Can Critical Realism be an adequate Philosophy of Science for Sustainability Science?

- when considering themes already extant in Sustainability Science

Karl Robert Isaksen

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LUCSUS
Lund University Centre for Sustainability Studies

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Karl Robert Isaksen
k.robert.isaksen@gmail.com

For the degree of Master of Science

Thesis Supervisor
Turaj Faran
turaj.faran@lucsus.lu.se

Lund University Center for Sustainability Studies, LUCSUS
Geocentrum 1, Sölvegatan 10
P.O. Box 170, SE-221 00 LUND, Sweden
Phone: +46 (0) 46 222 48 09
Fax: +46 (0) 46 222 04 75

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Abstract

Sustainability Science (SS) has, as of today, no explicit agreement on which philosophy of science should be used to guide its research. Though SS is a broad and often diffuse concept, there are certain guiding principles which are generally agreed on. Based on these principles, it has been seen if Critical Realism (CR) could be an appropriate meta-theory for SS. The approach used is therefore primarily practical, as opposed to philosophical. The 1st chapter is an introduction to the research done in this paper. The 2nd chapter introduces some of the main tenets of CR which are for example the three domains of reality, stratification and emergence, agency and structure, retroduction, and emancipation. The 3rd chapter introduces some of the main tenets and themes of SS. These are for example human-environment systems, the importance of spatial and temporal scales, systems and complexity, interdisciplinarity, and how SS relates to sustainable development. The 4th chapter looks at how possible syntheses of the different aspects of SS and CR may fit together. The methods for looking at possible syntheses are through case examples and arguments of how well viewpoints seem to correspond between CR and SS. Chapter 5 gives a conclusion and provides suggestions for further research.

It was found that there were 1) some issues where CR and SS have similarities, 2) some issues where CR could help deepen the understanding of SS, and 3) other instances where CR can give guidance in which strand of SS should be pursued. Finally it is concluded that CR can be an adequate meta-theory for SS, because they have several affinities and because CR can help further the work of SS.

Keywords: Critical Realism, Sustainability Science, Philosophy of Science, Human-Nature systems, interdisciplinarity.

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I would especially like to thank my dear wife, Kristina, for her constant support in listening to my constant babblings about meta-theory, critical realism, epistemology, dominating social structures, and so on. She has been there when I have needed to try to explain something to myself, and she has spent several days reading my work to give ideas for clarification at different stages in the project.

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Abbreviations

Critical Realism = CR

Sustainability Science = SS

Classical Empiricism = ES

Post-Structuralism = PS

1 Introduction

During the past two years, as part of my Master of Science program at LUMES, I have been learning about a new science called Sustainability Science (SS). One of the things which became clear early on was that it is not fully developed, and there are some explanations lacking, as well as having some tensions within the field. Though there are several aspects which have general consensus in SS, there are also these issues. This should not be unexpected however, as the science is a young and maturing discipline[1]. During the time at LUMES I have also heard of a philosophy of science called Critical Realism (CR).

Having looked more into CR and finding an interest in it, I will write this paper attempting to show how some areas of SS may be benefitted by having CR as an underlaborer. Høyer & Næss have pointed out that much sustainability research has already been carried out implicitly using critical realist perspectives[2], and sustainability research has also been carried out explicitly using this meta-theoretical position[3], but as far as I can tell no one has discussed directly the appropriateness of CR as a meta-theory for SS as a discipline.

This will be a practical paper, as opposed to philosophical; the reasoning for CR being an appropriate philosophy of science for SS will be based on the elements which are already discussed in SS, and then it will be seen if CR supports those statements or can help SS in areas where there are some issues, rather than philosophical argumentation of why one meta-theory is better than another. Though this paper is not focused on philosophy, it will necessarily discuss philosophical topics because CR is a philosophy of science. The purpose of the paper is not to see if CR should be a universal meta-theory for SS, only that it might be, and if some parts of CR could be used in a practical manner for the purposes of furthering the work of SS.

This paper will attempt to see if CR could be a beneficial meta-theory for SS, by 1) being able to help SS in some of the unsettled areas and 2) if it fits with the subject matter which is more agreed upon. I will start by giving a brief introduction to CR. Following this I will give a brief introduction of SS, based on definitional articles and literature reviews. Finally, based on the previous sections, I will see in what ways CR may be an appropriate philosophy of science for SS.

[1] Clark & Dickson 2003
[2] Høyer & Næss 2008
[3] Høyer & Næss 2008, Næss 2005, Bhaskar in Bhaskar et al. 2010, Trosper 2005

2 Critical Realism

This chapter is an introduction to CR, though it is not meant as a universal introduction. The footnotes in this chapter may be a good place to start for further understanding of CR. The subject matter discussed in this chapter is provided to help explain, in chapter 3, how a critical realist understanding could be beneficial to certain issues in SS.

CR was founded by Roy Bhaskar in the 70's and 80's[4]. Bhaskar did not call his philosophy Critical Realism, but rather "Transcendental Realism" as a philosophy for physical sciences, and "Critical Naturalism" for the social sciences[5]. It was others who later created the term "Critical Realism" to cover both philosophies, which Bhaskar has since accepted[6].

2.2 Scientific Critical Realism

Bhaskars first books were focused on traditional matters of ontology, epistemology and methodology, first in the natural[7] and then the social sciences[8]. Following this he moved on to a more dialectic perspective of CR[9], and then to more spiritual aspects[10]. Bhaskar has himself called this development a "deepening of ontology"[11], while other critical realists have called it his spiritual turn and prefer to work from the 'Scientific' Critical Realism[12]. Not only because of this critique, but also because most scientists who apply CR apply the scientific version[13], and because there is not room here to go into detail with the newer developments of Bhaskar, we will focus on Scientific Critical Realism. I will still use CR as an acronym of Scientific Critical Realism (rather than SCR), as this is what is done in most cases in the literature. The main interest of CR is to explain how and why the world functions as it does, as opposed to a focus on prediction and quantification[14], though quantification may be used and some general predictions are possible.

2.3 The transcendental question as the start of CR

Bhaskar based his meta-theory of natural science on a transcendental question as employed by Kant. This is a question that takes something which is uncontested and asks what must be the case for this to be as it is[15]. Bhaskars uncontested foundation was that natural science happens and that it has had

[4] Bhaskar & Hartwig 2010
[5] ibid
[6] ibid
[7] Bhaskar 2008
[8] Bhaskar 1998
[9] Bhaskar & Hartwig 2010
[10] ibid
[11] Bhaskar in ed. Bhaskar et al. 2010
[12] Elder-Vass 2010
[13] ibid
[14] Sayer 2000a
[15] Bhaskar 2008

some success, and then he asked what needed to be the case for this to be. He saw, among other things, that there were two things which were necessary; the first was that there must be a reality which is apart from human knowledge (real ontology), and secondly that scientists necessarily come to scientific experiments with theories of how science is done, and that human knowledge therefore is fallible (relativist epistemology). This stance helped pave the way for including parts of, as well as critiques of, both Classical Empiricism and Post-Structuralism.

Classical Empiricism (CE) is a philosophical stance that accepts an objective reality[16]. From this ontological stance it goes on to accept that we can get knowledge of this objective reality through constant conjunctions of empirical results. An example of CE could be a study where it is hypothesized that happy people live longer. If statistically more people who defined themselves as happy lived longer lives, then CE would see the hypothesis as confirmed. CE is the common philosophical groundwork for most of the natural sciences, and in social science it is often referred to as Positivism[17]. CE is critiqued by CR for committing the 'ontic fallacy' which is to confuse epistemology (what we can know) for being ontology (what is real)[18].

Post-Structuralism (PS) starts at the epistemological end, and with determination points out that all humans see the world through theories, and that human knowledge is fallible for a multiplicity of reasons. The logical argument for post-structuralists from this is that there is no singular objective reality, or they are at least agnostic about the matter[19]. CR claims that PS commits the 'epistemic fallacy' which is to confuse ontology (what is real) for being epistemology (what we can know)[20].

From the above we see that CR critiques both CE and PS for reducing epistemology to ontology, or ontology to epistemology. However, CR also accepts parts of both CE and PS claims. From CE it accepts that there is an objective ontology which can be known, and from PS it accepts that human knowledge is fallible.

2.4 Three domains of reality and what this means for methodology

2.4.1 Real, Actual and Empirical

Bhaskar explained that there are three levels, or Domains as he called them, to ontology. The three domains are the Real, the Actual, and the Empirical[21].

> The 'real' refers to objects, their structures or natures and their causal powers and liabilities. The 'actual' refers to what happens when these powers and liabilities are activated and produce change. The 'empirical' is the subset of the real and the actual that is experienced by actors.[22]

[16] ibid
[17] Clegg 2006
[18] Bhaskar 2009
[19] Sayer 2000a
[20] Scott 2001
[21] Bhaskar 2008

The Real is here referred to as all *things* which have the ability to have *causal powers* and are prior to, and separate from, our knowledge of them. Examples of this could be physical objects with their attendant gravitational pull, or human individuals with their power of agency[23].

The Actual are all *events* (and non-events) that take place when mechanisms in the real domain work to create events. Even though a man may have the capacity to work, if he is not granted the opportunity to do so, he will not work and it will not be an event[24]. This domain, in the same way as the Real, is existent whether we know of the events or not.

The domain of the Empirical is where there is *human knowledge* of the event. Critical realists stress the fact that just because events happen does not mean that researchers observe all events[25], or even acknowledge them when they are observed[26]. Figure 1 below shows that there can be several mechanisms, or powers, which co-create emergent events or non-events, which scientists may then observe. We see that the structure and mechanisms are in the domain of the Real, the event is in the Actual, and the observation is in the Empirical.

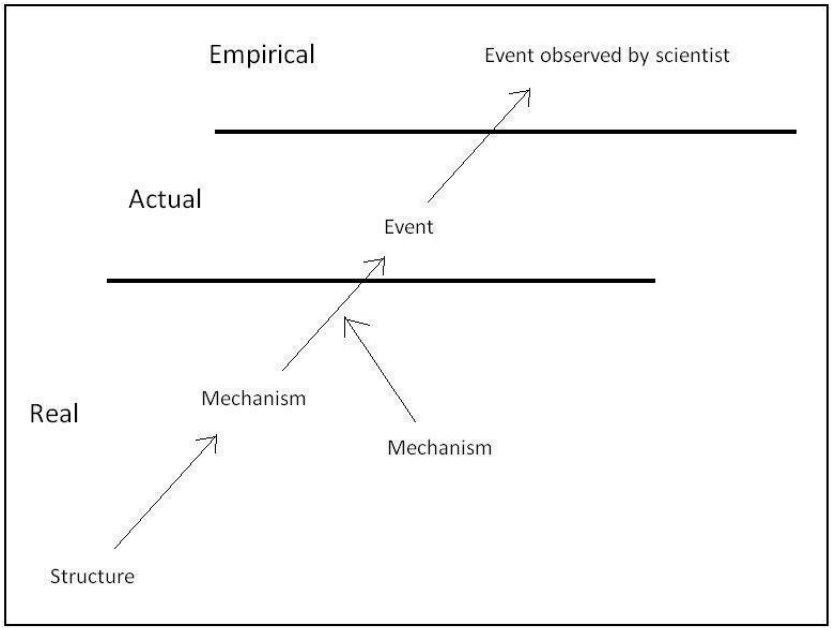

Figure 1. Three Domains. Based on figure in Sayer 2000b, p.15

[22] Fairclough et al 2002
[23] See section 2.6.1
[24] Sayer 2000a
[25] Bhaskar 2008
[26] Sayer 2000a

A simple example of how the Real, the Actual and the Empirical correspond can be given in the case of a tree falling in a forest. One of the mechanisms in the Real domain which made the tree fall would be gravitational pull. The fact that the tree fell would be in the Actual. If somebody saw the tree fall it would then be part of human knowledge, and part of the Empirical domain.

