay, I argue that the America COMPETES Act provides philosophers of science in the U.S. with a perfect opportunity to make important and heretofore relatively neglected contributions to science curriculum, and to do so in a way that makes clear the important role of philosophy of science in advancing an understanding of scientific practice. My position is that we cannot have an adequate impact on science education and practice by limiting our contributions to scholarship about science, but, like many bioethicists, must also partner with scientists in the classroom as well as on the research team. In the second half of the essay, I develop an analysis of the value, importance, and urgency of philosophers of science contributing to the development of scientifically informed policy. I illustrate my claims by arguing for the important contributions philosophers of science could make to climate change policy development and contend that a more adequate approach to philosophy of science emerges from efforts to impact policy.

1 Leading with ethics

As universities respond to the America COMPETES Act, the most typical response is to focus on traditional Responsible Conduct of Research (RCR) topics: research misconduct; authorship; conflicts of interest; data management; animal welfare; and human subject protections. While these topics, and the typical approach to training scientists proper "procedures," are certainly important, this vision of research ethics is far too limited a venue to convey an appreciation of the full spectrum of ethics relevant to scientific research.

Although research ethics may seem a strange place to begin an argument for a more robust approach to philosophy of science, I will argue that they are in fact an excellent venue for illustrating the important contributions philosophers of science can make to the practice of science, particularly at a time, at least in the U.S. context, when governmental agencies and universities alike are demanding more attention to research ethics.

The second section of this part of the essay will be devoted to a brief discussion of a more adequate model of research ethics, one for which the contributions of philosophers of science would be essential. The aim of the discussion is to illustrate an important role for philosophers of science in working with scientists to identify and appreciate the full range of ethical issues relevant to scientific practice.

I will begin, however, with a brief discussion of ethics research relevant to NIH related research. Before providing an account of the value of philosophers of science embracing the field of research ethics, I believe we can learn some valuable lessons from the field of bioethics, which provides a model, as well as a cautionary tale, as we philosophers of science consider our role in responding to initiatives such as America COMPETES.

1.1 The example of bioethics

The NIH made an early commitment to human subject protections well before the emergence of the first bioethics centers at Hastings and Georgetown (Fletcher 1995). In 1973 the National Institute of General Medical Sciences provided support for the study of the ethical, legal, and social issues in genetic screening and prenatal diagnosis. The idea of setting aside a percentage of the NIH's annual budget to fund studies of ethical issues was proposed as early as 1983 by Charles McCarthy, head of the NIH Office of Protection from Research Risks, and Mortimer Lipsett, director of the NIH Clinical Center. The proposal was not funded, but it became an early model for the Ethical, Legal, and Social Implications (ELSI) Program of the National Center for Human Genome Research in 1989.

This commitment to a broad notion of research ethics provided the impetus for the rise of bioethics as a field within the United States. Bioethics initially focused on clinical issues and was eventually widely integrated into medical curriculum. In the last decade, bioethics has begun to incorporate a more global perspective and has expanded its venues to include such topics as public health issues and questions of food safety and security, as well as health related questions of distributive justice from a global perspective. I would note, however, that critics of bioethics, particularly as it is practiced in the United States, argue that the clinical focus still dominates the field and bioethicists still remain all too silent regarding issues of social justice and collective responsibility (Benatar and Fleischer 2006). Some bioethicists are beginning to urge an even more robust broadening of the field. Normal Daniels, to take just one example, urges that bioethics deepen its engagement with methods like cost-benefit analysis in order to ensure that policies and practices are attentive to issues of equity and distribution (Daniels 2006).

In addition to America COMPETES, the past decade has witnessed a heightened interest in research on ethics and science and engineering from the NSF that can be seen as parallel to the NIH's commitment to ethics. Recent funding opportunities provided by the NSF's Ethics Education in Science and Engineering (EESE), the Ethics and Values Studies (EVS) components of the Societal Dimensions of Engineering, Science, and Technology (SDEST) program, and the Science, Technology, and Society program (STS) testify to the growing importance of attention to ethics within the NSF. While these funding opportunities are admittedly significantly lower than those provided by the NIH's ELSI Program, it is nonetheless troubling that these opportunities have not been actively embraced by philosophers of science as an opportunity to enhance and expand the impact of our work. In this portion of the essay, I will argue that this is a lost opportunity. As I will demonstrate, attention to the various and complex ethical issues relevant to scientific practice is a way to build on the strengths of philosophy of science and make our work far more relevant to scientists, as well as to policy-makers.

Having said this, I would also stress that as we move to engage with the questions animating NSF's recent attention to ethics, we must be cautious not to respond simply with approaches from applied ethics, as has typically been the case with bioethics. I think there are a number of lessons, both positive and negative, to be learned from bioethics as we move to consider how philosophers of science can richly contribute to such policy decisions as the America COMPETES Act, as well as research and practice surrounding research ethics. In addition, as I will argue in the second half of the essay, philosophers of science can and should collaborate with scientists to address global problems such as climate change both within the context of scientific research as well as through providing resources for scientifically informed, epistemically and ethically responsible policy development.

Let me begin with the positive lessons to carry from the field of bioethics[1]:

Lesson 1*: Bioethics is most effective when the practitioner is knowledgeable not only in the field of ethics, but also in the relevant scientific discipline, i.e., medicine, neuroscience, or some other field in the life sciences.*

Erich and Roberta Springer Loewy, for example, stress that bioethics, at its best, is a richly interdisciplinary field. When practiced within the healthcare context, they argue that bioethicists must not only be trained in the relevant philosophical approaches, but must also understand the "physiology and disease process and have experienced what it is like to make decisions that may spell life or death," as well understand the context in which medicine is practice. They argue "it is also very important that, in addition, bioethicists know something about the sociology of medicine and some anthropology (at least be sensitive to the fact that health, disease and cure mean different things in different cultures), have some idea of the law as it pertains to medicine and, above all, understand the economic and cultural suffering of their fellowman" (2005, pp. 77–78).

