Insolvent

How to Reorient Computing for Just Sustainability

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Citation:

Insolvent: How to Reorient Computing for Just Sustainability
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DOI: 10.7551/mitpress/14668.001.0001
ISBN (electronic): 9780262374668
Publisher: The MIT Press
Published: 2023

The MIT Press

NOTES

INTRODUCTION

1. Economists call effects such as pollution externalities because they are external to the established economic system. That these are real and enormous has been known for a long time (e.g., Ayres and Kneese 1969).

2. By computational system, I understand any sociotechnical system whose behavior is partly determined by algorithms implemented by computing devices. I will use IT as the overall term for information, communication, and computing technology, and IT systems or computational systems for identifiable sociotechnical systems that incorporate IT.

3. Ken Fleischmann, who was not at the workshop, has written about this (e.g., Fleischmann and Wallace 2005; Fleischmann, Hui, and Wallace 2017).

4. The original *Devil's Dictionary*, published by Ambrose Bierce in the early twentieth century, contains such gems as "PLAN, v.t. To bother about the best method of accomplishing an accidental result" (1906).

5. Systems thinker Russell Ackoff pointed out that observing the US system of "healthcare" shows that its purpose is not to produce health: "It is not a healthcare system, but a sickness- and disability-care system. . . . Whatever the intentions of the individual servers, the system produces and preserves sickness and disability" (Ackoff and Pourdehnad 2001, 200).

6. Disability scholars use the term "crip time" to describe a more flexible approach to time that takes into account diverse abilities and needs (Price 2011, 62–63). "Rather than bend disabled bodies and minds to meet the clock, crip time bends the clock to meet disabled bodies and minds" (Kafer 2013, 27).

7. Feenberg defines "margin of maneuver" more narrowly as the "reactive autonomy" of those marginalized by technological rationalization (2002, 84–85).

Nevertheless, the concept has informed my thinking about the room for maneuver available to all stakeholders involved in systems design.

8. For a gentle introduction to systemic thought, see D. H. Meadows (2008) but be mindful it calls system dynamics "systems thinking." For an excellent overview of approaches, their underpinning epistemologies and methods, and how each approach can and cannot be brought to bear on sociotechnical questions of design, see Michael C. Jackson (2003; 2019). For a sense of the vast diversity of perspectives to be found in systems thinking, see Ramage and Shipp (2009). And for the critical turn, see Flood and Jackson (1991c) and Flood and Romm (1996).

9. Patricia Hill Collins also labels her work "black feminist thought," not theory, for related but distinct reasons, but she characterizes black feminist thought "as a critical social theory" (Hill Collins 1990, 22).

CHAPTER 1

1. To name just two examples, the $100,000,000 Schwartz Reisman Institute for Technology and Society at the University of Toronto quickly adopted the #LetsSolveIt hashtag on social media, and the $1 billion MIT College of Computing will "bring the power of computing and AI to all fields of study at MIT" so that students can "responsibly use and develop AI and computing technologies to help make a better world," emphasizing that "computing reshapes our world" and will "fundamentally transform society" (MIT News Office 2018). Note the absence of the reverse. What would a $1 billion initiative look like that brings the power of all fields of study to computing?

2. See, for example, Bijker et al. (2012); MacKenzie and Wajcman (1999); Gitelman (2013); and Iliadis and Russo (2016).

3. The NATO Software Engineering Conference in 1968 is commonly taken as the founding moment of the discipline (Naur and Randell 1969).

4. The resistance to acknowledging this in software engineering runs deep, as existing dogmatic beliefs remain insistent on an exclusive focus on software artifacts (Ralph and Oates 2018). See also Kaczmarek et al. (2020).

5. This figure is redrawn based on figure 1 in (Becker et al. 2015). The figure on the top left is adapted from ("Sustainability: Can Our Society Endure?" n.d.), the figure on the right from (*Engineering for Sustainable Development: Guiding Principles*. 2005).