As can be seen from the model by Downward and Mearman[27] below, the knowledge of the *causal powers* of structures is gained through a mode of reasoning called retroduction of events[28].

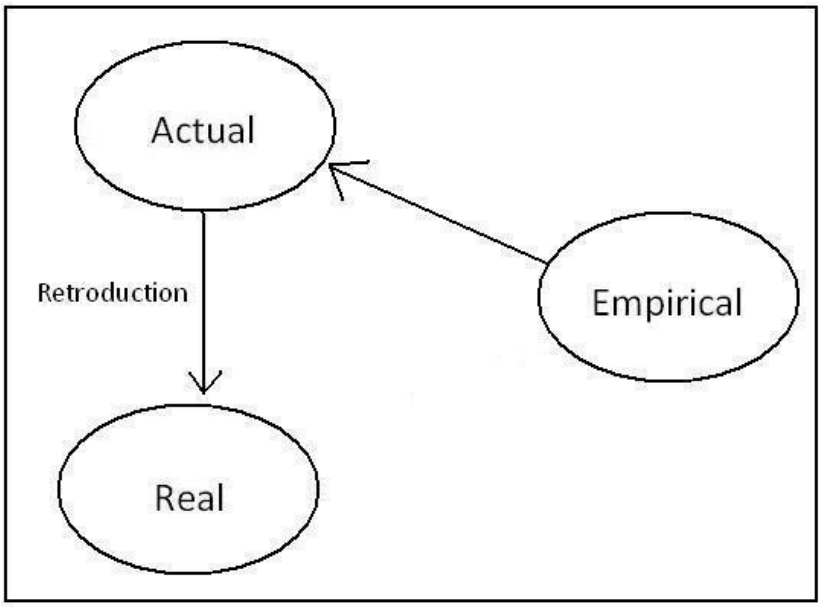

Figure 2. Retroduction. Redrawn in simplified form from Downward & Mearman 2007

2.4.2 Retroduction as an important form of reasoning in CR

Retroduction is not to deduce or to induce, but to look at the empirical experience, and then reason as to why it could be so. Critical Realist ontology and epistemology was founded on transcendental arguments, and Bhaskar has said that retroduction is a form of transcendental question[29]. Therefore the same question which Bhaskar asked about what needs to exist in order for science to function can be used in other cases to find possible underlying mechanisms. The main purpose of using retroduction is in fact to imagine deep causal mechanisms, and then test the presumed mechanism.

[27] Downward & Mearman 2007
[28] Sayer 2000a
[29] Danermark et al. 2002

Næss & Jensen have given a clear and concise overview, based on work by Danermark[30] over the four modes of reasoning which CR employs:

- *induction*: inference from a number of observations to draw valid conclusions about a whole population (for example, 30% of the Swedish population is in favor of the EU);
- *deduction*: logical inference where the conclusion must follow from the premises (for example, deduction of agent's maximization of profit in neoclassical economic theory);
- *abduction*: a creative process by means of re-description and re-contextualization (for example, Sherlock Holmes' ways of finding the perpetrator);
- *retroduction*: events are explained by postulating (and identifying) the mechanisms that are capable of producing them (for example, profit, rent and interest presuppose surplus value).

The hallmark of CR in this context is that of retroduction, even though CR is not dismissive of the other forms of reasoning but rather complements these three ways with a fourth option.[31]

2.4.3 Methods in CR

Because of the above, CR can be very flexible when it comes to reasoning in scientific research. Sayer[32] has explained that CR is also open to a wide assortment of research methods, and that methods depend on the research question and research area. CR is open to quantitative and qualitative methods[33], and open to mixed methods[34].

2.4.4 Scientific knowledge and other knowledge

CR is a philosophy of science which is open to new knowledge from the natural and social sciences, and even from lay-knowledge[35]. CR sees all types of knowledge as valuable, though some might have more justification for being valuable than others because of research being more or less coherent[36]. For this reason, CR also argues that scientific research should be open to several forms of knowledge, especially context-specific knowledge and the knowledge of people who are involved in the research area, even if these are not scientists[37].

[30] Danermark et al. 2002
[31] Næss & Jensen 2002
[32] Sayer 2000b
[33] Scott 2007 and Lund 2005
[34] Downward & Mearman 2007
[35] Sayer 2000a
[36] ibid
[37] ibid

2.5 Stratified and emergent reality

We now turn to the issue of stratification and emergence in CR. When something is stratified it means that it is layered. When there are for example several layers of rock and soil on top of each other it is stratified. In CR this term is used as a metaphor for a layered reality, as shown below.

Social science
Psychology
Anatomy
Organic chemistry
Physical chemistry
Physics

Figure 3. Emergence and Stratification. From Benton 2010

The 'bottom' building blocks, so to say, are objects and structures at the level of elementary physics; atoms which consist of protons, neutrons and electrons, and where protons and neutrons are themselves built up of quarks. The next level up would be physical chemistry, then organic chemistry, anatomy, human psychology and then the social structures, as seen above. Though physical chemistry necessarily includes the 'lower' level of atoms and so on, it cannot be reduced to this level, because of emergence. Emergence occurs when certain objects form structural relations and make a new entity which has causal powers which are qualitatively differentiated from its constituent parts. An example of emergence in the case of water is explained by Elder-Vass[38];

> Many of the properties of water, such as being liquid at room temperature, or being able to put out fires, are clearly different from the properties of its constituent hydrogen and oxygen atoms (Mihata, 1997: 31). If these atoms were present but simply as atoms, or organized into molecules of other types than water, the resulting substance would not have the properties of water. It is the fact of being organized into the specific form of water molecules that gives this collection of hydrogen and oxygen atoms the particular properties of water.

With this water example Elder-Vass[39] goes on to argue that the same organization of properties can be applied to any emergent entity. This means that characteristic properties or powers of an entity need to have both the constituent parts (of for example hydrogen and oxygen) as well as being organized so as to create the new emergent structure (for example water).

[38] Elder-Vass 2007
[39] ibid

2.6 Human agency and social structures because of emergence

Many of the discussions in sociology have not had an explicit focus on physical and temporal dimensions to social life[40]. A stratified and emergent reality makes it clear how human life is not only interpretive as argued in PS[41], but also embodied and grounded in a material reality.

2.6.1 Agency

An emergent and stratified reality explains how the causal powers which people have, in the form of agency and the ability to think reflexively, cannot be reduced to its constituent parts, but exists because of the relation of molecules to form what we know as a human[42]. CR argues that humans, as opposed to nature, have a special capacity to have intentions, and that this intentionality is always related to agency (actually doing something)[43]. The International Association of Critical Realism sums this up by explaining that;

> …human agency is seen as a: "causally and taxonomically irreducible mode of matter [which] is not to posit a distinct substance 'mind' endowed with reasons for acting apart from the causal network, but to credit intentional embodied agency with distinct (emergent) causal powers from the biological matter out of which agents were formed, on which they are capable of reacting back" (DPF, 51).[44]

Agential causal powers come not from some independent mind as Descartes postulated, but from the emergent properties of biological matter. It is also argued that agents can act back on lower level physical matter in certain ways, both their embodied selves and their physical surroundings.

2.6.2 Social structures

According to CR, such emergence and stratification continue from human agency to social structures because of the relations of several agents as causal mechanisms. Critical realists point out that there is not just one overarching social structure, but that there are several social structures working at different spatial and temporal levels[45]. Since both physical and social realities are based on the same underlying principles of stratification and emergence and both seek to fins underlying mechanisms with some form of causal power, critical realists argue that social science can be a science in the same sense as natural science is a science[46].

There are, however, some differences between social structures compared to natural structures, which cause implications for how such social science must be carried out differently than natural science. Two important differences are that social structures do not exist independently of agents who can reflect on their own choices, and therefore these structures, along with their powers and liabilities, can change in

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[40] Sayer 2000a
[41] See section 2.3
[42] Elder-Vass 2010
[43] Bhaskar 1998
[44] IACR Social Ontology
[45] Archer 2003 & Elder-Vass 2010
[46] Bhaskar 1998

time and space[47]. These structures may therefore be difficult to study and categorize[48]. To study social structures, which are in the Real domain, and which are not visible as such, the most effective advance is in many cases to observe the actions of people or social phenomena and to retroduce what sorts of social structures must be in place for such events to be[49]. Bhaskar also made it apparent that social structures can only have an indirect causal effect on the material world through conditioning the actions of agents[50].

2.6.3 The Transformational Model of Social Activity

The main discussions on agency and structure in CR have tended to be based on theories by Bhaskar and Archer, though Elder-Vass has recently come to be of importance also[51]. One of the concepts which has been foundational to critical realist discussions on agency and structure is the Transformational Model of Social Activity (TMSA), related by Bhaskar in The Possibility of Naturalism. Bhaskar argues that social life precedes agency as well as enables and constrains agency;

> *…people do not create society. For it always pre-exists them and is a necessary condition for their activity. Rather, society must be regarded as an ensemble of structures, practices and conventions which individuals reproduce or transform, but which would not exist unless they did so.*[52]

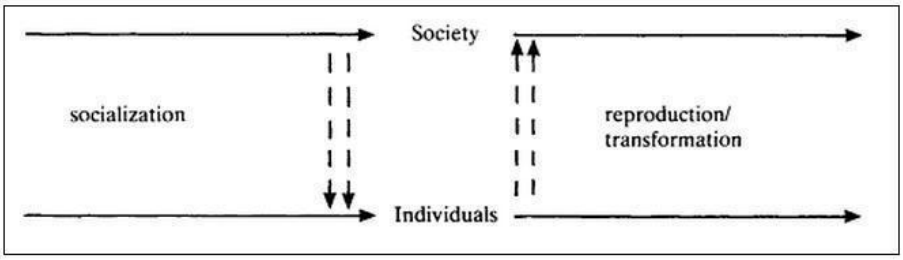

Figure 4. Transformational Model of Social Activity. From Bhaskar 1998, p.40

The above model shows how society has an effect on how agents think and act, and that agents, through time, may in turn reproduce or transform society. The fact that people reproduce social structures is often involuntary, for as Bhaskar puts it;

> Thus people do not marry to reproduce the nuclear family or work to sustain the capitalist economy. Yet it is nevertheless the unintended consequence (and inexorable result) of, as it is also a necessary condition for, their

[47] ibid
[48] Sayer 2000a
[49] ibid
[50] Bhaskar 1998
[51] Archer & Elder-Vass 2012
[52] Bhaskar 1998, p. 39

activity.[53]

Margaret Archer has further developed the TMSA into what she has termed the Morphogenetic approach where she creates a theory of how to be able to analytically separate structures and agency by applying the temporal perspective of structures existing prior to agency. By explicating this temporal difference it is analytically possible to distinguish between causes from agents and causes from structures.[54]

2.7 Need for different disciplinarities because of stratification as well as distinction of ontology and epistemology

Bhaskar has critiqued much of the interdisciplinarity literature for being focused on epistemology rather than on ontology[55]. With the contribution by CR of separating epistemology from ontology[56] CR sees an ontological necessity for pluridisciplinary research;

> The (philosophical) ontological nature of the case for interdisciplinarity developed here differentiates it from most of the literature in the field, which is overwhelmingly epistemologically (and sociologically) orientated.[57]

Mono-disciplinarity is important in a critical realist perspective because it helps scientists and researchers get deep knowledge of certain objects and structures, along with their powers and liabilities, at one particular stratum. An example of this may be the physicist who studies at the level of elementary physics.