In this regard, philosophy of science and bioethics are very similar. Philosophy of science, as a field, has been committed to practitioners being knowledgeable in the

[1] Here I am referring to bioethics at its best. I readily admit that these claims are not true of all work in the field.

field of science they research as well as appreciating the social contexts in which that science was practiced.

Lesson 2 *: The focus of bioethics scholarship has been directed to actual problems within the contexts of medicine or public health.*

Bioethics scholarship has a wide range, but it includes research designed to assist healthcare practitioners and researchers make decisions "in the field," so to speak. From better appreciating informed consent and what practices might encourage or obstruct it, to the creation of guidelines for ensuring proper ethical review of biomedical research, to research on the ethical challenges for public health officials, healthcare professionals, and the general public arising from the AIDS epidemic, bioethicists have worked to contribute directly to practice and to policy. These contributions have been encouraged by the fact that many bioethics positions are in or affiliated with Colleges of Medicine and have as a major component of their aim to collaborate with practitioners.

The focus of scholarship in the philosophy of science, with only a few exceptions, is not designed to assist scientists to "make decisions in the field."[2] And it is even less common to have philosophers of science partnering with scientists on research or even on pedagogy. As I will argue in this essay, this is a mistake. And it is a mistake for many reasons. First of all, such partnerships would augment both areas of scholarship. Not only would philosophers of science learn from working with scientists in the field, as is evidenced by the wealth of knowledge cultivated by those who engaged in careful lab studies,[3] but scientists would also learn from philosophers in ways that promise to open up new and exciting avenues for research,[4] as well as augmenting the science to policy relationship. In this respect, the bioethics model of collaboration and partnership is something philosophers of science should strive to replicate.

Lesson 3 *: Bioethics as a field has been interested not only in communicating with healthcare providers but also with policy-makers.*

The most well known example of this lesson in the context of U.S. bioethics is the participation of bioethicists on the National Bioethics Advisory Committee (NBAC). The NBAC was established in 1995 to advise governmental entities on bioethical issues arising from research on human biology and behavior. It has advised the government on various issues including the protection of human participants in research, stem cell research, cloning, and clinical trials in developing countries. In addition, bioethicists serve on ethics boards of hospitals as well as Institutional Review Boards (IRBs) of their home institutions.

In this arena, philosophy of science lags far behind bioethics. It is extremely rare for philosophers of science in the U.S. to be selected to participate on science advisory committees. Unlike bioethics, where the government has recognized that there are bioethical issues facing biomedical researchers as well as policy-makers, no such recognition has occurred with science advisory committees. Nor have philosophers of

[2] The work of Kristin Shrader-Frechette, Carl Cranor, and Heather Douglas are the most obvious exceptions.

[3] As just two of many examples see the work of Traweek (1988) and Knorr Cetina (1999).

[4] This is evidenced by my own work in the field of climate science. See, e.g. Schienke et al. (2010)

science succeeded in demonstrating the value of our work to these committees. While there have been efforts, such as those of social epistemologists who have argued for the value of what Steven Fuller (1993) has called "knowledge policy," namely, the study of what kinds of knowledge are desirable and how such knowledges can best be produced, assessed, and circulated, as well as calls for a philosophy of science policy (Mitcham and Frodeman 2004), few philosophers of science have embraced this important field of study.[5] This is, I contend, another lost opportunity. We must not only direct more of our attention to the applicability of our work in philosophy of science for policy, but also learn how to communicate our results to multiple audiences, including policy makers.

As a model, however, bioethics is not unequivocally inspirational. There are important negative lessons and cautions to carry away from this model, particularly if we focus on the history of bioethics in the United States. Here I mention two:

Caution One: *While the clinical domain is a valuable one, it has overshadowed global health issues, such as the huge inequities in health between nations or attention to public health issues at both a local and a global level. This unbalanced focus has obscured many important links between environmental or social impacts and health issues, and has led to a truncated understanding of health and health care in both international and national contexts.*

Paul Farmer has been one of the most effective and outspoken critics of business as usual bioethics. He argues that despite the fact that the majority of "international biomedical research has inequity as its foundation," little attention is paid to these issues (Farmer and Campos 2004, p. 22). In *Pathologies of Power* (2004), Farmer cites the example of the recent (1994–1998) Ugandan study in which 15,000 HIV-positive individuals were studied to determine the relationship between various factors, such as serum viral load, concurrent STDs, and male circumcision, on HIV transmission. None of the volunteers in the study were offered treatment such as antiretroviral therapy, nor were their sex partners informed that the research subjects were HIV positive. He argues that such a research protocol would have never been accepted if the study had been proposed for a population from a developed nation.

Farmer clearly voiced a concern that has been echoed by others when he argued that contemporary bioethics lacks a social justice perspective, without which it "risks becoming yet another strategy for managing inequality" (Farmer 2004, p. 201). Farmer argues that bioethics must always be done with attention to historical, economic, and cultural contexts. Furthermore, he argues that we must balance the current focus on individuals in clinical settings to the larger national and international issues that face us as nations and as members of a global community such as how to assure effective and affordable healthcare to all. Watching congress debating Obama's health care plan is a clear reminder that this is an issue that is a challenge even in developed countries, but it is even more taxing an issue for underdeveloped nations with far fewer resources.

