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The Quality of Sustainability Science: An Analysis

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Abstract
Sustainability science becomes important in research to maintain quality and quantity of finding in solving society issues and problems. Various expertise commend and giving opinion towards sustainability science, which become a model that appropriate to applied in daily life. Sustainability science consists of normativity, urgency, inclusion of nonscientists, and interrelation of environment and society. Therefore, sustainability science is able to increase the quality of human life, while maintaining the environmental quality for coming generation.

Keywords: Quality, quantity, model, human life, environmental.

Introduction

Sustainability science becomes a very important for the scientific funding. There are two example programs in Research for Sustainability organized by the German Ministry of Education and Research, and the Science and Technology for Sustainability Program of the National Academies in the United States. Funding by itself does not legitimize sustainability science. However, it can be calls for reflection on such scientific activities, their key feature, and the reasons for them. There are some scientist regard themselves as sustainability science and who claim to do such science in the sustainability science (Hua, 2016a). So, if there are funding or a mere presumption to do science is sufficient to establish a scientific field. Sustainability science must continue on its practice and its feature if dogmatism is to be avoided. For this, there come out from a philosophical perspective four questions regarding key feature of Sustainability Science. How are this question dealt with strongly influences the quality of Sustainability Science. The respective choices and positions should be made explicit so as to avoid confusion and to improve understanding of the concept "sustainability science" (Hua, 2016a).

In this essay report, will be examines the key feature of the projects and research activities of sustainability science; which involves the features concept of "sustainability science" or "science for sustainability development". These elements are normativity, the temporal character (urgency) of the research, the inclusion of nonscientists into sustainability science, and the task of understanding social and environment interrelations. This four factors concern the explication and articulation of values and principles (normativity), addressing the temporal relation of the research to what is at stake (urgency), the justified inclusion of nonscientists (participation), and the joint research of natural and social scientists (interdisciplinarity). These features make sustainability science difficult to evaluate

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according o the standards of disciplinary science, especially of the natural science. The overall field of sustainability science, with its explicit inclusion of normative considerations, seems to rest on shaky ground by the standards of customary disciplinary approaches. However, since the challenges of sustainability are real and unresolved, and a high quality of scientific inquiry desirable, a deeper understanding of these features matters. Philosophical considerations, in particular from philosophy of science, can contribute to this task. For the investigation of the quality of sustainability science, it is of primary importance to ask methodological questions and to examine ways of defining a problem. As important as the development of indicators and tool sets for evaluation is the philosophical task of examining major presuppositions of sustainability science and their justifications. The main approach aims at deep and comprehensive questioning in sustainability science: depth with respect to each feature, comprehensiveness as covering all major feature.

The first introduce a famous example to demonstrate that philosophy of science plays a role by costructuring the debate in sustainability science. The illustration is the ongoing dispute between weak and strong sustainability. In this paper will show how Popperian and Kuhnian philosophy of science costructure Neumayer's (2010) classic contribution to the debate. In addition, the paper also demonstrate this to be an uptake of philosophy of science that leads to a conceptually problematic way of framing the debate. The paper then discusses how a critical re-examination of the Kuhnian and Popperian views can inform an analysis of the four key features mentioned above; and with it shed a different light on the debate between strong and weak sustainability. Philosophy of science so conceived is enabling and its attempt to pose the relevant questions is one contribution to a critical self-understanding for sustainability scientists. Rather than uncritically stating certain features, re-examine why and under what conditions features are justified, thereby improving the quality of the research. Finally, some tentative conclusions are draw for the emerging culture of sustainability science.

Discussion

The Difficult Heritage of Philosophy of Science

The relevance of philosophy of science for the way questions are asked in sustainability science can be demonstrated via the discussion of weak and strong sustainability. This key debate revolves around the question of whether natural capital, in particular natural resources and natural sinks, should be regarded in principle as substitutable ("if we run out of coal or oil it does not matter, for we will be able to substitute another energy source"). *Weak sustainability* (WS) in Neumayer's definition requires "keeping total net investment [or total savings], suitably defined to encompass all relevant forms of capital, above zero." *Strong sustainability* (SS) "calls for the preservation of the physical stock of those forms of natural capital that are regarded as nonsubstitutable (so-called critical natural capital)."