6. See Agyeman et al. (2003, 5). In a widely cited book, Neumayer (2013) explores and contrasts strong and weak sustainability from an economic perspective. In his characterization, weak sustainability distinguishes the utility derived from natural resources from the resources themselves, based on the assumption that the same utility can often be derived from a different resource. Strong sustainability rejects the substitutability assumption and requires that the resources themselves must be maintained. Neumayer shows that on an aggregate scale, the general principle of substitutability cannot be defended.

7. Neumayer (2013) concludes his discussion of quantitative cost-benefit analysis (CBA): "Whether and how to act on climate change cannot be decided on the basis of

'hard numbers' because there are no 'hard numbers' when it comes to climate change. To outsiders, the CBA studies of economists may suggest otherwise. But those who understand what the studies do, also know two things. First, many effects of climate change simply cannot be adequately monetarily valued. Second, what can be valued needs to be transformed from values in the far distant future to present-values and any CBA recommendation is therefore crucially dependent on the discount rate used, which is in turn inextricably linked to normative value judgments" (44). Neumayer shows that the debate between strong and weak sustainability cannot be resolved by theoretical argument nor empirical evidence, since both approaches rely on nonfalsifiable assumptions. "The contest between WS and SS cannot be settled by theoretical inquiry. Neither can it be settled by empirical inquiry since such an inquiry would be dependent on information that is only 'forthcoming in the always receding future,' where 'predictions are clouded by uncertainty regarding preferences, human ingenuity and existing resource availability' (Castle 1997, p. 305)" (Neumayer 2013, 95).

8. What appears to be missing or not fully developed in their approach is a full appreciation of the challenges of intergenerational justice and the concerns of critical systems thinking about handling the limits of equitable participation. Because soft systems thinking assumes a basic and free goodwill among participants, the proposed approach relies to a large degree on their willingness to communicate in the negotiations fairly and sincerely without being unduly restricted. This is rarely the case in situations where sustainability is a major concern, and it is impossible to ensure full participation given that many affected stakeholders live in the future. It will thus be necessary to introduce critical systems thinking concepts into this type of framework (cf. Martin Reynolds 2007).

9. An overview of sustainability and IT (Hilty and Aebischer 2015a) cites a cybernetics conference in the 1970s as a precursor and points to the emergence of *environmental informatics* in the 1990s (Avouris 1995), as well as the surfacing of sustainability in the proceedings of the IFIP TC9 Human Choice and Computers conference series in the late 1990s.

10. This overview makes no claim to be comprehensive. Other areas could certainly be included here. For example, *environmental informatics* has a well-established scope and direction, leveraging IT for environmental research (Avouris 1995; Huang and Chang 2003).

11. See Kelly (2019); Jessica Shankleman et al. (2017); and Crawford and Joler (2018).

12. Multiple tech companies have been sued over human rights violations in cobalt mining (Kelly 2019; Frankel, Chavez, and Ribas 2016). The Whanganui River and other natural entities in New Zealand have been declared legal persons (Hickel 2020; Lurgio 2019).

13. (Crawford and Joler 2018). It received widespread praise and attention and was ultimately acquired by the Museum of Modern Art.

14. A systematic review in *The Lancet* (Grant et al. 2013) errs on the side of extreme caution, but still reports "extensive evidence of a causal link between exposure to individual chemical compounds common in e-waste and negative health outcomes."

The authors emphasize that there is a dearth of studies aiming to collect empirical evidence and highlight that there is of course "strong biological plausibility of an association between e-waste exposure and health outcomes," urging the international community that "the health effects of exposure to e-waste must become a priority for the international community" (358).

15. The Ethereum "merge," which switched from proof of work to proof of stake in fall 2022, is a different, interesting case. The efficiency gain is enormous with a factor of about 1000. That bodes well unless it triggers an avalanche of new uses.

16. This is shown by Tsao et al. (2010), later clarified in Saunders and Tsao (2012).

17. Easterbrook made an excellent argument for the importance of this shift (2014a). We will return to this argument later.

18. An early compilation of such work is represented in Calero and Piattini (2015). A series of workshops at ICSE has focused on "Green and Sustainable Software" as well (http://greens.cs.vu.nl/).