Nor has bioethics as a field been attentive to the ways in which environmental issues and health issues overlap in crucial respects. Critics such as Paul Ehrlich have argued that the field of bioethics must be expanded from its current focus on medical

5 Again, the previously cited theorists are amongst the exceptions. My point is not that no one is doing this work, but that far too few philosophers of science have embraced the importance of this work.

issues to include attention to ethical issues involving environmental degradation, as well as "the ethics of preserving capital for future generations and those of dealing with overconsumption" (2003, p. 1207). From pesticides to anthropocentric climate change, the health of the environment and human health are intertwined in ways that have been largely ignored by the field of bioethics.

What I will advocate in this essay is what I call an *embedded* philosophy of science, that is, a practice in which philosophers of science are part of scientific and engineering teams, participating in the process of research design and practice and are partners in field and lab studies, as well as working with scientists and engineers at the intersections of science and policy. In thinking about how best to encourage more philosophers of science to take on this role, I believe we can both learn from bioethicists, but must also take care not to be limited in the scope of our interactions. It is for this reason, I will argue that embedded philosophers of science must tend not only to issues of responsible conduct of research when interacting with scientists, but be involved in ethical issues deeply embedded in the practice of science, as well as attending to issues of science's and engineering's impact on society. In addition, we need embedded philosophers of science when scientists and engineers are working on global as well as local issues, and particularly when a topic demands a richly interdisciplinary research team to address an issue or when a research topic has an especially immediate link to policy.

Caution Two: *Bioethics as a field has, with only a few exceptions, overlooked important research questions and opportunities to make important contributions due to its general absence of attention to epistemological issues within medicine and public health and how these intersect with questions of ethics and equity.*[6]

Rather than citing a negative example of this caution from bioethics, it is more helpful to offer an illustration of what philosophy of science *can* contribute. There are two fine examples: Kristin Shrader-Frechette's careful analysis of risk associated with nuclear waste in *Burying Uncertainty* (1993) and Carl Cranor's work on toxic substances in *Regulating Toxic Substances* (1993). Both authors bring in tools from philosophy of science and epistemology to examine ethical issues involved in such topics as risk assessment, establishing responsibility, and action in the face of scientific uncertainty. The nature and importance of the work is well summarized in Shrader-Frechette's statement in *Burying Uncertainty* that "we ought to use philosophy of science, epistemology, and ethics to help shape contemporary science, public policy, and democratic thought" (1993, p. xiii).

This pairing of philosophy of science, epistemology, and ethics in the service of public policy is exactly what I am advocating in this essay. The first case, namely, the demand from the NSF and other STEM (Science, Technology, Engineering, and Medicine) agencies for more robust attention to research ethics, is one example of a venue in which this pairing of philosophy of science, epistemology, and ethics has the potential to both enhance and extend the domain of philosophy of science and, in the process, ensure the depth of analysis and insight that the topic of research ethics deserves. The contributions of philosophers of science would transform research

[6] The recent work of Miriam Solomon on the epistemology of medicine is an exception to this rule. See, for example, Solomon (2007).

ethics from its current state as a domain largely populated by Institutional Review Board (IRB) staff who are largely focused on compliance, into a field of study that has the same reach and value as bioethics, while at the same time potentially avoiding the limitations of current practices of bioethics. However, and as I will argue in the next two sections, to accomplish this the scope of research ethics must also be expanded well beyond the typical attention to Responsible Conduct of Research (RCR) issues.

1.2 The broader impacts criterion

At the same time that the NSF has been pushing for more robust training in research ethics, it has arguably led the way in requiring scientists to attend to the broader impacts of their work. The NSF's Second Merit Criterion was introduced in 1997 as the result of an earlier Congressional movement to enhance the accountability and responsibility as well as the effectiveness of federally funded projects. The 1993 Government Performance Results Act (GPRA) required federal agencies to measure the effectiveness of their programs. Part of the NSF's response was to streamline their review criteria from the original four criteria to the two criteria that are now used to assess grant applications. The first of these criteria focuses on the intellectual merit of the proposed project and research capability and capacity of the investigators; the second criterion requires consideration of the broader social impacts of the research.

The mission of the NSF has always included attention to the broader impacts of science. However, by streamlining the criteria into intellectual merits and broader impacts, and adopting the policy of not reviewing proposals that do not explicitly address both criteria, the changes have had the effect of focusing attention on the broader impacts criterion.[7] As was set out in the National Science Foundation Act of 1950 (Public Law 810507), the NSF aims "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."

The NSF identified the following as desirable outcomes from its investments:

- Discoveries at and across the frontier of science and engineering;
- Connections between discoveries and their use in service to society;
- A diverse, globally-oriented workforce of scientists and engineers;
- Improved achievement in mathematics and science skills needed by all Americans; and
- Timely and relevant information on the national and international science and engineering enterprise (National Science Foundation 1997).

As is clear from this list, the NSF's mission is to balance excellence in scientific and engineering research with the broader impacts of that research upon (i) the educational and research infrastructure, (ii) the diversity of the fields themselves, as well as (iii) supporting projects with positive social impact.[8]

[7] See, for example, Mervis (2001) and the NSF's response, National Science Foundation (2002).

[8] The second merit criterion emphasized components of the original Criterion Three: Utility and Relevance of Research, and Criterion Four: Effect on Infrastructure of Science and Engineering; with two new

Neither philosophy of science nor philosophy in general has taken advantage of this movement within the NSF through contributing to a better understanding of how best to achieve these outcomes or a philosophical examination of the value of the NSF's goals. It is particularly surprising that despite more than a decade since the NSF implemented these new criteria, and a wealth of work in the area of feminist epistemology and philosophy of science that has focused on the epistemic importance of diversity within science, little has been done to link this work explicitly to the broader impacts criterion.[9]

The America COMPETES Act provides a new opportunity for philosophers of science to contribute to the NSF. In the next Sect. 1 provide an admittedly brief overview of one approach that weds issues of ethics with methods and insights from the philosophy of science to provide a model that would enable this new Act to develop into far more than an empty compliance exercise.