Neumayer states his goal as follows: "It will be argued here that both paradigms are non-falsifiable under scientific standards. Therefore, there can be no unambiguous support for either weak

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sustainability or strong sustainability." At the end of his extended debate, he states: "the contest between WS and SS cannot be settled by theoretical inquiry. Nor can it be settled by empirical inquiry." For the present purpose, we need to pay attention to the way Neumayer frames the question: *Can the paradigms of WS or SS be falsified*? This question (as Neumayer indicates via his references) points directly to two seminal contributors to philosophy of science: Karl Popper and Thomas Kuhn. We will therefore very briefly introduce a few essential points pertaining to these respective philosophers so as to highlight the philosophical structure of Neumayer's question.

Karl Popper and Scientific Method

Karl Popper (1963) influentially argued for the idea that science is distinguished by a scientific method consisting of an evolutionary process of conjectures and refutations. Popper's work has been doubly influential: with respect to reinforcing the meta idea that science is distinguished by a method and his specific idea of falsification, which has been endorsed by numerous scientists, as well as suitably for a discussion of sustainability science a wider public.

The specification of this scientific method, Popper argues, allows science to be distinguished from pseudoscience (the so-called demarcation problem). Popper believed fields such as psychoanalysis or scientific socialism belong in the domain of pseudoscience because they do not follow the scientific method. Popper did not describe how the fabric of science works in its day-to-day routines. His philosophy of science is prescriptive, since it tells courageous scientists how they should proceed, a method, Popper believed, that would bring about scientific progress in the long run. On the one hand, scientists (should) advance bold and risky hypotheses and, on the other hand, they (should) attempt to derive empirical predictions from these conjectures and seek to refute them. This process of conjectures and refutations is (or should be) in Popper's view at the core of the scientific method. A proposition is only scientific if it is possible to falsify it. Thus, if neither WS nor SS can be properly falsified, both concepts would not belong to the realm of scientific knowledge. If key approaches in sustainability science turned out to be nonfalsifiable pseudoscience, then this way of framing the problem could have serious consequences in general for sustainability science well beyond the focus of Neumayer's claim.

Thomas Kuhn and Scientific Community

Kuhn's (1996) paradigm account of science has been similar in scientific and popular influence in the twentieth century. Paradigms, in one key meaning of the definitive term in Kuhn's work, offer a vision of what scientific work ("puzzle solving") is worth performing in terms of theory articulation, empirical experimentation, and measurement, and which scientific work is secondary or even illegitimate. A paradigm in this sense includes generalizations along with preferred instruments and methods. It is furthermore structured by ontological commitments about elements and concepts and powered by the faith that nature can be fit into the box of the paradigm via puzzle solving (such as the often brilliant work of more elegant theory formulation and extension or more precise measurements).

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Kuhn describes the social structure of science as one of particular scientific communities that are constituted by a shared faith in a paradigm. In his view, the scientific community is the supreme authority for validating and assessing scientific claims. Scientific claims are adopted and rejected according to criteria that stem from the paradigm itself. Students are initiated into the scientific community via textbooks, academic study programs, and laboratory training and they adopt basic axioms, concepts, and mindsets. Specialized conferences and peer-reviewed journals make it possible to assure the quality of research done within the community. In such ways, normal science becomes established.

The Problematic Structure of Neumayer's Question

In light of Popper's and Kuhn's views on science, the philosophical structure of Neumayer's question emerges. From a Popperian perspective, the structural process of science is one of conjecture and refutation with falsification as the selection, or rather elimination, criterion. From a Kuhnian perspective, scientific work mostly takes place in paradigm-based normal science. There will be scientific revolutions and new paradigms will emerge and take hold according to Kuhn, but the selection criterion for the new paradigm is *not* one of falsification. Moreover, falsification plays little role for (faith-based) normal science. So, there are some problem – either WS or SS really are genuine paradigms-but then we should not expect any attempts at falsification, rather "puzzle solving" (much of such puzzle solving is in evidence in the materials Neumayer cites); or WS and SS are falsifiable. In terms of these philosophies of science, Neumayer's guiding question is indeed a difficult one, not only because of empirical problems (missing or incomplete data on resource availability, substitution elasticities, and so forth), but because conceptually the question; can paradigms be falsified? That paradigms cannot be falsified is a conceptual truth and Neumayer's thesis is in this sense correct—but this of course is hardly what he meant to show.

Because the debate between WS and SS depends strongly on ethical arguments about our responsibility to future generations, about precautionary motives, and about our relationship to the natural environment, excluding normative propositions from method-based investigation amounts to a problematic, and more precisely, to an insufficiently comprehensive way of posing the question. This analysis of the structure of Neumayer's argument demonstrates that philosophical questions play a role in the analysis of sustainability science and the self-understanding of sustainability scientists. One might abstract them away in the routines of individual projects, but one should not overlook them in basic debates. If sustainability science is to stand for a distinctive way of doing science, the philosophical dimensions of this mode need to be considered. Both Kuhn's focus on the scientific community and Popper's call for a scientific method continue to raise important questions. The point, however, is not to uncritically accept their philosophies, but to reconsider them in their respective contexts.