It is however also important to widen this understanding because complex areas of research are usually open systems, and there are therefore several mechanisms from several different strata involved in events which occur, as seen in figure 5. When adding knowledge of possible mechanisms from different *strata*, it is called multi-disciplinarity. It is important to take it one step further because also *causes* from mechanisms at the different strata are emergent as explained in section 2.4.1, and also as seen in figure 5 below. With this in mind, there needs to be created a synthesis of the knowledge of structures and their causal powers from the different strata, to gain a comprehensive understanding of the events being studied. This is called inter-disciplinarity.

[53] Bhaskar 1998, p.38
[54] Archer 2003
[55] Bhaskar in ed. Bhaskar et al. 2010 for references to this section unless otherwise stated
[56] See section 2.3
[57] Bhaskar in ed. Bhaskar et al. 2010

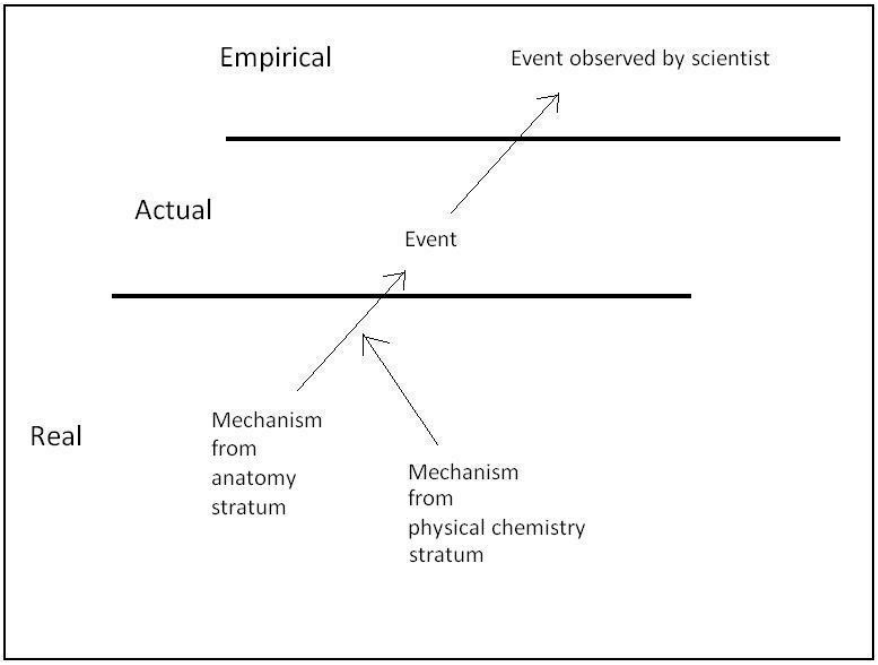

Figure 5. Three Domains and Stratification and Emergence.
Based on Sayer 2000b and Benton 2010

As multi-disciplinarity and inter-disciplinarity are related to the understanding of an emergent world, trans-disciplinarity and cross-disciplinarity are related to the methods for the new knowledge to be created. Trans-disciplinarity is here related to creating new theories and understandings from the inter-disciplinary work which will help explain the events under study. Cross-disciplinarity has to do with the importance of communicating effectively with researchers from other disciplines.

CR can be an effective guide in working across disciplines, not only because of an ontological understanding of the need for disciplinarities, but also because it can agree with both the realism of CE and the epistemological relativism of PS[58]. PS and positivism have very different meta-theoretical foundations and can therefore have issues in incorporating knowledge from the other philosophy, while CR does not necessarily have this same issue.[59]

To sum up; because there are stratum with their own unique objects and structures there is a need for mono-disciplinarity. Because the world is mostly an open system, the events which occur come from mechanisms at several strata, and multi-disciplinarity recognizes this by adding the knowledge of mechanisms. Mechanisms from different strata create new emergent events, which inter-disciplinarity recognizes by synthesizing knowledge of known events with underlying mechanisms. For researchers to create knowledge of the phenomena being studied there is a need to create new theories (trans-disciplinarity) and to work cooperatively with other researchers and other disciplines (cross-

[58] See section 2.3
[59] Bhaskar & Hartwig 2010

disciplinarity). Because CR is both ontologically realist and epistemologically relativist, it has a unique position to incorporate knowledge from both CE and PS.

2.8 Emancipatory purposes of CR

The fact that agents are conditioned by social structures while still having the possibility to change these social structures becomes a normative argument in CR for emancipation and of a critical stance towards society. Emancipation may be defined as;

> to free from restraint, control, or the power of another; *especially* **:** to free from bondage.[60]

Especially Bhaskar has been outspoken about the emancipatory purpose of CR[61]. Sayer here expands upon the importance of, in particular, social scientists being critically involved in their objects of study;

> So the radical nature of this proposal that social science must stand in a critical as well as explanatory and interpretive relationship to its object and to common-sense knowledge should not be underestimated. It means more than merely a different way of 'doing social science': it implies a different view of the social role of this type of knowledge and for 'intellectuals'. It means that social science should not be seen as developing a stock of knowledge about an object which is external to us, but should develop a critical self-awareness in people as subjects and indeed assist in their emancipation.[62]

Sayer here explains that when people see themselves more as agents, and when dominating social structures are identified, people can act on social structures more reflectively for their own betterment, as well as that of others. Social scientists have a role, as part of society, to find and study structures which may be oppressive and communicate the knowledge gained to people. They also have a social responsibility to make explicit in what way people have agential causal powers in certain contexts which can in turn affect social structures. It is here important to mention that since the social world is seen as being embedded in a material reality[63] an emancipatory critique it is not merely an argument on discourses;

> Likewise, it is not just the *ideas* (of racial differences, etc.) behind *apartheid* in the abstract that are wrong, but the actual practices (enforcement of laws, etc.) and material structures (segregated and materially deprived townships, etc.) which reciprocally-confirm, legitimate and are legitimated by those ideas.[64]

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[60] Merriam-Webster Online Dictionary 1
[61] Sayer 2000b and Bhaskar 2009
[62] Sayer 2000a, p.41-42
[63] See section 2.5
[64] Sayer 2000a, p. 40

2.9 The main tenets of CR for this paper

- CR accepts an objective reality, but that we approach it with theories, culture and being embodied. Because CR is both ontologically realist and epistemologically relativist, it therefore has a unique position to incorporate knowledge from both CE and PS.

- CR states that structures have causal powers which may cause events.

- Knowledge of mechanisms in open systems is gained primarily through retroduction of events.

- CR is open to different sorts of knowledge, lay as well as scientific, though scientific knowledge is usually seen as less fallible than other forms of knowledge.

- CR is open to many methods, as well as to mixed methods.

- Both the natural and social sciences are involved in the same work of seeking to understand underlying structures, with their attendant causal powers and liabilities. Even though these structures and mechanisms may be at different levels of stratification, the above means that these sciences can find commonalities and work pluridisciplinary.

- CR finds mono-, multi-, inter-, trans-, and crossdisciplinarity important forms of scientific endeavor because of emergence and stratification.

- Though people are materially based they can act back on physical matter intentionally and unintentionally.

- Scientists have a role to help people see detrimental social structures as well as help people see how their agency can work in different circumstances for their emancipation.

3 Sustainability Science

In this chapter I will not attempt to give a general overview of what SS is. SS is not yet a fully developed discipline[65], and defining the boundaries is therefore tantamount impossible. What will be discussed in this chapter are a handful of recurring themes, and some of the tensions and problematiques which I have come across.

Rather than basing my explanation of SS on an extensive literature review, I will give an explanation based on a few journal articles which seek to define the scope and characteristics of SS. Some of these articles are literature reviews[66] or bibliometric analyses[67] showing the state of SS, while others are more definitional in that they state what SS should be like. Among the definitional articles there are some which are somewhat critical to SS done in the past[68], while others do not criticize but merely explain what SS should entail[69]. Several of these articles have produced differing conclusions, or at least differing priorities, for SS[70]. As I focus my attention on these articles in SS, it is clear that I will likely miss several parts of the SS debate, and this needs to be taken into account every time I explain my understanding of SS. Some of the differences and tensions will here be explored. Though there are differences, there are also principles in SS which have general consensus, some of which will also be mentioned. Based on the topics here discussed, it will be seen in chapter 3 if CR can be of service to help SS resolve some of its tensions and whether CR and SS have a familiar affinity.

3.1 Sustainability, sustainable development, and sustainability science

There are differences between the concepts of 'sustainability', 'sustainability science', and 'sustainable development', though there is clearly some overlapping, and the words are sometimes used interchangeably, as will be seen. To situate the connections and differences it is necessary with some background information.

Sustainable development was a term that became well-known with the Brundtland Report in 1987[71]. It is this definition which is most common according to Martens[72], and was defined in this way;

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of

[65] Clark & Dickson 2003
[66] e.g. Kajikawa 2008
[67] e.g. Schoolman et al. 2012 and Bettencourt & Kaur 2011
[68] e.g. Spangenberg 2011 and Jerneck et al. 2011
[69] e.g. Kates et al. 2001 and Cash et al. 2003
[70] e.g. Kates et al. 2011 and Spangenberg 2011
[71] Kajikawa 2008
[72] Martens 2006

limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.[73]

The purpose of *sustainability science* is to help achieve sustainable development[74], as explained by PNAS;

…sustainability science, an emerging field of research dealing with the interactions between natural and social systems, and with how those interactions affect the challenge of sustainability: meeting the needs of present and future generations while substantially reducing poverty and conserving the planet's life support systems.[75]

As in the quote above, the word 'sustainability' may often stand alone to connote sustainability science or sustainable development[76]. These connections are shown in figure 4. The definitional articles I am drawing on in this paper would be the sustainability science theorists, while the literature reviews and bibliometric analysis take articles both from the sustainability science theorists and work actually carried out in SS.

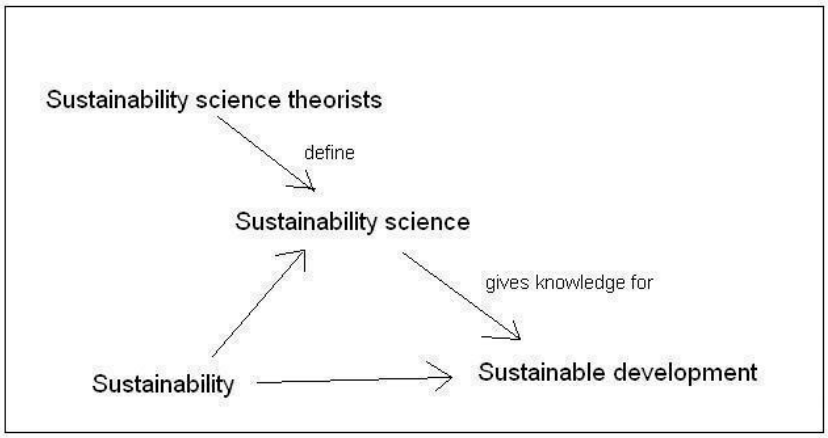

Figure 6. Sustainability Science connections

3.2 Interactions of nature and society

3.2.1 Common view on physical interactions and priority given to humanity

A point which seems to be agreed upon is that SS is interested in the interactions between society and the natural environment[77]. This is often called coupled human-environment systems[78] and understanding these interactions is the centerpiece of SS[79].