As research universities move to respond to the America COMPETES requirements, the focus is all too often limited to Responsible Conduct of Research (RCR) compliance training.[10] While I do not deny the importance of RCR issues, they are far too limited to provide a basis for scientists and engineers to appreciate the full range of ethical issues they face. Here I suggest that a more robust model, what I and my colleagues have labeled the Ethical Dimensions of Scientific Research (EDSR) (Schienke et al. 2009), provides a more adequate model of the ethical literacy needed by scientists and engineers, and provides an opportunity for philosophers of science to help develop ethics training responsive to epistemic concerns.

1.3 Ethical dimensions of scientific research

The EDSR model, while incorporating RCR topics and training, recognizes that these typically constitute only one domain of ethics relevant to STEM research. RCR training is particularly limited in domains where ethical issues and value choices are embedded within the content of science as I will explain below, but such training also typically overlooks ethical issues relating to the impact of scientific research on society and thus provides inadequate training relevant to the NSF second criterion. The EDSR model identifies three domains of research ethics. In what follows, I will define each domain and provide an initial discussion of the potential contributions of philosophers of science (Fig. 1).

- ***Procedural ethics**: ethical aspects of the process of conducting scientific research, such as: falsification, fabrication, and plagiarism; care for subjects (human and non-human animal); responsible authorship issues; analysis of and care for data;*

Footnote 8 continued
concerns, namely, (i) broadening the participation of underrepresented groups and (ii) promoting teaching, training, and learning.

[9] I would note that a forthcoming special issue of *Social Epistemology* devoted to the NSF Broader Impacts Criterion promises to correct some of these omissions.

[10] See, for example, Penn State's Scholarship and Research Integrity (SARI) program at http://www.research.psu.edu/orp/sari/.

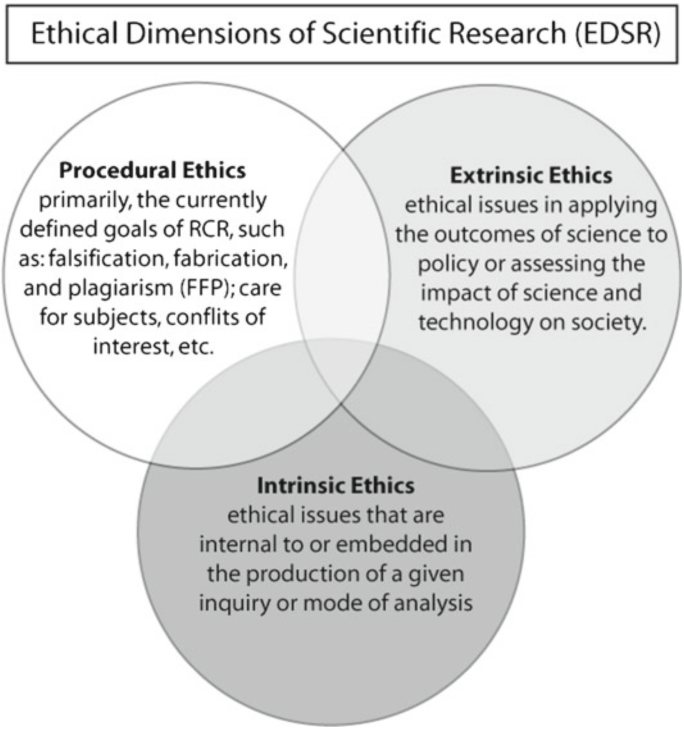

Fig. 1 Diagram of the Ethical Dimensions of Scientific Research model of a broader conception of "research ethics"

and conflicts of interests. Procedural ethics is contained almost entirely within the currently defined goals of RCR.

There is certainly a role that philosophers of science can play in this domain of research ethics, particularly in the context of better identifying the ways in which interests can pose a conflict to research objectivity, the relationship between trust and the interests of science, as well as aspects of data management. However, in comparison to the other domains of research ethics, RCR issues are more transparent *and* RCR educators have over the past decade developed pedagogical skills in this arena. Let me stress that although I do not want to preclude a positive role for philosophers of science in this domain of research ethics and I would be delighted if this essay encourages others to identify and implement important contributions of philosophy of science to this domain of research ethics, my argument in this essay is that it is in the next two domains that our skills and expertise are essential.

- ***Extrinsic ethics****: ethical issues that are external to the production of scientific research. These arise, for example, when considering the impact of scientific research on society; e.g., the effects of technological innovations on social ends such as health and well-being, whether pressing social and economic issues are likely to be addressed and if so, who benefits, and the role of science in policy-making. This domain of ethics also includes ethical concerns arising from* *the impact of society upon science, for example the impact of funding on research trajectories or the ways in which wide-spread societal biases can impact research trajectories, as they arguably did with eugenics research. In the latter case, there are often links between the domains of extrinsic and intrinsic ethics.*

The second domain, *extrinsic ethics*, is most relevant to NSF's second merit criterion and provides ample opportunity for valuable contributions by philosophers of science. Questions that philosophers of science might address specifically related to the broader impacts criterion include: (i) Is the second criterion which demands attention to societal benefit in tension with the first criterion of intellectual merit?; (ii) Is the demand for a diverse, globally-oriented workforce of scientists and engineers simply a matter of justice or are there also epistemic benefits?; (iii) Are there adequate measures for assessing components of the second criterion?; and the like.