Sustainability Science

In the sustainability science, the four key features of sustainability science will be discuss in the coming section.

(1)*Normativity*

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Sustainability science explicitly acknowledges a normative context, that of sustainability development (Clark and Dickinson, 2003). As "sustainability" and "sustainable development" are contested concept, many definitions and approaches have been argued for. However, it seems fair to say that the so-called Brundtland definition - "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" - defines a vague space of global intergenerational and intragenerational justice and development that, nevertheless, no specific or more rigorous definition can ignore (Jacobs, 1999). If so, any concept of sustainability must clarify notions and theories of justice with respect to development.

(2)*Urgency*

A commitment to the fulfillment of human needs in a world where even the basic requirements of a large part of the human population are often not met implies a dimension of urgency (Hua, 2016c). How can science and technology help move society toward a more sustainable future (Clark & Dickinson, 2003)? There is an ethical supposition in claims of urgency: as moral persons, we are not neutral to whether a specific problem might be addressed now, in some decades, or even in centuries. Andrew Wiles and Richard Taylor discover that in the intermediary time those interested simply had to wait and, or puzzle. The patience of the puzzle solver is a virtue. In puzzle-solving science, one might trust that all major problems will be solved in the longer run and that science will, in the end, discover some ultimate truth (Peirce's "final opinion") about how the universe is. Meanwhile, down on earth, there is suffering, injustice, and devastation of the biosphere. The puzzle-solving scientific attitude can abstract away from such pressing concerns, transforming them into private opinions a scientist may (or may not) hold. However, in the case of sustainability science these moral concerns are intrinsic (Hua & Marsuki, 2015). Those whose needs are to be met may simply no longer be alive in the long run. There is still another aspect of urgency: in the case of climate change the risks associated with waiting for better science might simply be judged too high. A purely scientific attitude can become a source of risk in sustainability science.

The context of discovery is distinct from the context of justification. According to this view, it is the reasoning for a scientific claim that counts, not its timing. We say that a scientific claim is valid if it can be shown to be a condition of the world, according to a specific observation or laboratory method that verifies or confirms the claim (this method usually involves a specific community structure for confirmation and testimony of experiments and observations). Such conditions of the world can have a temporal reference. For example, the passenger pigeon—once an abundant species in North America—is supposed to have become extinct in the early twentieth century. A scientific claim (or entire set of claims) can involve a reference to a specific time or temporal dynamic (such as the once abundant passenger pigeon becoming extinct). However, such temporal references are irrelevant with respect to the validity of the scientific claims.

Many events and temporal dynamics are relevant within sustainability science. "Urgency" is determined by temporal considerations (how much time do we

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have?) as well as ethical stakes (how important is the event/dynamic?). For example, predictions and forecasts regarding single events and dynamics of stocks are frequently related to human options. If global temperature is likely to increase by two degrees within the next generation, this can affect environmental security (for example, shelter due to increased risks of floods). Accordingly, there can be questions of mitigation (fight temperature increase) and adaptation (improve shelter). As the adaptation example shows, the relevance of scientific claims is not dependent on the human capacity to influence the occurrence of an event or the pattern of a dynamic. In any case, sustainability science is interested in the dynamics of specific stocks and flows over time. These dynamics (Aristotles' *kinesis*) are perceived from the normative perspective: in sustainability science one must, *ceteris paribus*, engage oneself against stocks of pollutants, declining stocks of resources, increasing stocks of greenhouse gases, and so forth. As in the case of atmospheric greenhouse gases, the dynamics of increase give reason to claim that mitigation is urgent. If a lake is close to collapse or a species is near extinction, action is urgent. Many stocks are goods that are components of the overall fair bequest package we owe to future generations. If so, sustainability science must schedule the relationship between stocks and time. A normative approach to the kinetics of stocks is required.