In synthesis, anthropogenic influences on global life support systems have reached a magnitude unprecedented in human history, levels that now jeopardise the well-being of humanity.[80]

[73] WCED 1987
[74] Clark & Dickson 2003
[75] PNAS 2012
[76] e.g. Kajikawa 2008 and Agyeman 2008
[77] Clark & Dickson 2003
[78] e.g. Kates et al. 2001 and Clark 2007
[79] Clark 2007
[80] Jerneck et al, 2011

As can be seen from the above quote, SS is not only interested in the interaction between humanity and the natural environment, but has an assumption that people can affect the environment, and that this may in return have an effect on people. This focus can be seen by looking at the most cited topics in SS which are[81]: Agriculture, fisheries, ecological economics, agroforestry, tropical rain forests, business, tourism, water, biodiversity, urban planning, rural sociology, energy, health, soils, and wildlife. Though SS may have had a start in environmental conservation, it is not focused on conserving nature for its own intrinsic sake, but for the purpose of people[82], and is therefore sometimes called anthropocentric[83].

3.2.2 Natural science focus on understanding nature-society interactions

Even though the normative stance in SS is anthropocentrism and not ecocentrism, about 2⁄3 of the research which has been carried out in SS has been related to environmental sustainability as opposed to the end goal of SS, which is betterment for people[84]. The chart below, figure 5, shows bibliometric findings of the relative size of each of the areas in SS.

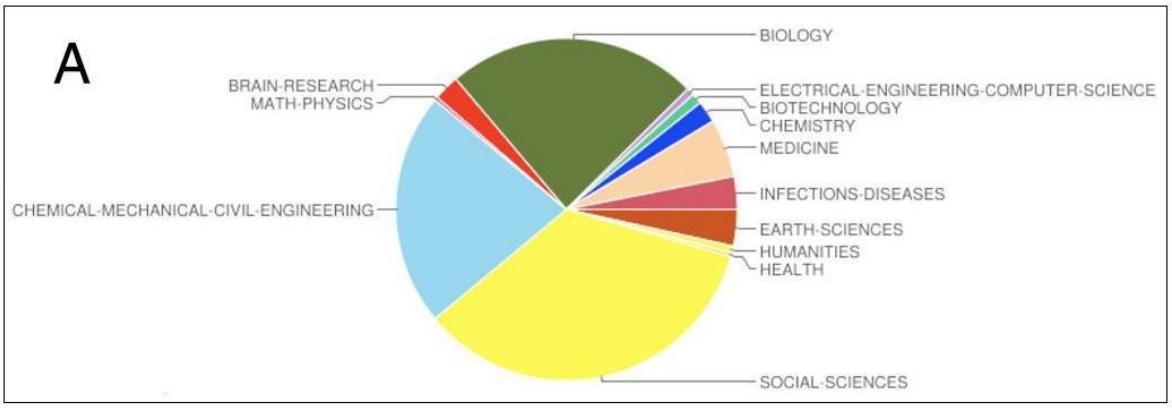

Figure 7. Size of areas in SS. From Bettencourt & Kaur 2011

Here we see that the social sciences seem to be the largest portion of the research, but if we simplify the pie chart to physical sciences and social sciences, we see that the largest portion of research in SS is done in the physical sciences. Kates[85] has argued that SS is mostly carried out in the natural sciences, and Jerneck et al. have commented on this fact and explained how intentionality is therefore often relegated in SS;

> Intentionality may, thus, distinguish social from natural systems. The debate on linked social and natural systems often downplays this crucial difference, perhaps because it is still largely dominated by the natural sciences.[86]

[81] Kajikawa et al. 2007
[82] Kajikawa 2008
[83] Carter 2007
[84] Kates 2011
[85] ibid
[86] Jerneck et al. 2011

If one of the main tenets of SS is to understand human-nature interactions, and if sustainability scientists to a large extent misunderstand one of the basic components of human-nature interactions, such as intentionality, then it will be very difficult to give any good explanations of how to make human-nature interactions function better for sustainability purposes. Though the quote above points out the need for intentionality, it also causes a problem in collaborating across the natural and social sciences. Jerneck et al. say that the lack of theory of human-nature interactions is a hurdle to SS, but that there are theories which are seeking to address these issues, such as industrial ecology, ecological economics, and transition theory[87].

As seen in figure 6, Schoolman et al., in their bibliometric analysis, have shown that most of the research which has been carried out in SS has had a focus on the so-called 'environment pillar' as opposed to the social and economics 'pillars'.

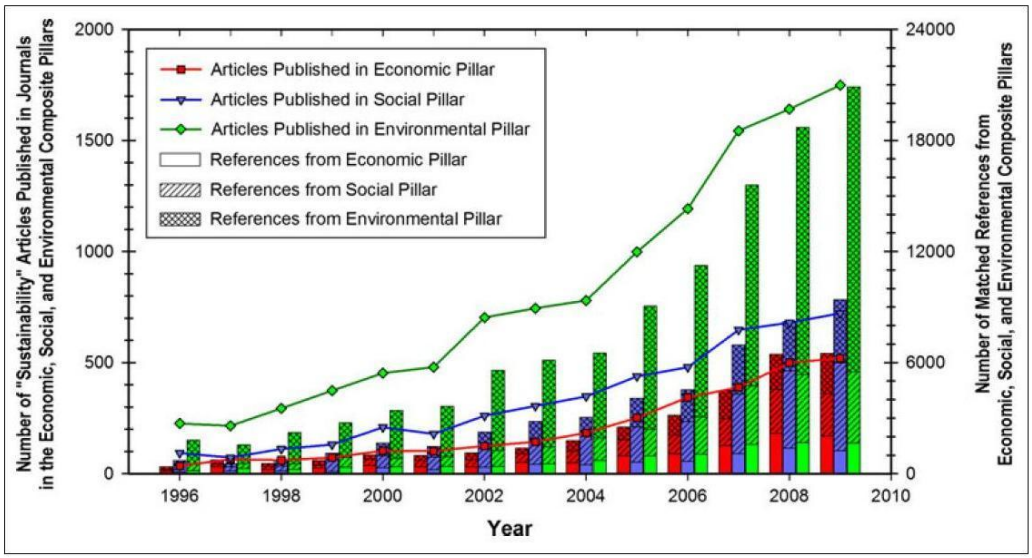

Figure 8. Three Pillars research in SS. From Schoolman et al. 2012

We can sum up this section by saying that environmental research has taken precedence over development research, natural science over social science, and the environment pillar over the social and economic pillars. This focus on natural science in the bulk of SS has been critiqued for lacking an understanding of intentionality in research on social systems[88], and while this insight is beneficial and should be addressed further, it can create a problem of how to collaborate across the natural and social sciences.

[87] ibid
[88] ibid

3.3 Spatial and Temporal scales

3.3.1 Temporal scales are intrinsic to Sustainability Science

Another theme which seems to be agreed on in SS is that of temporal scales, namely that SS needs to be aware of causes and effects through time[89], especially related to inertia in causes and effects[90]. For example, inertia and lags have been found in coupled human-natural systems related to fisheries, landscape, population distribution, human activities, crop yields and effects on groundwater[91]. The dimension of time is an integral part to the dictionary definition of sustainability; to prolong, support or keep up[92]. It is therefore not surprising to find that matters of temporality are found in most of SS. In sustainable development this aspect of temporal scales is often related as the idea that future generations should not be worse off than the current generation, and is often called intergenerational equity[93]. Martens[94] has said;

> …if we wish to say anything meaningful about sustainable development, we have to take into account a time span of at least two generations. The time period appropriate to sustainable development is thus around 25 to 50 years.

The concept of spatial scales is also often important[95]. SS takes an interest in spatial and temporal issues because it assumes that there will be distinctions across time and space, which can create qualitatively different effects on human-environment systems.

3.3.2 Differences in assumptions on spatial and physical contexts

Though SS may converge around the concept that people affect nature (which may in turn affect people), and that these interactions happen at different time-scales, exactly how these interactions will have causal effects on people vary within differing perspectives. A common distinction is found in so-called strong and weak views of sustainable development[96]. I include this tangent in sustainable development, because as seen in figure 4 SS and sustainable development are closely connected, and because this discussion is so important[97].

Weak sustainability is sometimes called soft sustainability[98]. Weak, or soft, sustainability has its intellectual foundation with economist Robert Solow[99]. He accepted that future generations need to have at least the same overall opportunities for well-being as today, and that the way we use the natural

[89] Mayer 2008
[90] Kates et al. 2001
[91] Liu et al. 2007
[92] Merriam-Webster Online Dictionary 2
[93] Brandon & Lombardi 2011
[94] Martens 2006
[95] Kates et al. 2001
[96] Hopwood et al. 2005
[97] ibid
[98] Briassoulis 2009
[99] Hopwood et al. 2005

environment has an effect on future generations[100]. Solow made a distinction between natural capital and manufactured capital, and assumed that manufactured capital would in many cases increase the value for people. Therefore, according to Solow;

> …the world can, in effect, get along without natural resources, so exhaustion is just an event, not a catastrophe.

According to weak sustainability, manufactured capital and natural capital are interchangeable. Weak sustainability is often linked to environmental economics, while strong sustainability is linked to ecological economics[101].

Strong sustainability has the underlying assumption that nature is materially foundational to our society and our economy[102], and that natural and manufactured capital are therefore not substitutable[103]. Though both strong and weak sustainability have a focus on temporal scales, strong sustainability is more explicit about the physical world[104] and about spatial scales[105] than is weak sustainability.

We can sum up this section by saying that SS accepts that there are qualitative differences across time, though there is a tension between strong and weak sustainability perspectives on the spatial and physical dimensions.

3.4 Systems and complexity

3.4.1 Systems and complexity often discussed in SS

A theme which seems to go through much of the literature in SS is that of systems. I will here list a few of the systems which SS has shown interest in, to show the broad use of thinking in systems in SS. Kajikawa mentions soil systems, mangrove systems, food systems, socio-technical systems, agricultural systems, global systems and human-environment systems[106]. Martens mentions complex systems, natural systems, social systems, transport systems and ecosystems[107]. Jerneck et al. mention natural systems, social systems, social-ecological systems such as fisheries or wetlands, and economic systems and political systems[108]. The term 'systems' is applied more or less analytically explicit[109], but more often than not systems are mentioned in some way. A system is defined by Merriam-Webster as;

> a regularly interacting or interdependent group of items forming a unified whole

[100] Solow 1993
[101] Venkatachalam 2007
[102] Hopwood et al. 2005
[103] Ayres et al. 2001
[104] Venkatachalam 2007
[105] Ayres et al. 2001
[106] Kajikawa 2008
[107] Martens 2006
[108] Jerneck et al. 2011
[109] Spangenberg 2011

It could be argued that the SS description of a system is to be seen as only being epistemological. However, considering the common natural scientific stance in SS[110], it seems that systems are mostly seen as being ontological, that they are in fact real and not just practical metaphors. Regarding the nature of systems Jerneck et al. have said;

> We proceed from the assumption that social and natural systems are characterised by complexity, non-linearity, self-organisation and strong interlinkages.[111]

The viewpoint that systems, and interlinkages of systems, are complex is also an idea which is a common stance in SS[112], and Martens[113] argues;

> The theory of complex systems can be employed as an umbrella mechanism to bring together the various parts of the sustainability puzzle.