But the value of philosophy of science for this domain of STEM ethics is not limited to the second criterion. The domain of extrinsic ethics calls for more careful attention to a host of issues including, but certainly not limited to:

- proper interpretation and application of the precautionary principle;
- furthering epistemically and ethically adequate societal understandings of issues of scientific uncertainty and risk;
- the role of scientists in the development of policy relevant research;
- the ethical responsibilities of scientists whose research reveals risks, for example, to human health or ecosystem sustainability.

My point here is that this domain of EDSR is ripe for research informed by philosophy of science perspectives. In many of these cases the links between ethical and epistemic concerns are inextricable and can only be unraveled through the efforts of those trained in the field of philosophy of science and well-schooled in the relevant sciences.

- ***Intrinsic ethics****: ethical issues and values that are embedded in or otherwise internal to the production of scientific research and analysis. These involve ethical issues arising from, for example: the choice of certain equations, constants, and variables; analysis of data; handling of error, and degree of confidence in projections.*

The third domain of EDSR, *intrinsic ethics* is another field requiring the expertise of philosophers of science. The identification of values and assumptions that are embedded in the very context of hypothesis development, data gathering and analysis, governing equations, models, strategies for addressing uncertainty, and the like, and the full analysis of their ethical *and* epistemic import is an excellent fit with the work of philosophers of science. Furthermore, I believe that the study of the domain of intrinsic ethics will not be fully successful unless it includes the expertise of philosophers of science. It is only when this domain becomes a focus of our field, that the range of relevant issues and their ethical and epistemic significance will be fully appreciated.

I would stress that although I have presented each field of research ethics as a separate domain, there are often instances where the ethical significance of the problem crosses between the various domains. Hence the employment of a Venn diagram to represent the EDSR. In fact, though I do not have the space to develop this claim in this essay, I believe that some of the most interesting coupled ethical-epistemic issues, and those most in need of study by philosophers of science, are those that are at the intersections of two or more of these domains. For example, the choice of research questions often falls within the intersection of intrinsic and extrinsic ethics. Another example arises out of current work of the scientific team of which I am a member regarding the decision by climate scientists not to include data on ice sheets into the integrated assessment models (IAMs) regarding sea-level rise until the data is more robust. This decision, while it may have epistemic grounding, results in the models being overconfident (intrinsic coupled epistemic-ethical issues), which in turn has an impact on how this aspect of climate science is deployed to inform adaptation policy such as decisions to build levees or dykes in coastal cities (extrinsic).

To further clarify these ideas and claims, the next section provides a more robust analysis of a case study that involves both intrinsic and extrinsic ethics in order to clarify these two conceptions of ethics and further illustrate my claims. This example also provides the transition to the second section of the paper, that is, on the role of philosophy of science for science policy.

2 Aiming for policy: climate change research

In my own work with climate scientists, we have focused on clarifying how climate models, which deal with high levels of uncertainty about future climate impacts, imbed values and assumptions that are ethically and epistemically salient. Since this research in turn informs policy development, policy-makers must also make decisions under conditions of uncertainty. Given this, it is crucial that the uncertainties embedded in climate science be carefully quantified and communicated. Indeed, scientists are well aware that "without explicit efforts to quantify the likelihood of future events, users of scientific results (including policy-makers) will undoubtedly make their own assumptions about the probability of different outcomes, possibly in ways that the original authors did not intend" (Mastrandrea and Schneider 2004, p. 571).

In order to illustrate the nature and importance of intrinsic ethics, my colleagues and I have developed a series of case study analyses designed to identify the values embedded in scientific research on climate change risks and examine the ethical and epistemic import of such values. In the following sections, I discuss two of these case studies: (i) integrated assessment models (IAMs) used in the context of climate change science and (ii) cost-benefit analysis (CBAs) used to make policy decisions about climate change investments. My examples are designed to demonstrate not only the importance of attention to intrinsic values and the role of philosophy of science in this endeavor, but also the value of this focus for policy.

2.1 Integrated assessment models

A substantial and growing body of scientific evidence reveals that anthropogenic emissions of greenhouse gases such as carbon dioxide have changed the Earth's radiative balance, leading to global warming. Temperatures have already risen 1.4°F since the beginning of the twentieth century, though much of this warming happened in the last 30 years. Scientists predict that these temperatures will continue to rise, with predictions ranging from 2°F to 11°F over the next one 100 years. These changes to the global climate are projected to cause increasingly serious consequences. While current generations are not untouched by climate change impacts, the risks are highest for future generations (Bernstein et al. 2008, p. 104).

It is certainly true that the magnitude of climatic change will be difficult to project. The global biogeochemical cycles involved are complex and made all the more complicated by the socioeconomic systems that impact them. However, the gravity of the ethical considerations at stake in making decisions about how to respond to our current understanding of climate change is underscored by the general agreement that anthropogenic climate change is highly likely to threaten the basic rights of many individuals (see, e.g., Adger 2004; Caney 2006; Sachs 2006). The likely harms of climate change include dramatic and quick changes in precipitation patterns leading to floods in some regions and droughts in others, sea-level rise, ocean acidification, and changes in the distribution of vector-borne diseases.

Furthermore, we know that the harms and benefits of anthropogenic climate change will not be equally distributed across groups or regions. The severity of the impact will "depend to an important degree on social, economic, governance and other forces that determine who and what are exposed to climate hazards, their sensitivities and their capacities" (Leary et al. 2008, p. 4). The burdens of climate change and risks of threats to basic rights are estimated to be higher for those individuals and communities who are worse off in terms of income, education, and/or social status (Louis and Hess 2008; Schneider et al. 2007; Shue 2003; Vanderheiden 2008). Threats to basic rights are, for example, often elevated for those in developing countries that have high vulnerability to the impact of climatic events on food security, flooding, or exposure to new health risks (Gardiner 2006; Paavola and Adger 2006; Parks and Roberts 2006).