19. As discussed in Hilty and Aebischer (2015a), the distinction between orders of effects goes back to Berkhout and Hertin (2001). Hilty and Aebischer also present a revised model called LES, for life-cycle impact, enabling impact, and structural impact. The LES model drops the distinction of problem and solution in favor of distinctions that vary between levels: production, consumption and disposal (L); production, consumption and technological change (E), and economic structures and institutions (S). Because the LES model has not received as much attention as the previous matrix, and because its economically focused structure makes it difficult to identify positive and negative effects, I summarize the two models more broadly in this section.

20. While Airbnb brands itself as a "sharing economy" platform, I follow the compelling arguments in Martin (2016) that this rhetorical branding move has to be resisted. Nothing is shared on platforms like Airbnb or Uber. The Airbnb example was first used to explain structural impact in Becker et al. (2016).

21. For example, Airbnb backed the development of a condo tower project (Sharf 2019) and the specialized operator Zeus Living (Josh Constine 2019).

22. A workshop series on Computing within Limits started 2015 (https://computingwithinlimits.org/), and an article on the subject appeared in the *Communications of the ACM* in 2018 (Nardi et al. 2018).

23. Collapse informatics refers to the "study, design and development of sociotechnical systems in the abundant present for use in a future of scarcity" (Tomlinson et al. 2013).

24. The Karlskrona Manifesto emerged from the Requirements Engineering for Sustainable Systems workshop (RE4SuSy) following my proposal in a paper presented at the workshop (Becker 2014).

25. Among others, a workshop at the 2015 iConference brought SE and ICT4S researchers together with HCI researchers and information scholars (Penzenstadler et al. 2016). Other workshops are listed at https://www.sustainabilitydesign.org/publications/.

26. Redrawn from C. Becker et al. 2016.

27. Notable exceptions include the "Denver Manifesto on Values in Computing," which took explicit inspiration from the Karlskrona Manifesto ("The Denver Manifesto—Values in Computing" 2017).

28. That ground however is still shaky, as misinterpretations abound. At least some work cites the Karlskrona Manifesto yet frames sustainability as a quality of the software system (e.g., Lago et al. 2015).

29. On an individual level, some of the beliefs highlighted as misperceptions in the Karlskrona Manifesto were identified. A lack of knowledge and experience can be addressed by concerted education efforts (Penzenstadler et al. 2018), while a lack of methodology and tool support motivates ongoing research in requirements engineering approaches for sustainability such as Mahaux, Heymans, and Saval (2011) and Chitchyan et al. (2015). On the level of professional norms, the lack of accepted responsibility for long-term consequences of software systems development is deeply embedded into the narrow framing of existing codes of ethics. On the level of the concrete professional environment, a more conflicted picture emerges. Some businesses are keen on opportunities to distinguish themselves, and some are taking very active steps to that end, but significant obstacles make it difficult for employees at lower and middle levels to find and enact their room for maneuver within their own practice. A lack of higher management support, coupled with a reliance on external stakeholders to advocate for sustainability, can exclude the concern from systems design practice. When sustainability is framed as a tradeoff with other goals, it is an uphill battle to get it addressed. This is amplified by a culture of risk aversion and a fear of lost income, exacerbated by short-term incentive structures.

CHAPTER 2

1. Many agree that sustainability always implies ethical judgments. For example, Neumayer (2013) highlights that even within a purely economic paradigm (optimizing the allocation of resources to maximize utility over a time period), the choice of discount rates cannot be theoretically or empirically resolved: "there is no 'right' discount rate," and the choices made in economic analyses "necessarily derive from ethical value judgments that, because they are normative judgments, can and will always be contested" (44).

2. It is worth highlighting that the common trope of the "tragedy of the commons" harks back to a highly problematic piece by a known white nationalist (Hardin 1968) that can only be described as baseless cold war propaganda (Mildenberger 2019; Southern Poverty Law Center n.d.). The tragedy of the commons has been their enclosure (Linebaugh 2014; Hickel 2020).