3.4.2 The complications of complexity

It is, however, a general problem that there is not a deep enough understanding of complexity in SS[114]. As complexity is so important to SS it would be beneficial to have a sound understanding of how it functions. Manson[115] has provided a typology of complexity where he distinguishes between algorithmic complexity, deterministic complexity, and aggregate complexity. Manson says that algorithmic complexity is only secondary to the main portion of complexity theory, and does not give it much space in his paper, and so I will also focus on the other two forms. Deterministic complexity has feedback loops as a common theme while aggregate complexity has the concept of emergence as a common theme. Both deterministic[116] and aggregate[117] complexity can be found in the SS literature. In many cases it is not clear if any particular complexity theory is being applied or proposed, only that the world is complicated;

> Problems are not given. They are constructed by human beings in their attempts to make sense of complex and troubling situations[118]

We can sum up this part by saying that SS assumes that interactions in systems, and especially between systems, can be very complex. Though complexity is important to SS, there are no clearly defined terms of how to understand complexity.

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[110] See section 3.2.2
[111] Jerneck et al. 2011
[112] See section 3.4.2
[113] Martens 2006
[114] Dahl 2012
[115] Manson 2001
[116] Martens 2006 and Ekins 2011
[117] Ehrenfield 2007
[118] Quote by Schon in Brewer 2007

3.5 Knowledge creation

3.5.1 Several forms of knowledge accepted and practical involvement advised

According to some definitional articles, SS has agriculture and medicine sectors as role models of knowledge creation[119]. Knowing this, we get some hints as to what the vision of SS knowledge creation and knowledge networks are to look like; knowledge is to be both practical for the situation at hand, and may come from a wide variety of stakeholders. Possible knowledge creators are government agencies, the business sector and civil society, as well as scientists[120].

SS is interested in both gaining understanding and being applicable, as opposed to traditional basic research[121]. As we can see from the matrix to the right, figure 9, this is called use-inspired basic research. The knowledge created should give new understanding as well as be practically relevant to society, as mentioned in section 3.2.1. SS is interested, then, not only in gaining deep knowledge about human-environment interactions, but also knowledge about how this will make a positive difference for people. SS wants to be socially and politically involved, rather than a mere producer of knowledge, because of the pressing and important nature of sustainability issues;

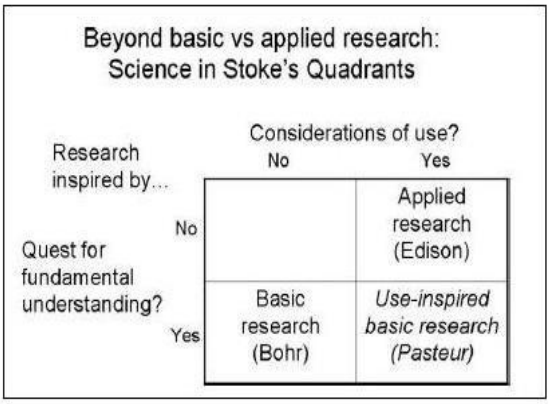

Figure 9. Use-inspired basic research. From Clark 2007

> Finally, in a world put at risk by the unintended consequences of scientific progress, participatory procedures involving scientists, stakeholders, advocates, active citizens, and users of knowledge are critically needed.[122]

Here we can sum up this section by saying that SS is open to several forms of knowledge. We can also say that SS states explicitly that it should be involved in society by creating knowledge which is beneficial to society, as well as being closely linked to societal actors.

3.6 Disciplinarities

3.6.1 Mono- and pluridisciplinarities accepted

Spangenberg has pointed out that in the area of SS there has been a distinction between science which has been done for sustainability and the science of sustainability[123]. The science of sustainability is the more use-inspired approach, while the science which has been done for sustainability has often been

[119] Cash et al. 2003 and Kates 2011
[120] Kates et al. 2001
[121] Clark 2007
[122] Kates et al. 2001
[123] Spangenberg 2011

more focused on traditional basic research. Both Kajikawa[124] and Spangenberg[125] agree that there is room for basic research because it has given valuable information for SS. Spangenberg has, however, some qualifications for what basic research must look like in order to be beneficial to SS;

> Sustainability science must be either interdisciplinary or at least 'interdisciplinarity-ready', conducted in a way which allows the integration of its results in an interdisciplinary context, bringing disciplines together to achieve greater consistency in approaches between them[126]

SS has a stated purpose to be, multidisciplinary[127] and/or interdisciplinary[128] and/or transdisciplinary[129]. Multidisciplinarity can be seen as focusing on one issue but coming at it from different scientific disciplines[130] and adding this knowledge together[131]. Interdisciplinarity can be seen as a team working in cooperation across disciplines on the same topic[132], or that researchers have knowledge of several related disciplines[133], or a mixture of these two[134]. Transdisciplinarity can be seen as taking it one step further from multi and interdisciplinarity by creating a new discipline where new theories and concepts arise, while still having connections to other disciplines[135]. The model below by Kajikawa gives a good overview of the three pluridisciplinarities;

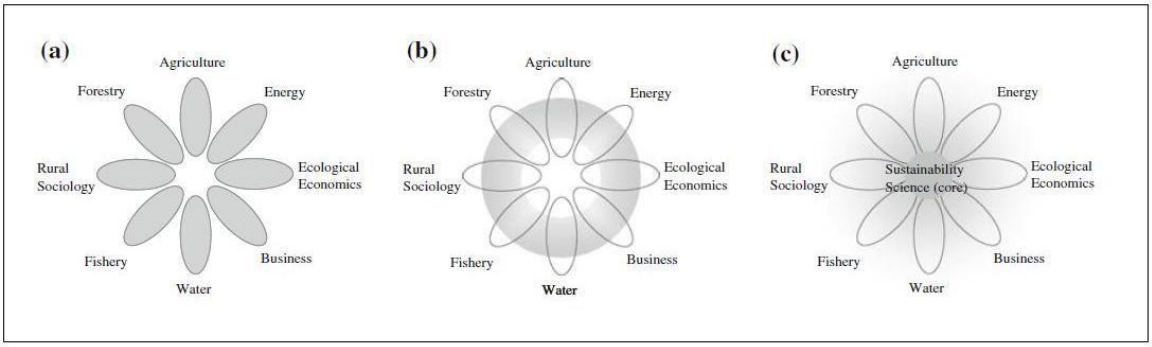

Figure 10. From Kajikawa 2008 where (a) is multidisciplinarity, (b) is interdisciplinarity and (c) is transdisciplinarity

The idea of having pluridisciplinary research fits comfortably with the view in SS that there is a need to understand complex systems;

[124] Kajikawa 2008
[125] Spangenberg 2011
[126] ibid
[127] Jerneck et al. 2011
[128] Bettencourt & Kaur 2011
[129] Kajikawa 2008
[130] Jerneck et al. 2011
[131] Kajikawa 2008
[132] Bettencourt & Kaur 2011
[133] Kajikawa 2008
[134] Jerneck et al. 2011
[135] Kajikawa 2008

> Research on complex issues is usually best pursued when researchers with different but related expertise and experiences form groups to investigate various aspects of a joint problem (Sherren et al. 2009)[136]

3.6.2 The problem with pluridisciplinarities

However, since SS does not have a clear conception of what constitutes complex systems or how they function[137] it is difficult to understand how SS assumes pluridisciplinarities can explain said complexity.

Schoolman et al. have done a recent study as to the interdisciplinarity of SS[138]. Basing their arguments on the small extent in which environmental articles reference social and economic articles, they argue that a large portion of SS up until now has not been as interdisciplinary as it is supposed to be, as can be seen in figure 8. A possible cause of this lack of interdisciplinary collaboration may be the differences in ontology and epistemology in disciplines, and in communicating these differences.[139]

3.7 Variety of methods and combinations of methods generally accepted

SS is open to a broad variety of research methods and techniques[140]. Methods can and should be used in new constructive ways, for example by mixing several methods for the research issue at hand[141]. As Spangenberg explains;

> Methodological pluralism is a necessary characteristic of sustainability science as a whole, although not necessarily of each research project.[142]

Some oft-mentioned methods are GIS and systems analysis[143], different forms of fieldwork[144], and scenarios[145].

We can sum up this section by saying that SS should be multidisciplinary, interdisciplinary (or at least interdisciplinary-ready) and/or transdisciplinary. These conditions make room for a multitude of methods and mixed methods. Though pluridisciplinarity has been touted by the sustainability science theorists as important, research actually carried out in SS has not yet reached up to this potential.

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[136] Jerneck et al. 2011
[137] See section 3.4.2
[138] Schoolman et al. 2012
[139] Spangenberg 2011
[140] Ascher 2007
[141] Kates et al. 2001
[142] Spangenberg 2011
[143] Jerneck et al. 2011
[144] Kates et al. 2001
[145] Jerneck et al. 2011 and Martens 2006.

3.8 Recap of SS points discussed

3.8.1 Some recurring themes

- Humanity and nature are interlinked and mutually causal, though final priority is given to humans.

- SS accepts that there are qualitative differences across time

- The world is often seen in terms of systems that act and interact complexly.

- SS should create knowledge which is beneficial to society

- SS is open to several forms of knowledge, for example knowledge created by societal actors.

- Though traditional disciplinary research is relevant, it is necessary to work between disciplines, and even beyond disciplines, to form new theories about how the world functions.

- SS accepts the value of many different methods, and the creative combinations of methods.

- Scenarios are often used to envision future states.

3.8.2 Problem areas

- The weight of the research has been on natural as opposed to social sciences, and understandings of particularly social phenomena such as intentionality are therefore often glossed over.

- SS is still in the beginning phases of learning how to overcome the distinction of natural and social sciences.

- Assumptions about spatial and physical aspects vary between weak and strong perspectives.

- Though complexity is an important part of SS, there is no clear discussion of what it is and how to comprehend it.

- Though SS is interested in interdisciplinarity and transdisciplinarity, it is not carried out to a great extent, and it is not explained how it functions in relation to complexity.

4 CR and SS together

Based on the recurring themes as well as some of the tensions found in SS from section 3, I will see if the main points of CR mentioned in section 2 could be of benefit to SS as a philosophy of science, by potentially clarifying some issues when there are tensions, as well as giving a meta-theoretical foundation for what SS already says.

4.1 Discussion points on nature and society

4.1.1 Physical aspects of human-nature interactions expanded by CR

Ontologically there seems to be a strong link between CR and SS with regards to how human-nature interactions are viewed. It is argued in SS that people may affect nature, and that nature may have effects on people in return[146]. The below list shows how CR views the interconnectedness of human agents, society and material reality;

- The natural world affects people physically, because people are physical beings[147]
- The individual is an agent, not just a physical object[148]
- Agents may affect one another, and intentionally and unintentionally create social structures[149]
- Society (social structures) affect agents[150]
- Agents may affect nature, because they are physical beings[151]

From this we can see that CR has a broader conception of how nature and society are connected than does SS. Though CR has the meta-theoretical framework for these interactions, it is up to science to find to what extent they are linked and under which circumstances[152]. I think SS would be a particularly good candidate for looking at these issues as it has a stated interest in identifying human-nature interactions.