Although the problem is often framed in terms of future impacts, it is important to appreciate that we are already experiencing harms from anthropogenic climate change impacts, harms that are not equally distributed. To take just one example, estimates of current mortality rates related to anthropocentric climate change show higher rates in low-income regions such as Africa compared to higher income regions such as the U.S. or Western Europe (Louis and Hess 2008). As we increasingly experience more of the impacts of climate change, not only will there be winners and losers, but the economic and social vulnerabilities of poorer countries are likely to be worsened by these impacts. The issues we face then involve both inter- and well as intra-generational justice.

Our research team has been working to examine integrated assessment models (IAMs) that are used in the context of climate change.[11] This field has been developing rapidly over the past two decades with IAMs employed (i) to inform policy and decision-making regarding responses to climate change; (ii) as a method for better understanding and assessing uncertainties and risks; and (iii) as a tool for scientific

[11] The lead PI on this research is Klaus Keller, Associate Professor of Geosciences. Ken Davis, Professor of Meteorology has also been an active participant. Our research has been enhanced through the careful research of a small group of postdocs and graduate researchers including Marlos Goes, Erich Schienks, and Seth Baum.

research that focuses on complex system interactions, such as biosphere-atmosphere linkages or linkages between socioeconomic and biophysical processes.[12]

IAMs that couple scientific and socio-economic aspects of climate change are widely used in the context of climate policy development to balance costs to society with decisions regarding mitigation (reducing greenhouse gas emissions) and adaptation (responding to unavoidable and unavoided climate changes, say through dikes or altered farming techniques). Delaying mitigation or adaptation responses may, on the one hand, increase the risks of dangerous and potentially irreversible anthropogenic interference with the climate. On the other hand, moving too swiftly may cause economic harms if we transfer funding from solving other problems such as poverty or basic health needs, and/or result in higher costs in not delaying until we have more viable technological options that provide a more cost-effective method for mitigation. IAMs are used to help make decisions in these complex contexts and are also used to help select from the various mitigation and adaptation strategies that are available.

According to Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), nations must strive to ensure the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (United Nations 1992). There is considerable uncertainty surrounding what constitutes dangerous anthropogenic interference and a number of decision points that must be made in developing an IAM. To clarify the role of intrinsic ethics, and, in particular, the value decisions that are made in the development and deployment of a model, I will focus on one of the many decision points that must be made in framing an IAM.

One area of uncertainty surrounding climate change concerns climate sensitivity. The answer plays a large role in determining how serious the consequences of global warming will be. Predicting the sensitivity of the climate to changes in CO_2 concentrations is a central focus of climate science and is the basis for making predictions regarding the severity of climate change related impacts. One common measure of climate sensitivity is the amount by which global mean surface temperature would change once the system has settled into a new equilibrium following a doubling of the pre-industrial CO_2 concentration. The uncertainty arises from the complexity of feedbacks (from clouds, water vapor, ice-albedo, etc). Without feedback, a doubling of CO_2 would result in a 1°C global warming; but the complexity of the feedback precludes a fixed answer. According to the IPCC Fourth Assessment Report, "it is likely to be in the range of 2°C to 4.5°C with a best estimate of about 3°C, and is *very unlikely* to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values" (IPCC 2007, p. 12).

Climate sensitivities are a key to responsible policy-making. The projected climate sensitivity is a measure of how much CO_2 and other warming gases can be emitted

[12] The first assessment model of a global environmental issue involved acid rain. See Alcamo et al. (1990).

without risking serious impacts, or conversely the severity of the impacts we or future generations are likely to face should we fail to reduce the levels of greenhouse gases.

A decision that must be made in developing an IAM is how to factor in the climate sensitivities higher than 4.5°C. While the climate sensitivity is very unlikely to be above 4.5°C, sensitivities higher than 4.5°C would result in very high negative impacts. In addition to impacts such as sea level rise and ecosystem disruptions, high climate sensitivities are more likely to be associated with extreme events such as a thermohaline circulation collapse which would result in major alterations in precipitation patterns. These 'high-impact, low-probability' events present climate modelers with a decision point. They are, as their very name implies, not very likely to reflect how our climate will respond, but their impacts are of such high magnitude that they could make adaptation or ecosystem survival very difficult.

One decision point that must be faced in designing an IAM is whether or not (and how best) to include the possibility that climate sensitivities are higher than 4.5°C. This is exactly the type of choice where attention to the complex intersections of epistemic and ethical issues by philosophers of science would be of tremendous value. One concern that some climate scientists are beginning to discuss is how ignoring such low probability, high impact events in models, a quite commonplace practice in climate modeling, can result in research being biased towards overconfident climate change projections (Mastrandrea and Schneider 2004; Schneider 2001; Urban and Keller 2009; Goes et al.. forthcoming). Theorists who focus on climate policy have begun to argue for the importance of including these low probability, high impact events into models on the grounds that not doing so is to overlook what is potentially the most important aspect of any analysis of the economics of climate change (Weitzman 2007).

In addition to serious attention to the value of including such events, philosophers of science would have an important role in these debates through examining whether and when models need not include such events. For example, must we always include these events in IAMs when one is engaged in policy-relevant science or are there exceptions? Are there examples of IAMs designed for understanding complex biophysical processes where these high impact, low probability events can be ignored without epistemic or ethical cost? Will the inclusion of such events require different models? And so on. Philosophers of science can play an invaluable role in identifying key sources of overconfidence and helping to critically reevaluate previous studies to help determine when omitting low probability, high impact events in the context of climate change science and/or policy can lead to poor decision making. This type of transparency would not only lead to better policy-making, but would also be likely to reveal significant questions in need of further scientific analysis.