3. For comprehensive reviews on further developments in environmental justice, see also Mohai, Pellow, and Roberts (2009), and Agyeman et al. (2016). On the evolution of the environmental justice paradigm, see D. E. Taylor (2000).

4. Hickel dissects the available evidence at length in chapters 3 and 4 (Hickel 2020). See also Wiedmann et al. (2020); Demaria, Kallis, and D'Alisa (2015); and Kallis et al. (2020).

5. Hickel (2020) aptly explains that "a recession is what happens when a growth-dependent economy stops growing: it's a disaster. Degrowth is . . . about shifting to a different kind of economy altogether—an economy that doesn't *need* growth in the first place . . . organised around human flourishing and ecological stability, rather than around the constant accumulation of capital" (149–150).

6. The term "unmarked" refers to users whose position in the matrix of domination is left unspecified, which often activates implicit assumptions that they occupy privileged positions (see Costanza-Chock 2020, 69–102).

7. An earlier well-known confrontation is given in Wajcman (1991).

8. See https://facctconference.org/.

9. It is not clear how aware technical debt researchers are of the linguistic theories that explain the underlying conceptual mapping structures of the metaphor. Even direct reflections that emphasize the term "metaphor" make no reference to the linguistic literature on the subject (e.g., Kruchten 2012).

CHAPTER 3

1. The polarized view of language will sound familiar to anyone concerned with the "capture" and formalization of stakeholder input to technical development processes in systems design and resonates with Goguen's (1994) writing about the "wet" and the "dry" in requirements engineering.

2. To be clear, the problematic dualism that shines through this statement by Lukács, which artificially separates "nature" from "society," is a distinct conceptual issue that CST has also grappled with in depth (Midgley 2000; Stephens 2013; Stephens, Taket, and Gagliano 2019). But the central point is that scientific reason has no tools or concepts to address questions around purpose that ask *what is worth striving for?*

3. Marcuse (1964) puts it very succinctly: "The terms 'transcend' and 'transcendence' are used throughout in the empirical, critical sense: they designate tendencies in theory and practice which, in a given society, 'overshoot' the established universe of discourse and action toward its historical alternatives (real possibilities)" (xliii).

4. Others have made this case too (Winograd and Flores 1986; Escobar 2018; Ulrich 1983).

5. See https://twitter.com/ylecun/status/1274782757907030016.

6. In my own searching for compelling examples within the domain of software systems through the literature of values in technology, I have also found that examples tend to be drawn from domains that appear far-fetched for those in computing—whether it is the electric power grid (Hughes 1993), the bicycle (Bijker et al. 2012), bridges in New York (Winner 1980), or the architecture of Nazi concentration camps (Katz 2005), the examples are too easy to dismiss for an audience in computer science. Recent studies in machine learning have begun to change that situation (Birhane et al. 2021).

7. This last point is pressing as I write these lines: Recent mobilizations of activists and scholars against the use of facial recognition technology (FRT) on precisely such

grounds have led some corporate vendors to cease offering concrete products to US law enforcement, and some municipalities and states across the United States have enacted legal bans. While this is a success for those fighting FRT, it illustrates what they are up against: the a priori assumption is that the technology is neutral, and the burden of proof lies on them to show otherwise.

8. The marginalization of disadvantaged perspectives will be a central theme of this book. How that burden has played out is illustrated perhaps best by books such as Eubanks (2018) and S. Noble (2018) that demonstrate the undue burden carried by marginalized communities and the practical, political difficulties in proving the unwelcome news that they are in fact being oppressed by technological developments.

9. This will be explored in more detail in chapter 6.

10. Neither can "mistakes" be easily rectified after the fact—despite the possibility to alter software code in principle, it is well established that changing systems is just as hard as building them. The *path dependence* of technological change means that adverse consequences cannot be so easily rectified (Liebowitz and Margolis 1995; Arthur 1994).

11. This crude characterization can of course not do justice to the nuanced debates about what objectivity *should* mean. See Reiss and Sprenger (2017) for an overview of objectivity in science and B. Smith (1998) on what it means for something to even be considered an *object*.