4.1.2 Intentionality, agency and social change more clearly defined in CR than in SS

One of the critiques mentioned earlier in section 3.2.2 was that since a great portion of the SS literature is based on a natural scientific understanding, it often lacks an understanding of human intentionality. This seems to be similar to the intentionality discussed in CR in that intentionality is particularly human[153].

[146] See section 3.2.1
[147] See introductory part to section 2.6
[148] See section 2.6.1
[149] See section 2.6.2
[150] See section 2.6.2
[151] See section 2.6.1
[152] Bhaskar 1998
[153] See section 2.6.1

An example of how including agency and intentionality in SS can be done can be found in a paper by Olsson & Jerneck[154]. In this article they discuss helping people (subsistence farmers in Africa) by seeing them as agents as opposed to victims so that the farmers may increase their own sustainable livelihoods. The stove helped reduce the amount of woodfuel needed to be hewn which is a benefit to climate change, and it gave improvements to health. The effectiveness of the stove also helped reduce the amount of time needed to fetch woodfuel, and time could therefore be spent in more productive ways.

With less time spent getting woodfuel and less disease from health problems from indoor pollution, their freedoms could be enhanced. Though these things are important, the aspect which was rather unique was that the researchers did not just give them stoves, as has often been the case[155], rather they helped inhabitants make a viable local business with relative autonomy. This was possible because the peasant farmers were seen as agents and were invited to act as such. This exploratory research was related to both aspects of sustainable development, namely making a better planet for people as well as alleviating poverty[156]. From this we see that SS may include agency and intentionality without explicitly accepting CR as a meta-theory. Yet CR would fit well as an underlaborer for such a piece of research because of its focus on agents and on increasing their freedoms.

As discussed in section 3.2.2, it is precisely because all people have intentions and agency that changes to a better society can be made. SS, which is a normative science striving for social change[157], may therefore benefit substantially by more extensively including theories of intentionality and agency to explain how a transition to a more sustainable society is to come about. CR has a comprehensive understanding of agency as related to structures, and may therefore be beneficial to SS in this regards.

4.1.3 Views on the link between natural and social science in CR and SS

In a critical realist perspective social and natural science do have commonalities in that they can both be defined as trying to understand the structures and mechanisms which cause certain events[158].

Because of an emergent and stratified reality, mechanisms may have different qualities. CO2 has physical effects which can cause the earth's temperature to rise[159] while agents have the possibility to intentionally release or not release CO2 into the atmosphere. Though different structures and mechanisms have qualitative differences, they are similar in that they have inherent causal powers which may cause events, which in turn may be experienced by scientists.

[154] Olsson & Jerneck 2010
[155] ibid
[156] See section 3.1
[157] See section 3.2.1
[158] See section 2.6.2
[159] Miller & Spoolman 2008

According to CR[160], the way in which science is done in social science needs to take into account the agency of individuals and the temporal and spatial dynamics of social structures. When these aspects are taken into account and understood by natural scientists, which many sustainability scientists are[161], it should not be too complicated for them to do social research[162]. They would still be involved in finding objective truths, even if the subject matter is different, and they would need to acknowledge that the results were fallible[163]. The fact that CR sees natural and social science as fundamentally involved in the same form of work, opens up for further communication and collaboration across disciplines as will be discussed in section 4.4.3.

4.2 Context and qualitative change

4.2.1 Temporal scales, and other contexts

As was mentioned in section 3.3.1, SS is particularly interested in temporal contexts, and how these contexts affect scientific inquiry (lags and inertia), as well as causal effects on society (intergenerational equity). CR also recognizes that there will be differences across time[164], and CR would add that there would be differences across many other forms of context, for example social context and culture[165].

4.2.2 CR perspectives on strong and weak sustainability

Having shown that CR agrees with SS regarding temporal differences, we can now look at the strong and weak distinction in SS[166] to see which version CR would most likely defend. As mentioned earlier[167], CR says that the social world is emergent from, but not reducible to, the material world. This could give a hint as to the direction that CR would argue regarding strong and weak sustainability. It would seem that CR would agree with strong sustainability that natural systems do have causal powers which can affect people, and that people are embodied and are therefore dependent on the natural environment. CR is also found to often defend more egalitarian perspectives[168], in the same way as strong sustainability does[169].

[160] See section 2.6.2
[161] See section 3.2.2
[162] Bhaskar 1998
[163] See section 2.4.4
[164] Sayer 2000a
[165] Sayer 2000b
[166] See section 3.3.2
[167] See section 2.5 and 2.6
[168] See section 2.8
[169] See section 2.3.3

4.3 Knowledge and method

4.3.1 Different forms of knowledge and a variety of methods

It seems that CR and SS are similar in the fact that they are both open to a wide variety of knowledge creators, and not only scientists in the traditional sense[170]. SS has been defined as wanting to get contextual knowledge from business, government and civil society, as well as from scientific knowledge[171]. CR has stated that it accepts all knowledge as fallible[172], and that therefore all knowledge can be of use, though some knowledge may be more useful than other types such as context specific knowledge[173].

Both CR and SS have stated that a variety of methods are important, both quantitative as well as qualitative and in mixing the methods[174]. On the whole CR and SS seem to fit very comfortably in relation to the type of knowledge systems used and methods applied.

4.3.2 Agreement that knowledge should be of practical use for society

SS sees it as important that knowledge should be use-inspired, which means that it should both gain deep knowledge while also being practical as shown in figure 7[175]. The importance of science being practical, as well as deep, is directly related to the normative stance in SS to be involved in society[176]. CR also sees it as the duty of scientists to be involved in society, especially social scientists[177].

For SS, the betterment of the world comes through an anthropocentric priority in nature-human interactions[178], and for CR it is related to emancipation of people from dominating social structures[179]. We could leave the issue at this and say that CR and SS both have normative stances towards a better world but different definitions of how the world is to be better, or we could see how a possible synthesis might look.

If we were to make a synthesis we could say that the anthropocentric conception in SS could be defined further as not only as giving final priority to people over natural structures[180], but also to individuals over social structures. In this case the research would not only be use-inspired for humanity at large for creating better human-nature interactions, but would also be use-inspired to certain social forms for helping people gain freedoms. Research would also be directed towards helping people know that they have agential powers, and this would necessarily start with SS being more explicit about agency as

[170] See sections 2.4.4 and 3.5
[171] See section 3.5
[172] See section 2.3
[173] Section 2.4.4
[174] See sections 2.4.3 and 3.7
[175] See section 3.5.1
[176] See section 3.5.1
[177] See section 2.8
[178] See section 3.2.1
[179] See section 2.8
[180] See section 3.2.1

mentioned[181]. An example of SS being carried out in a similar fashion to the synthesis here proposed was shown in section 4.1.2.

To sum up: CR and SS have similar normative stances in that they are related to the betterment of people, though the norms they have are somewhat different. By making a synthesis of the normative positions of both CR and SS, a possible new normative stance for sustainability scientists could be that they seek to understand deep knowledge of natural as well as social structures for the practical purpose of the betterment of people, both physically and related to individuals freedoms.

4.3.4 An example of empirical SS accomplished using CR as a meta-theory

A piece of research which shows a critical realist approach to SS may be found in an article by Næss called 'Residential location affects travel behavior – but why and how?'[182] It is interdisciplinary, building on research from different disciplines and also applying different research techniques. The research question in the title is the quintessential critical realist question as it seeks to find underlying mechanisms and their causal powers[183].

The paper gives an introduction stating previous research which has looked into the correlations of residential location and peoples travel habits. It has been seen that people who live closer to the city centre generally use the car less, and thereby pollute less and cause less problems for the environment. He explains that these results have been interpreted by physical planners and politicians as being a spatial issue, that living closer to amenities causes less travel by car, thereby implying that compaction is a benefit for reducing car travel. He then proceeds to explain social scientist critiques of the assumption that spatial aspects are the main drivers of human behavior. Social scientists have mentioned how socioeconomic aspects could have a greater effect on travel behavior than physical attributes. Næss includes both these perspectives in the study, and also includes attitudes and intentions in the study. He wants to look into the actual causes people have for travelling as they do, and this is done by accepting that people have intentionality, and though subjected to social and natural structures which must be taken into account, people may act in opposition to what could be assumed. People therefore need to be asked for their reasons and intentions for their transport habits.

To understand the mechanisms of why people chose a certain mode of transportation there were used qualitative methods, and interviews in particular. To get an overview of which mechanisms were most common quantitative methods in the form of statistical analysis of large surveys were used. This shows how CR may use both quantitative and qualitative methods to gain understanding. He also made clear that the results could in reality only be generalized to the area studied, because of cultural and other qualitative contexts;

[181] See section 3.2.2
[182] Næss 2005
[183] See sections 2.3 and 2.4

> But this method of selecting respondents also makes it problematic to carry out statistical generalizations from our sample of respondents to the populations of the Copenhagen area. Therefore, the statistical levels of significance are only indicators of the certainty of the various relationships found within the sample.[184]

Though there were these problems of generalization beyond certain parts of Greater Copenhagen, Næss seemed open to the idea that it was not unlikely that results would be similar in other parts of the Greater Copenhagen Area, as well as other Scandinavian and Northern European cities because of qualitative assumptions about the relative homogeneity in the area[185].

Retroduction was also used as the foremost form of reasoning, and was seen as a great asset in gaining a deeper understanding of mechanisms which were anticipated, and importantly also mechanisms which were not expected;

> Retroduction has also played a crucial role in the current interpretation of the empirical results. This applies to the quantitative material as well as the qualitative interviews. Each time we found something surprising, we speculated on what might have produced these results. Often, these speculations led to additional and more elaborate analyses of the quantitative material. The statistical analyses were thus explorative (yet theory-informed) processes rather than a pre-programmed, deductive way of working.[186]

From this we can see the practical relevance of retroduction in empirical research, in that it deepens analysis and knowledge of both qualitative and quantitative results. The use of retroduction helped lead to a more exploratory process and not get caught up in a priori assumptions of what causes what. This lead to the discovery that it is not only physical distance which caused choice of travel behavior, but many interconnected factors, as seen in the causal model below;