Although admittedly quick, my aim here is to illustrate the value and importance of philosophers of science engaging in analyses of intrinsic ethics with the goal of ensuring that all science, but particularly policy-relevant science, is as transparent as possible concerning embedded values and their intertwined epistemic and ethical import.

In the next and final Sect. 1 outline a preliminary analysis of the importance of philosophers of science following in the footsteps of bioethicists and embracing a far more robust role in the policy realm. As valuable as it is to develop an analysis of the domain of intrinsic ethics, philosophers of science can make important contributions to policy debates by helping policy makers and the public better understand the often coupled epistemic-ethical issues relevant to policy choice. Given this, I would urge that we ensure that our work is framed so as to be of benefit in this arena. In other words, we need to both make sure that we translate our own policy-relevant research in ways that are helpful to the realm of policy *and* ensure that our work also tracks and analyzes the policy debates themselves.

2.2 Philosophy of science (for) policy

I intend this essay to be a prolegomena to a future philosophy of science. In this final section, I provide a brief overview of the value of philosophy of science for climate policy and some ideas arising from my own participation in the United Nations Framework Convention on Climate Change about how to proceed.

Science policy is the arena in which our work could make important and essential contributions. And here I would argue that we can learn from climate scientists and bioethicists alike in making sure that we focus at least some of our efforts on policy relevant research. To underscore this point I will provide an admittedly brief overview of a second example of research that is attentive to issues of intrinsic ethics, namely, work our research team has conducted on models of climate change cost-benefit analyses which examines how different prescriptive ethical assumptions produce initial starting conditions for the model which result in distinctly different descriptive outcomes.[13]

2.2.1 Intrinsic ethics and cost-benefit analysis

The model we analyze, namely cost-benefit analysis (CBA), is a standard tool in many arenas, and has become an important instrument that is often used in analyzing potential responses to climate change in an effort to determine which of the possible response options is "optimal," i.e., which response is best for society. As a case study of intrinsic ethics, our research is designed to illustrate how cost-benefit analysis in the context of climate change modeling embeds a set of ethical assumptions or decisions that are intrinsic to the analysis, and to demonstrate how descriptive analyses can be constrained by prescriptive assumptions.

CBA research is designed to identify actions that will have the largest overall benefits for society. This is determined by calculating total benefits minus total costs. There are a variety of methods for structuring and interpreting CBAs depending on how costs and/or benefits are defined, measured, or aggregated.

In our study we examine the Ramsey-Koopmans-Cass "optimal growth" model (henceforth the RKC model) of CBA, the specific form of CBAs used in climate change.[14] What we aim to demonstrate is that there are a series of value decisions

[13] This following discussion is based on our forthcoming essay (Schienke et al. 2010) which contains a more detailed account of this case study.

[14] The RKC model is built on the dynamic optimization work of Ramsey (1928), Koopmans (1965), and Cass (1965).

which have ethical significance embedded in the use of CBAs. The most obvious and generally agreed upon assumption, as noted by Amartya Sen, is that all forms of CBA assume a form of consequentialism, taking for granted that an aggregation of costs and benefits is an adequate technique for determining which actions are to be preferred or avoided. “The basic rationale of cost-benefit analysis lies in the idea that things are worth doing if the benefits resulting from doing them outweigh the costs” (2000, p. 934).

Climate change CBA models are used to determine climate management strategies that optimize “utility,” a measure of time-aggregated societal wealth. But decisions also have to be made regarding threshold constraints. For example, McInerney and Keller (2008) add an inviolable constraint, not found in other models (cf. Nordhaus 1992). In the McInerny and Keller model it is impermissible to exceed a certain probability of triggering a collapse in the North Atlantic meridional overturning circulation (MOC).[15] In their model the MOC constraint must be satisfied, regardless of the implications for the total net benefits. In our analysis we argue that the difference between the two approaches, namely, whether to represent the MOC threshold or not, is both a function of description within the governing equation *as well as a difference in values* (Schienke et al. 2010).

We use the comparison of these two models as a vehicle to engage climate science graduate students in identifying intrinsic ethical issues embedded in these and other climate change models as a way to help them appreciate the ethical choices they make in their own work. This helps these emerging scientists appreciate, for example, the embedded assumptions involved in the definition of global utility in CBAs, namely that optimizing global utility, summed over time, does not distinguish between a population that consists of both the wealthy and the poor, that is, where consumption is not equally distributed, and a population where consumption is equally distributed, as long as the globally aggregated utility in these situations is the same. Other examples that involve values are the choices of the utility discount rate and the elasticity parameter. Values are also often embedded in conversions of damages, such as droughts or floods, into units of money and utility.[16]

While there has certainly been attention from philosophers and others to the limitations of consequentialist approaches to global environmental problems, the fact that there are a series of values and assumptions embedded in the maximization criterion and the utility function of CBAs has not received sufficient attention from philosophers of science. There are some laudable exceptions, such as the work of Broome (1991, 1992, 1999, 2004) and Sagoff (2004). But the field is a complex one in need of additional theorists for there are multifaceted issues in the field of climate science

[15] The MOC is part of a global-scale ocean circulation system also referred to as the “conveyor belt circulation” (Broome 1991). In the North Atlantic, this circulation system consists of warm surface waters flowing from the tropics to higher latitudes. Due to heat loss to the atmosphere and brine rejection due to sea ice formation, some water parcels become denser than the underlying water masses and form deep waters. These deep waters then return southwards to the tropics (and flow further south). The overall flow problem in the North Atlantic is hence a meridional overturning, hence the name MOC. The MOC may collapse in response to anthropogenic CO_2 emissions (Meehl et al. 2007). An MOC collapse is predicted to pose special risks to natural and human systems (Schneider et al. 2007).