12. This is illustrated by the contrasting definitions of what "a system" is. Even for Ackoff, "A system is a set of interrelated elements" with certain relationships (Ackoff 1971). For Checkland, the concept "embodies *the idea of* a set of elements" (Checkland 1981, emphasis added). Checkland thereby rejected the realist notion that the social world *is* systemic. In his view, models of systems do not have to correspond to anything; they only have to be useful in structuring a conversation.

13. In his history of automation, industrialization, and the emergence of engineering and management within the capitalist context, David Noble has shown that this is no accidental development: The role of scientific method in engineering, and the way it shapes the agency of specific roles in the division of labor, was significantly shaped by the particular interests of capitalist actors (D. Noble 1977; 1984).

14. I am no stranger to MCDM: my doctoral thesis centered on an MCDM approach to software component selection. I developed a decision-making process based on utility theory (Becker et al. 2009), a decision support system that was widely used and evaluated in digital preservation, and a suite of tools to automate evaluation based on a taxonomy of criteria and measures (Becker and Rauber 2010).

15. The idea of the "geek gene" itself is a dangerous myth in computing education (Patitsas et al. 2019).

16. This is not surprising because Checkland's writing itself shifted over the years (Checkland 2000) and because adopting his real intentions requires a significant rethinking of fundamental assumptions and metaphors.

CHAPTER 4

1. See https://twitter.com/ConsentTracker/status/1120623599868624897.

2. See https://twitter.com/ConsentTracker.

CHAPTER 5

1. I believe Jon Whittle made me first aware of the term and has written about it in an agile design team context, where one person was assigned the "critical friend" role "to raise concerns about design decisions that may interfere with agreed values" (Whittle et al. 2019, 110).

2. I make no claim to have compiled a comprehensive list of critical friends. Critical race studies may be the most important example not currently covered at depth in this chapter, and it offers significant insights to computing particularly when it comes to social justice and environmental justice, as discussed in chapter 2.

3. Advocates of participatory design may disagree with the stark distinction made here between the roles of supposed experts and lay people and instead propose that true collaboration in design will involve everyone in the translation effort. Otherwise, the danger is that their participation turns into "pseudo-participation," where participants are treated not as sources of insights but as sources of data to be consumed by experts (Palacin et al. 2020). I suspect that Feenberg would not disagree, but the quote seems to reinforce the boundaries between professional designers and others.

4. Reading this strange book, I was puzzled and found myself in a situation comparable to Agre. I expected a dialectic resolution, a final synthesis to resolve the dilemmas. Somehow, I expected the rational planner to find a way to deal with the enemies, because I had been brought up intellectually in a group of fields in applied computing where each contribution is expected to pose a problem, propose a solution, and demonstrate the solution's efficacy. But that synthesis never comes. Churchman never resolved his fundamental questions (Ulrich 1985).

5. See M. Jackson (1982, 1985a); Ackoff, Checkland, and Churchman (1982); and M. Jackson (1983).

6. See M. Jackson (1991, 2019); Flood and Jackson (1991c); Flood and Romm (1996); and Ulrich (1983).

7. In Ulrich's language, "the social system S to be bounded" contains "social actors defining the normative content of S," with the disjunct subsets "Those involved in the planning of S" and "Those affected by S but not involved in its planning" (Ulrich 1983, 248).

8. Ulrich references Marcuse in his use of that term.

9. This becomes visible when we consider the metaphors that underlie their paradigmatic image of social reality. Jackson drew on the use of metaphor in organizational theory (Morgan 2011; 2006) to distinguish a wide range of systems approaches according to the images that underpin their understanding of the structure of organizations as machines, as organisms, as brains, as cultures, etc. (M. Jackson 2003; 2019).

Focusing just on the main paradigm of cybernetics, Ulrich distinguishes the original (physical) cybernetic paradigm and its reliance on the "machine" metaphor of servomechanisms from the later cybernetic paradigm, which relies on the organism as metaphor. In Stafford Beer's work on managerial cybernetics, this becomes explicit (Beer 1972). In contrast, the organizing metaphor for Ulrich's view of social reality is the purposeful *polis*—the social group formed around an issue (Ulrich 1983, 333).