The quality of sustainability science is codependent on an explicit way of dealing with urgency: How do stocks change over time? What are the temporal windows? How can long-term objectives be combined prudently with first steps and a transition period? In our view, these questions do not necessitate a departure from sound scientific standards, but augment them. The pathos of urgency as such clearly does not make any claim a scientific one. Scenarios being presented in a context of urgency must*in principle* be open to disciplinary scrutiny and critique. Even the claims of urgency themselves must be open for refutation. What is required is the explicit contextualization of scientific claims (and practices) in a temporal framing of dynamics and events. Whether a scientific claim is considered as evidence and reason for action is ultimately an ethical question. (This establishes a double link to the inclusion of nonscientists: Who decides on ethical stakes? Who has knowledge of and influence on windows of opportunity for action?)

These questions also need to be asked for the weak versus strong sustainability debate. Consider the example of energy substitution, such as the substitution of nonrenewable oil with renewable solar energy that Neumeyer discusses. There are optimistic scenarios that suggest substitution is possible and there are pessimistic scenarios that put the possibility of substitution into doubt. As Neumeyer notes, "Which of the two projections will be closer to reality we do not know." Again, we need to pay attention to the formulation of the question. No doubt, there are energy optimists and energy pessimists, but what, in this context, are the meaning of "closer to reality?" The discussion above suggests that for sustainability evaluation of these scenarios should have to ask whose needs are likely to be affected and how and when they will be affected (with respect to the question of substituting oil with solar power). With regard to urgency, WS would likely rely on economic wisdom about how depreciation of a resource motivates the search for substitutes, while SS would

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recommend political measures to speed up such substitution. In such matters, there is no such thing as empirical "closeness to reality." "Closeness to reality,", requires an account of these questions of needs and urgency without which a dimension of sustainability science is missing.

(3) *Inclusion of nonscientists*

Sustainability science typically endorses a commitment to the inclusion of nonscientists in the process of research itself. Funding bodies might even require the satisfaction of this condition. As Kates et al. (2001) observe, "Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information." Sustainability science thus supposes that nonscientists can contribute to projects in the field in ways that the scientists involved cannot substitute for.

An important contribution, explicitly informed by philosophy of science, is the post-normal science proposed by Silvio Funtowicz, Jerome Ravetz, and others (Funtowicz & Ravetz, 1991; 1993; van der Sluijs & Funtowicz, 2008). This approach specifically focuses on the inclusion of nonscientists (as a matter of extended peer review). This context of sustainability science calls for a revision of the organization of science; the scientific community, in the context of sustainability issues, must open itself to extended peer review and the extended facts it might offer. However, there is also a separate series of arguments for the inclusion of nonscientists in sustainability science. We discuss first five epistemological, then three political, and finally one ethical argument for the inclusion of nonscientists in project-based sustainability science.

(a) *Local Knowledge:* The inclusion of nonscientists opens sustainability science to local knowledge and tacit knowledge considerations. Ravetz & Funtowicz (1991) assert that "knowledge of local conditions may not merely shape the policy problem, it can also determine which data is strong and relevant" (see also Renn, 2008). Thus, the inclusion of nonscientists might be relevant for both problem formulation and for contextual knowledge application. Local knowledge is found in laypersons and it may also be stored in literature that does not count as scientific. According to contemporary standards of peer-reviewed journals, such literature is very often "dark grey." Local knowledge often comes in "thick" narratives that are not "stored" in the same way as disciplinary knowledge.

(b) *Bias:* Funtowicz & Ravetz (1991) contend that "experts lack practical knowledge and have their own forms of bias." Normal science involves a process of initiation; assumptions have to be internalized, methods learned—in short, a paradigmatic view acquired. The result is a certain way of seeing the world; we see evidence of this, when, for example, laypersons strongly react to the economists' point of view. Because biases need to be unnoticed to be biases, the antidote against biases tends to come from outside. The inclusion of nonscientists can serve as an antidote against specialization and can help expose the limits of science. For instance, scientists are often ignorant about history, while history plays an important role for local people.

(c) *Self-criticism and normal science:* Precisely because academic science has a strong institutional character that involves hierarchies, careers, and hence

people's life prospects, internal criticism may be difficult or even rare (Betz, 2006). The outside perspectives not so constrained can be helpful in engaging in such criticism. Laypersons do not have blind faith in science and often challenge scientific claims. In this way, the scientific virtue of a critical attitude is turned against science from the outside.

(d) *Alertness:* Normal science can be compared to a large tanker. It is the tanker of science at sea and it is difficult to change its course once it has picked up speed. Research programs involve significant human and monetary investments and paradigm work on measuring and theory articulation is likely to have a long-term perspective. As a result, scientists as a community may have difficulty being alert to novel challenges that do not easily fit into their prevailing theoretical outlook. Nonscientists are not so constrained; hence, they can serve the function of communicating novel issues, thereby possibly making the ship of science more responsive.