[16] These points are developed in Schienke et al. 2010.

IAMs and related CBAs that are in need of careful analysis, ones that would not only benefit from the expertise of philosophers of science, but would provide us with links to scientific practice and policy. The following are examples of questions that philosophers of science can raise and help to address:

1. The IAMs that incorporate socioeconomic factors are large and seldom transparent models. How might identifying and analyzing the import of the assumptions embedded in these models transform policy-decisions or the form of IAMs themselves?
2. Is the RKC model epistemically adequate and ethically satisfactory? Here it would be especially important to develop robust analyses of the particular definitions of utility in specific models, with attention to what is overlooked or excluded by such definitions.
3. What value and empirical judgments are included in the discount rate,[17] which describes how the value of utility is deemed to change over time? How would rendering these judgments transparent impact the models or debates? This is one of the issues at the heart of the Stern/Nordhaus debate.[18]
4. What are the best (epistemically and ethically) models in climate change policy for representing how risk, uncertainty, and discounting interact? For example, and to relate this back to the previous section, is it the case that the current debates over discounting are "secondary to debates about the open-ended catastrophic reach of climate disasters" (Weitzman 2009, p. 15).
5. Another significant parameter included in the RKC model that would be a fertile arena for philosophy of science policy is the elasticity parameter, which defines the relationship between utility and consumption. The question of how to set this parameter is epistemically and ethically relevant because it determines if a unit of consumption, for example, a dollar, is worth the same or more to those who start off at lower levels of consumption, that is, whether a dollar of consumption is worth more to the poor than to the rich.[19]

My list here is not meant to be exhaustive, but rather to provide a glimpse into the value and importance of the analyses that philosophers of science can bring to this arena of policy-relevant research.

3 Conclusion—climate policy

Although my earlier narrative regarding bioethics included a cautionary tale, the discipline as it has emerged has been very successful in contributing to policy formation.

[17] The concept of discounting is central to economics whenever judgements are being made about activities that will have a future impact. Discounting provides a measure for comparing, e.g., present costs in relationship to future benefits, by converting each future dollar into a common currency of equivalent present dollars. However, there are significant disagreements by those using CBA for there is a high degree of uncertainty about the appropriate rate of return on capital in the long run.

[18] The Stern/Nordhaus debate revolves around a set of complex questions concerning how best to set the discount rate. Stern (2007) represents an approach that sets a comparatively low discount rate, which as been criticized by Nordhaus (2007).

[19] My thanks to Klaus Keller and Seth Baum for their help in identifying these areas of concern.

Here it is important to emphasize that I am not referring to "being political" in the sense of partisan politics, but rather providing a clear analysis of issues that are both policy-relevant and policy-ready in addressing issues in ways that can be understood and effectively used by policy makers.

Here there are a wide range of topics in need of the attention of scholars, from energy to national security, food production, water security, and climate change. Some of the best of the policy-relevant research produced by philosophers is coming out of an interesting hybrid of ethics, philosophy of science, philosophy of law, and environmental philosophy. Fine examples of research reflecting this hybridity include the work of Shrader-Frechette (1993, 2007) and Carl Cranor (1993), both of whose work includes a focus on policy-relevant research in such areas as nuclear waste and environmental pollution.

Climate change science and policy is not only a fertile ground for contributions from philosophers of science; it is an arena that urgently needs our skills. It is also an arena which requires work at the intricate intersection between the epistemic, the ethical, and policy.

As we all look to the negotiators who will meet in Cancun for the 16th Conference of the Parties of the UNFCCC to hammer out an international agreement that will replace the Kyoto Protocol as it expires in 2012, I would urge that philosophers of science recognize the contributions we can make to these decisions. I invite those interested to join me and the other members of the international program on the Ethical Dimensions of Climate Change who are working with climate scientists and policy makers to ensure epistemically sound research and policy and to help make sure that the decisions our generation makes are those best suited to an ethically just and flourishing future.[20]

Amongst the questions that are at the focus of our attention as we prepare for these negotiations are the following:

- What are the epistemic and ethical strengths and limitations of policy frameworks such as contraction and convergence, greenhouse development rights, and REDD (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries)?
- How do we best balance our efforts between mitigation and adaptation? What are the coupled ethical-epistemic issues we must address in order to best determine how to equitably share theses burdens?
- Should historical responsibility for greenhouse gas emissions be factored into policy mechanisms and if so how?
- Is the "polluter pays" principle embedded into the Kyoto Protocols a fair principle?
- Should all emissions be counted in the same way? That is, should subsistence emissions, such as the methane emissions from subsistence rice farmers, be counted in the same way as luxury emissions, such as SUVs?

My aim in this essay was to gesture at the importance of and range of contributions philosophers of science can make to an enriched understanding of the complexity

[20] For information on the international program on the Ethical Dimensions of Climate Change see our web page at http://rockethics.psu.edu/climate/.

of the ethical dimensions of scientific research, to policy-relevant science, and to epistemically and ethically adequate science based policy. I urge that we work together to develop better models for what I am calling embedded philosophy of science and identify how we might provide future generations of philosophers of science with the training that they need to be effective members of interdisciplinary research teams with scientists and engineers, and who can provide much needed resources the coupled epistemic-ethical issues that are part of their research. While my discussion is far from comprehensive, my hope is that it is at least inspirational.

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