10. This is crucial for CST practice because it routinely incorporates rationalistic methods within a carefully designed framework *if* their application is appropriate to the context and legitimate (Flood and Jackson 1991a; M. Jackson 2019; Midgley 2000).

11. The validity of Habermas's theory of knowledge-constitutive interests and its role and relevance for critical systems thinking has been discussed at length (Reynolds 2002; Midgley 2002; M. Jackson 2019). It is important to recognize that the role of this theory is not foundational for the development of the critical categories of heuristics in CSH, and that later critique of Habermas and this particular part of his work, as well the evolution of his own position away from the emphasis on technical control in the original argument, do not invalidate the argument and conceptual framework introduced here (see also Reynolds 2002; Ulrich 1993; M. Jackson 2019; Habermas 1985).

12. Purposeful systems are also a central element of soft systems methodology. Its central modeling techniques represent hierarchically contained networks of purposeful activities and their dependencies on each other. Purposeful activity models capture systems relevant to the problem situation. They are used to structure a discussion among everyone involved in the situation (Checkland 1981; 2000).

13. For critiques and further commentary on CSH, see also M. Jackson (1985b, 2003, 2019); Ivanov (1991); Flood and Jackson (1991a, 1991b); M. Brown (1996); Willmott (1989); Mingers (1992); Romm (1995, 1994); and Midgley (1997).

14. See, for instance, The Refusal Conference 2020 (https://afog.berkeley.edu/programs/the-refusal-conference) and the Resistance AI workshop at NeurIPS 2020 (https://sites.google.com/view/resistance-ai-neurips-20/home).

CHAPTER 6

1. The idea of VNT is not innocent. The examples in (Pitt 2014) are explicitly about guns, and a counterexample brings up the technology of the holocaust to demonstrate the absurdity of VNT (Katz 2005). But it is perhaps precisely because those technologies are so viscerally murderous that it is too easy to focus on what is different in computing—even if automated weapons targeting systems are not all that different in their attempt to scaling up the extermination of human life.

2. This distinction was a crucial part of establishing the social sciences *as sciences* and deeply influenced the debate around the nature of objectivity in science (Reiss and Sprenger 2017; Douglas 2011).

3. In their recent case study of three maps, D'Ignazio and Klein (2021) mobilize the commitments of data feminism to similarly compare whose values are turned into maps.

4. The uncritical lens of VBE shines through in some misinterpretations of prior work too. For example, Spiekermann cites Ulrich but misrepresents the purpose of CSH as a tool to select stakeholders (Spiekermann and Winkler 2020, 7). CSH is referred to as a "checklist" and Ulrich as "the originator of CST" (Spiekermann 2016, 202), which is inaccurate. In contrast, Ulrich emphasizes that the entire point of CST lies not in determining correct answers but in continued questioning of categories and answers. The point is not to optimally select stakeholders considering *their* motivation, but to critical *reflect on* the sources of motivation, power, knowledge, and legitimacy underpinning *the claims made when selecting* stakeholders. In a sense, Spiekermann mistakes the surface boundary judgment of including or excluding a stakeholder with the boundary of the *reference system* (see chapter 5).

CHAPTER 7

1. For examples, see behavioral studies of design practice (Cross 2006; Dorst 1995; Dorst and Cross 2001) and this review of behavioral studies in software engineering (Lenberg, Feldt, and Wallgren 2015).

2. The principal focus on description, explanation, and analysis on the one hand, and prescription or action on the other hand, distinguishes two paradigms: Empirical research aims to describe and explain behavior, while normative research establishes standards to evaluate behavior (Ralph 2018). Normative models such as SE methods, process models, and quality models establish standards for evaluation. But there is a significant grey area because the object of empirical SE research is prescribed by normative models. Because research in SE often combines normative and empirical elements, even research that understands itself as empirical often relies on theories that are normative.