(e) *Conjectures:* Conjectures require imagination. Imagination is, like prudence or even wisdom, not only found among scientists. The inclusion of nonscientists may open the scientific communities to new conjectures: wild ideas, naïve questions, and unexpected observations that the scientific community has the resources to state rigorously, refine, or refute.

(f) *Care and Concern:* Funtowicz & Ravetz (1991) write that "those whose lives and livelihood depend on solutions of the problems will have a keen awareness of how general principles are realized in their 'back yards.'" Science that aims to have a practical influence must be especially cautious with respect to the real-world impacts it may have. To the extent that people most affected by environmental issues are not generally scientists, the care argument is sociologically plausible: those most affected are likely to care the most, and hence care that the policy instrument (or similar) is appropriate. In medicine, it is the patient who must live with the consequences of a physician's recommendation for surgery (Hua, 2016b). Because of this, the ultimate decision is up to her (informed consent). In similar ways, local stakeholders have to cope with the consequences of projects designed by scientific experts.

(g) *Timing:* If sustainability science seeks to contribute to practical problem solving, then generally timing will be one component of successful science. For example, if a scientific report, however brilliant, misses the window of opportunity provided by an election cycle, it might be practically useless. Here, too, the inclusion of nonscientists may offer insight. Such inclusion also gives scientists a better understanding of the affected people's perception of the pressure and urgency of a given problem (for example, a problem could be less urgent for local people than the scientists believe.)

(h) *Power:* Nonscientists may not only offer insight, but they can also generate the power to help advance a proposal resulting from sustainability science. Nonscientists who are informed and have the necessary influence can help effectively communicate or even implement a policy proposal (Bergman, 2008).

(i) *Normativity:* A normative science needs to take care with respect to the social values it seeks to achieve or promote. However, as Funtowicz & Ravetz (1991) note, values are in dispute. Precisely for this reason, it seems

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important to make this dispute public and not to leave science with the decision of which values to prioritize (Renn, 2008). The inclusion of nonscientists can contribute to this end. Scientists as such are not experts in value judgments. Ethicists may offer skills for the investigation of normative intuitions and their implications, historians may offer insight into the contexts of such intuitions, and so forth. However, here, too, bias and limited self criticism can pertain. Scientists should not have ultimate authority in moral matters.

These various arguments partly complement one another and may also be in many contexts quasi-independent. It is conceivable that in a context concerning basic needs, the value dimension is trivial and uncontroversial. This does not mean that there is no value dimension in this context, but only that it may justifiably fade into the background as far as the possible inclusion of nonscientists is concerned. More generally, it seems that some set of these arguments ought to be made explicit for the specific context of the sustainability project at hand. Put differently, for each sustainability science research project that includes nonscientists, the various epistemological, political, and normative relationships between the scientists and nonscientists ought in principle be made explicit.

The establishment of sustainability science has meant that some funders mandate the participation of nonscientists. In some cases, inclusion does not need to be justified, but becomes an expectation or simply a dogma of sustainability science. However, one can endorse the nine reasons just mentioned and remain critical of dogmatic ways to perform participation for the sake of funding requirements. We may face such dogma if participation and inclusion seem to be mere add-ons to a given project, are disconnected to the scientific objectives, or do not rely on a sound concept. Wolfgang Zierhofer & Paul Burger (2007) have a valid point when they question whether the inclusion of nonscientists in trans-disciplinary research always serves epistemic ends. They define trans-disciplinary research formally by interdisciplinary and participation (of nonscientists), and they view problem-oriented research as its main epistemic end. Problem-oriented research in their understanding aims to reduce knowledge gaps that "hinder some stakeholders or institution to pursue certain actions." Based on a survey of sixteen trans-disciplinary research projects, they found that few projects really investigate goals or knowledge objectives. They conclude that trans-disciplinary research should not be regarded as a distinct mode of knowledge production. Instead, it "should be considered rather a class of epistemically and methodologically heterogeneous research activities which are only formally unified by the two general properties 'interdisciplinary' and 'participatory.'"