[184] Næss 2005, p.190
[185] Næss 2005
[186] Næss & Jensen 2002, p.301

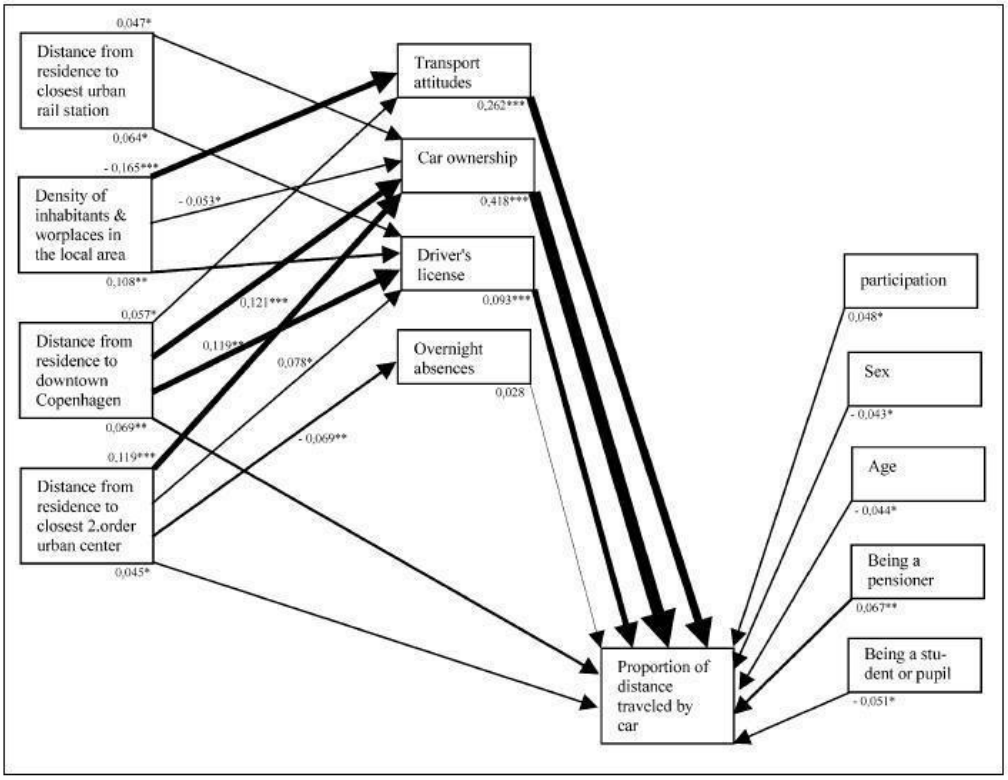

Figure 11. Factors for car travel. From Næss 2005

From this case example we see how CR fits well with the interdisciplinary approach proposed by SS (this will be discussed in more detail in the next section). The article shows the practical relevance of using retroduction to find and understand mechanisms which might not have been thought of before. The article also shows a practical way of mixing methods in a conceptually coherent way to gain important understanding, which is also important to SS[187]. Næss shows how generalizations in a critical realist perspective need to be qualitative and take into account context, both physical and social. Finally, the article shows the importance of looking for intentionality, and this is done by first framing people as agents with intentions.

4.4 Understanding complexity through pluridisciplinarities

4.4.1 CR and SS on complexity and pluridisciplinarities

An assumption which is agreed upon in both CR and SS is that there are needed different forms of pluridisciplinarity to understand complex systems[188]. Before going on to discuss multi- and interdisciplinarity it could be useful to compare the terminology and meanings of complexity and different disciplinarities in CR and SS.

[187] See section 3.7
[188] See sections 2.7 and 3.6.1 and figure 5 for references on disciplinarities in this section

The SS view of complex systems is often related to there being difficulty in understanding causal relationships and difficulty in predicting events, though complexity could also be related to some form of complexity theory[189]. SS is usually not explicit about this position[190].

The critical realist understanding complexity is directly related to an emergent and stratified reality, as explained by the necessity of multi- and interdisciplinarity[191]. To get a better picture of the whole complex area it is good to have knowledge both of mechanisms from different strata (multidisciplinarity), and of the emergent events they create (interdisciplinarity).

Monodisciplinarity is seen as a foundation of knowledge creation in both SS and CR, but it in both cases it is seen as not being sufficient to handle complex issues[192]. The definitions seem to be the same as they are related to knowledge gained from one particular discipline. In CR the reasoning for monodisciplinarity is however deepened by relating it to the ontological assumption that disciplines search for knowledge at some particular strata.

Multidisciplinarity is seen somewhat differently in CR than in SS, though there could be areas where the ideas overlap. In CR the validation for multidisciplinarity is found in the ontological status of emergent and stratified reality. Knowledge from different strata can be put together in an additive manner. Also in SS addition of knowledge from separate disciplines is recommended in multidisciplinarity. The epistemic matter of addition is similar in CR and SS, though in CR it is explained what the world must be like for multidisciplinarity to be important.

Interdisciplinarity is also seen somewhat differently in CR than in SS. In CR, the ontological justification for interdisciplinarity is seen in connection to there being mechanisms at different emergent strata, and these mechanisms form emergent events. It is therefore necessary, not only to add knowledge from different strata, but to synthesize and integrate knowledge of the different mechanisms and their causal powers. From a SS point of view interdisciplinarity is related to scientists having a broad variety of knowledge, or when teams of scientists work collaboratively across different disciplines. As in the case of multidisciplinarity it is here related to an epistemic focus, rather than ontological. In SS and CR, interdisciplinarity is said to be an integration and deep collaboration, while in CR it is explained further what the world must be like for interdisciplinarity to be important.

Transdisciplinarity is seen in CR as being related to creating new theories (epistemic) based on the observed interdisciplinary phenomena. In SS it is seen in the same way, in that there would be new theories created while SS would still be connected to other disciplines.

Crossdisciplinarity is mentioned in CR as being related to working cooperatively (interpersonal). While I did not see this wording in the SS literature, it could be implied in the SS conception of interdisciplinarity since it was said that interdisciplinarity could in certain cases be related to working collaboratively.

[189] See section 3.4
[190] See section 3.4.2
[191] See section 2.7
[192] See sections 2.7 and 3.6.1

To sum up we can say that the transdisciplinary perspectives are very similar in CR and SS while mono-, multi- and interdisciplinarity in CR are given an ontological justification which is not given in SS. Crossdisciplinarity in CR could be comparative to the collaborative part of interdisciplinarity in SS.

4.4.2 CR can synthesize knowledge from different disciplines, sciences, and meta-theories

As well as supporting interdisciplinary research because it has a coherent theory of how complexity functions, CR is also good at supporting interdisciplinary research because of the possibility to bring in knowledge across natural and social sciences[193]. Another important aspect of collaborating more effectively across disciplines can be gained by having a common understanding of meta-theory;

> Thus, successful interdisciplinary communication requires its own dictionary of clearly defined terms. For disciplines whose object requires knowledge historically generated by other disciplines, this 'disciplinary multilingualism' (Spangenberg 2003), the mutual understanding of epistemologies and ontologies, becomes particularly important (Horwitz 2003).[194]

Since CR can help integrate knowledge from CE and PS[195], it has a unique position to be a meta-theory for interdisciplinary science. As mentioned in section 3.6.2 Schoolman et al. have shown empirically that SS has not yet been as interdisciplinary as it is intended to be, especially when the research has been focused on the natural environment. This could indicate that natural scientists, in particular, could be benefitted by having a meta-theory to help guide interdisciplinary and transdisciplinary work.

CR can be an effective philosophy of science for SS because it can bridge knowledge from natural and social sciences, knowledge across different disciplines, and from different meta-theoretical positions. CR both explains the necessary conditions for understanding complex systems, and provides the means to fulfill the conditions.

4.4.3 CR example of understanding a complex open system

A prime example of a critical realist perspective on seeking to understand a complex open system is a model created by Fleetwood for a socio-economic theory of labor markets[196]. To provide a comprehensive model Fleetwood takes perspectives from a wide variety of disciplines such as;

> …social scientists who study labour markets from disciplines like labour law, industrial or employment relations, human resource management, education research, socio-health studies, industrial organisation theory, organisational and management theory, social theory, sociology of work and employment, state theory, urban geography, women's studies, working life science and so on. It also consists of heterodox labour economists such as Feminists, Institutionalists, Marxists, post-Keynesian's, Segmented Labour Market theorists and the Societal Effects and Regulation Schools, those who treat labour markets as key parts of Systems of Production, Business

[193] See section 4.1.3
[194] Spangenberg 2011
[195] See section 2.3
[196] Fleetwood 2011

Systems, Welfare Systems and Employment Systems, some of those taking a Varieties of Capitalism approach, and many of those who specialise in international comparative labour market analysis.

Fleetwood explains that his model is a sketch, and that one person cannot create a model of such a complex system alone. Here we see how CR can, and sees it as important to, bring in several different viewpoints and arguments across many disciplines.

He explains that in a large amount of the research mentioned above it has been found that orthodox economics has made many mistakes, often because it tries to explain and predict the world based on oversimplified assumptions. The orthodox model of labor markets is some derivative form of a supply of people and demand from companies, and the function of these gives the mathematical answer of what the market looks like, or should look like. The orthodox view of economics sees the labor market as a closed system, and then works deductively from simplified factually false assumptions. One example cited of how the assumptions of the orthodox models are simplified into false statements is the assumption of infinitely lived individuals. The critique of the orthodox view can be summed up in a statement something like the following: If orthodox economics starts from factually false assumptions about components parts, and place these parts in a supposedly closed system, when scientists then deduce from these statements the results may be mathematically accurate but they will be far from reality.

Though there has been a great deal of critique, there has not yet been created a comprehensive competing model of how labor markets actually function. Fleetwood argues that this is because, even with knowledge from many different disciplines, without a common meta-theoretical foundation it can be very difficult to create a new coherent trans-disciplinary theory. The priority in a new model should be that it be realistic rather than mathematical. With a model that is based on understanding how labor markets function and why they function in a certain manner, the model can later be used to find quantitative correlates, if that is desired. The first step in understanding a complex system is to know what the component parts are. This has been accomplished to a great extent already in the individual disciplines quoted above (i.e. the importance of monodisciplinarity). It is because many of the component parts have been found that Fleetwood wants to synthesize the knowledge. The second step is therefore to understand the general aspects of the complex system as a whole, which is what Fleetwood attempts to do in this article by providing a socio-economic model of labor markets. Following this the model may then be used in for example guiding empirical research, in developing theory, and in teaching.

Below is the model by Fleetwood. At first glance it is perhaps overly complicated and seems to cause more questions than answers, but in the paper Fleetwood explains each part effectively and clearly. I will not go into each and every aspect of it as the purpose is only to show how CR may seek to understand functionings of complex open systems. I will therefore only mention certain parts of the model (A-C) to help explain why this model is more realistic than the traditional model, and what this means for research, teaching, policy, and for SS.