Skepticism as to the inclusion of nonscientists is reasonable in view of participation as dogma. However, Zierhofer & Burger's (2007) conclusion that trans-disciplinary research is "not a distinct mode of knowledge production" does not logically follow from the observation of a sample of empirical examples. Moreover, their conclusion seems to be the consequence of a formal description of trans-disciplinary research that does not specify a domain of investigation, which could be numbers as in mathematics, life as in biology, the commitment to sustainability as in sustainability science, and so forth. These

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domains of investigation stand for distinct epistemic ends (What is number? What is life? What is sustainability?). Once we have stated these domains, we can ask whether trans-disciplinary research contributes to the respective ends. For example, sustainability science focuses on the promotion of normative sustainability goals and to this end on an improved understanding of nature-society relations. The inclusion of nonscientists can serve this end (see the list of arguments above). Therefore, trans-disciplinary research in conjunction with a domain of investigation does seem to yield distinct modes of knowledge production.

(4) *Interrelation of environment and society*

Sustainability science seeks to "understand the fundamental character of interactions between nature and society" (Kates et al. 2001; see also Renn, 2008), to find joint ways in which natural and social scientists can improve the understanding of environment-society relations. Typical tools for such attempts are scenario techniques that depend on information and causal mechanisms from natural and social sciences. Another example might be coupled models that shed light on the interactions between human and natural systems. In the subsequent sections, the discussion on the questions raised by these features and their contribution to the quality of sustainability science.

Sustainability science, it will be recalled, seeks to understand the "interactions between nature and society," and it is in principle plausible that it needs to draw on the knowledge of both natural and social scientists, as well as the humanities and vocational disciplines (such as engineering, law, and medicine) to advance this understanding. As a minimum question of quality, the various scientists working on the respective issue should be included (Jahn, 2008). For example, research on a problem pertaining to floods requires hydrological (and possibly climatological) knowledge, but also political knowledge regarding the societal actors and their coalitions.

The debate of weak versus strong sustainability can serve as an instructive illustration of this feature of sustainability science. Both paradigms presuppose some ideas of how humans and natural systems are related. So, there will be three observations with respect to nature-society relationships:

1. The definitions of weak sustainability, strong sustainability (see the above explanation), and natural capital and their terminology originate in economic thought about investments, substitutes, complements, capital, and so forth. Thus, it is already a challenge to translate the weak versus strong debate into a genuine debate of social *and* natural science.

2. The debate issues from another debate between much wider paradigms: those of neoclassical economics and ecological economics. Roughly put, the first paradigm conceives of the economy as an autonomous entity in which economic growth can be examined and explained without reference to exogenous variables. Endogenous growth is in principle unlimited. The second paradigm conceives of the economy as a subset of the biosphere and claims that economic growth cannot be explained without reference to the enveloping biophysical system that also limits economic growth. The anomaly in the Kuhnian sense is the problem of substitution (the old neoclassical paradigm is pushed to defend

the increasingly contested claim that natural resources and services are substitutable). *Prima facie*, the paradigm of ecological economists necessitates nature-society integration due to its image of the economy as a subset of the biosphere. Its paradigmatic image is one that fits well with respect to sustainability science, whereas the same cannot be said, at least at first sight, with respect to neoclassical economics.

3. Precisely because the debate is in the first place one between economic paradigms, we need to pay attention to the structure of the argument and to the burden of proof. The following structure in Neumayer's discussion of the debate, he subjects the four premises of weak sustainability to the logical and empirical objections of opponents, concluding that SS proponents cannot decisively refute WS because their objections are inconclusive or logically flawed. But there is no complementary examination of the premises of strong sustainability. In short, Neumayer does not ask whether proponents of WS have good arguments to put the SS premises into doubt. Therefore, the burden of proof is not applied in an even-handed manner.

We submit that the normative considerations, along with the observation that this very debate has a disciplinary bias (it is in the first place posited as an economic debate, in which ecologists do not really have a say), suggest a reasonable argument in favor of strong sustainability. The evidence is that ecologists clearly tend toward the non-substitution view (e.g., MEA, 2005). Indeed, some of them might not accept the terms of the debate as meaningful to begin with. How could life-supporting ecosystems possibly be substitutable?

Conclusion

As a conclusion, this paper explores the way in which philosophy of science constructs a key debate in sustainability science, showing how philosophy of science can thereby become a problematic heritage. There also argued that a critical examination of this heritage points the way to an enabling, critical re-examination of the way sustainability science understands itself. The quality of sustainability science is in the view of a matter of constantly stating and re-examining the reasons for the inclusion of nonscientists, the normative issues at stake (and in conflict), the temporal relation of the research to the stakes at hand, and finally, the cooperation of the relevant natural and social sciences based on joint problem formulation. Keeping in view the debate of weak versus strong sustainability throughout our discussion of these key features, the paper conclude that comprehensive questioning supports strong sustainability.

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