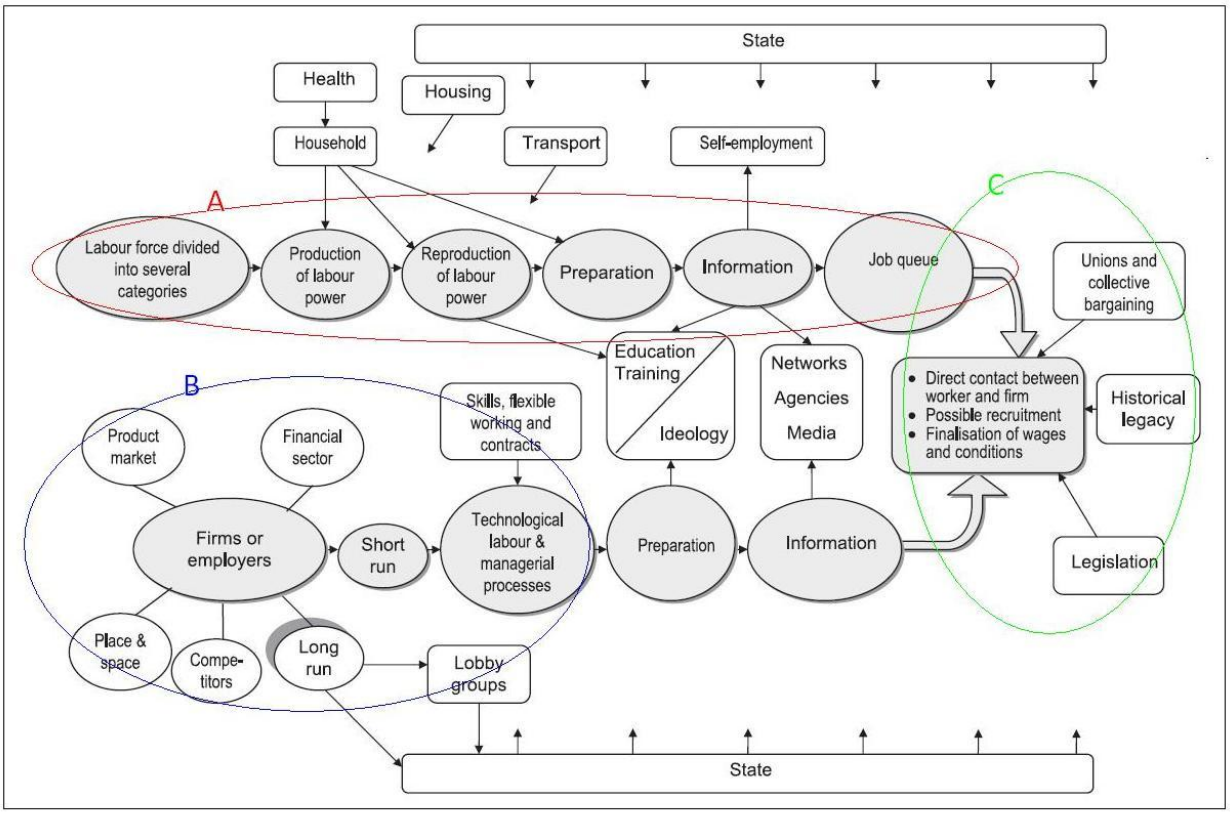

Figure 12. Socio-economic model of Labour Markets, from Fleetwood 2011

One aspect which separates Fleetwoods' model from orthodox economics is that the model is founded on an explicit critical realist conception of agency and structure. This means that structure is seen as preceding agency and therefore both constrains and enables it, while agency may in turn reproduce or transform structures[197]. The employees as well as the employers are the agents, while the structures are for example institutions, legislation, ideology, and technology. Fleetwood sees social structures and socio-economic phenomena as being the same concept matter and therefore interchangeable terms. The quote below shows how the theory that agents may reproduce or transform the structures is applied in this model;

> Labour markets, as social mechanisms that coordinate the labouring activity of society, are sets of socio-economic phenomena that are reproduced or transformed by labour market agents who draw upon these phenomena in order to engage in actions they think (consciously or unconsciously) will meet their employment-related needs.

An example of reproduction of the structures comes in the form of women often accepting lesser pay and thereby continuing that particular structure, while an example of transformation is found in firms hiring temporary rather than permanent employment. From the perspective of employees and employers being agents, a deep critique of orthodox economics is identified in that people are more than math and statistics;

[197] See section 2.6.3

> The way firms react to a downturn is not mechanically governed but open to a degree of managerial discretion…There are several ways of dealing with a downturn, ranging from immediately downsizing and shedding labour, via making alterations to the way existing labour is utilised, managed and new labour recruited, to hoarding labour and waiting for an upturn. Through these actions, firms play a role in producing or transforming slack or tight labour markets.

In a traditional perspective when there are less sales a company needs less employees and this will automatically change the supply-demand curve. It is shown however, that sometimes hoarding and other forms of employment management are applied, because of agency and structures, as opposed to what would be expected in a strict supply-demand theory.

The model also explains that there is more to supply than just numerical entities as in orthodox economics. The following which will be discussed is shown in part A of the model. First there are social structures defining categories of workers such as class, gender, race and nationality. Into these social structures there needs to be physically produced (sic) potential employees. These potential employees need to be prepared for labor through gaining knowledge and a desire to work, then they need to have knowledge of what work is available, and finally;

> At some stage, workers enter the labour queue. Here they 'wait', as it were, for an employer to register an interest in recruiting them. It is here that membership of one, or several, of the above categories has causal implications not only for which labour queue the agent enters, but also for whereabouts in the queue they are ranked. Employers are not neutral vis-a`-vis the type of workers they prefer, and in many cases this results in certain categories of workers being overlooked, thereby remaining in the queue. At some point, workers are recruited from the job queue.

Having explained how the supply side is very complex, it is time to look very briefly at the demand side where there is also more to the situation than just a simple demand curve as shown in the quote below and in section B;

> Firms are heterogeneous, divided by size, corporate structure and culture, nature of production (process, manufacturing, extractive, service), the nature of the technology employed, the way they are financed, the stage of maturity, private or public sector, and so on. These factors often play a role in the way firms take actions, some of which are involved in reproducing or transforming labour markets.

There are also agent and structure interactions involved in the actual recruitment process and contract conditions. There is not just an adding up the numbers as explained in the quote below and seen in section C;

> When workers are recruited from the job queue, several things are finally decided upon, most notably: pay and conditions; the employment level of the firm; the quality (e.g. skill, motivation) of the labour force; the nature of employment relations; mix of employment contracts etc. This is also where the consequences of the initial categorisation of the labour force come into effect as (say) whites are recruited before blacks. The 'final decision' about things like pay and conditions, the nature of employment relations and the nature and mix of employment contracts in operation, is influenced by socio-economic phenomena like collective bargaining and, therefore, labour unions, historical legacies and legislation, especially labour laws.

From the above discussion we see that there is much more to the real social world than just demand meeting supply. There is a very complicated context which may cause qualitative differences across time, space, agents and social structures. With a better understanding of how the world functions and why it does so, further empirical work can more accurately be accomplished.

I have here shown one example of how CR could be an effective meta-theory for working across disciplines to create a model of a complex open system founded on factually correct statements. Fleetwood argued, and has shown, that with a common meta-theoretical foundation it is easier to create a new coherent trans-disciplinary theory. A model was created which better explains reality than previous models because it takes into account the many causal aspects which are realized in a broad variety of disciplines, as opposed to cases where only one perspective is applied. Another aspect which makes this particular model more realistic in a continuously changing world is the explicit inclusion of agents and structures causing change and reproduction. Because the model is closer to reality than previous models Fleetwood argues it can therefore be of benefit to research, as well as giving a sound foundation for socio-economists in teaching and in advising policymakers.

It should be noted that though the model did mention physical aspects such as health and housing, it did not discuss the causal effects of the natural environment on human populations, as SS would be interested in. In a discussion on a complex open system in SS this aspect would also need to be addressed. As an example, the model above could be used by sustainability scientists as a foundation for making a model of an eco-socio-economic model of labor markets by including knowledge of specific mechanisms known in the natural sciences. Though this model was not related directly to SS, I chose to share it because it shows succinctly how CR can function as a meta-theory to handle complex open systems.

4.5 Recap of SS and CR together

4.5.1 Affinities in CR and SS

- Both CR and SS agree that people may affect nature, and that nature may affect people.

- Both CR and SS accept explicitly that temporal dimensions may lead to qualitative differences in scientific results.

- They are both open to, and argue for the importance of, including knowledge from a wide variety of possible knowledge makers, lay as well as scientific.

- Both CR and SS are open to a wide variety of methods, mixing methods in a coherent manner, and in applying both qualitative and quantitative methods.

- They both see it as important that knowledge be practical for society. In SS this is related to final priority given to people, while in CR is it related to emancipation of people from harmful social structures. It was shown how SS could comfortably incorporate the normative stance of CR.

- Both CR and SS argue that pluridisciplinarities are needed to understand complex systems.

- The meanings of different pluridisciplinarities are similar in respects of epistemology. Monodisciplinarity was seen as traditional disciplinary research, and was seen as important, but not sufficient. Multidisciplinarity was in both cases seen as related to adding knowledge from different disciplines. Interdisciplinarity was in both cases seen as making a synthesis of knowledge from different disciplines. Transdisciplinarity was seen in both cases as creating new theories out of the interdisciplinary research. Cross-disciplinarity was mentioned in CR but not in SS, though it seems to be implied in the SS explanation of interdisciplinarity.

4.5.2 CR can help SS with deeper understanding in certain aspects

- CR has a broader conception of nature-society interactions than does SS usually does. CR makes explicit that people are embodied intentional agents and are separate from, though connected to, social structures.

- With a more explicit discussion of intentional agents who are constrained/enabled by, and may reproduce/transform, social structures, SS can gain a clearer understanding of how a transition to a more sustainable society is to come about.

- CR claims that not only will there be differences across different temporal scales, but across many other types of context also, such as social context and culture.

- Retroduction could be a beneficial mode of reasoning to find mechanisms which were not previously considered in complex systems.

- CR has an ontologically grounded justification for mono-, multi- and interdisciplinarity, which can help explain the link between complex systems and pluridisciplinarities. Understanding this link can help in knowing how to approach such systems in a systematic manner.

- CR can include knowledge from both CE and PS, and can therefore be a help in interdisciplinary research. Fleetwood also mentioned that it was beneficial to have CR as a meta-theory to create a model of a complex system.

4.5.3 CR can help solve possible tensions

- CR claims that natural and social science are both involved in finding deep structures and mechanisms which may cause events, and the natural-social science divide can therefore be overcome. Also, by understanding some of the particularly social phenomena, natural scientists, who constitute the majority of SS, can have a good understanding of social research, because they are people and can act hermeneutically.

- CR would likely support the strong sustainability perspective rather than the weak because of the affinity CR and strong sustainability have in the areas of a materially grounded social reality and egalitarian perspectives.

5 Conclusion and further research

As mentioned in the start of this paper, SS is a relatively new discipline, and for this reason there are some tensions and areas of ambiguity though there are also some themes which are very much agreed on. This paper has attempted to see if CR could be a beneficial meta-theory for SS, by 1) being able to help SS in some of the unsettled areas and 2) if it fits with the subject matter which is more settled.

Based on several of the themes and concepts discussed in SS, it seems that CR could be an adequate philosophy of science for SS; CR and SS have an affinity in several areas, CR may help SS have a deeper understanding in certain key areas, and CR can give guidance in solving some possible tensions in SS. I would in particular advise SS to apply the CR view of agency and social structures, as I think this would be very beneficial to understanding how a transition to a more sustainable society could be achieved. I think it would also be very important for SS to understand the ontological foundations of pluridisciplinarities, thereby being able to more systematically carry out pluridisciplinary research.

This research was subjected by a number of limitations, such as time and space. Though I tried to get SS articles which gave an overview of the field, only a small portion of the extensive SS literature was covered. It could be very helpful to include more literature, as well as more topics in SS in future research. The same applies to CR. The introduction to CR was necessarily a narrow introduction because there was not room to go into more details in a systematic manner.

Another thing which could be good to discuss in further research would be to focus on potential problem areas in applying CR as a meta-theory for SS. One such potential area is that SS often sees scenarios as being important while Bhaskar has stated clearly that induction can be an oversimplified form of reasoning. It could also be beneficial to look more systematically into PS and CE to see how CR compares to them as a meta-theory for SS. I have here only looked at these meta-theories eclectically.

Having said this, from the paper it seems that CR could be an adequate meta-theory for SS because of the affinity found in many aspects, and especially because CR could help SS gain a deeper understanding in certain key areas of SS. Further research will need to be undertaken to see if SS should use CR as a universal meta-theory, this research has merely shown that it could be a potential meta-theory, and that certain aspects of CR can be used practically by SS to further the work of sustainability.

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