3. For their brief overview of the rationalist tradition in design, see chapter 3. I use the term *rationalist* here consistent with their critique and the critique of decision-making researchers to refer to streams of research that take rational ideals too far, at the detriment of situated knowledge and other, broader forms of reasoning.

4. On the relationship between Simon's work and that of contemporaries, and the various streams of work that gave rise to the metaphor of the mind as a computer, see Crowther-Heyck (1999, 2005); Gigerenzer and Goldstein (1996).

5. This is a complex argument but very worth retracing (Maturana 1980; Maturana and Varela 1992, 141–76; Varela, Thompson, and Rosch 1991, 133–214). The falsification of information-processing theories of mind is perhaps most compellingly demonstrated, and most easily traced, by studies on color perception (Varela, Thompson, and Rosch 1991, 147–184).

6. Crowther-Heyck (2005) reports that Simon reacted strongly to his critics but failed to see their point. Instead, he seemed so beholden to his rational worldview that his critics appeared to him as mystics, and he felt he could not reach them.

7. I will here treat rationalist theories broadly, acknowledging that there are of course significant differences too. Simon's work pursued a path distinct from Tversky and Kahneman, for example, and placed more emphasis on the metaphor of the brain as computer than their work. This does not affect my observations.

8. This is still leaving aside that in reality, ambiguity will prevent such clear numeric probabilities from being precise estimates. Once we appreciate ambiguity more fully, we realize the normative fallacy is often even more pronounced than in this example, because it strongly suggests that people use these probabilities even when they don't.

9. The empirical validity of that calculation is dubious. Recall that even statistically, the expected value is not a reasonable approximation of a single gamble, only of a long series of identical gambles.

10. Actual research will of course often use a combination of theoretical frameworks. This can make it difficult to detect instances when normative assumptions slip into descriptive research.

CHAPTER 8

1. They have been further discussed, grouped, and refined over the years (Termeer, Dewulf, and Biesbroek 2019; Alford and Head 2017; Brown, Harris, and Russell 2010; Head and Alford 2015).

2. Ulrich is decidedly democratic in his ideals here. "The democratic consensus of affected citizens is a mandatory source of legitimation for 'rational' planning *whenever the involved and the affected are not identical*"—and admits that "Of course, there ultimately remains a rationally unverifiable (decisionistic) value judgment in this ideal" (1983, 297). Ulrich's use of the term "citizen" stems from his primary interest in policy and social planning and the language common at the time. While Graeff (2020) and others advocate for the term "citizen professional" or "citizen engineer," I will not continue this use of the term "citizen" because it suggests to many that important stakeholders who are affected by tech, including noncitizen residents or undocumented immigrants, are excluded.

3. The lineage of this diverse body of work is best appreciated by following in chronological order the key works in CST (Flood and Jackson 1991c; Flood 1990; Flood and Romm 1996; Ulrich 1983; Midgley 2000; M. Jackson 2019; Stephens 2013).

4. Escobar (2018) highlights the arrogance of the development discourse and summarizes critics such as (Redclift 2005): "critics have pointed out that such a definition is oxymoronic in that the interests of development and the needs of nature cannot be harmonized within any conventional model of the economy" (Escobar 2018, 43). Instead of the "impoverished" sustainable development agenda (225), Escobar calls for the elimination of "the structures of unsustainability that maintain the dominant ontology of devastation" (7). See also Chambers (1997) and Kothari et al. (2019).

CHAPTER 9

1. This is not to say that these are the only myths and counternarratives. For example, if we consider the tendency to disregard the historicity of IT as a myth, we can understand the work of historians of technology as producing the counternarrative (e.g., Hicks 2017).

2. For example, data feminism, design justice, and autonomous design all present a critically appreciative, value-sensitive view of systems design for a more just and

sustainable world. From that vantage point, the shift away from VNT is overdue, and the view of problems as contingent framings is accepted. I do not suggest that JSD should replace these approaches but that its framework can help reorient other approaches, such as requirements engineering (RE). In addition, JSD may still contribute two concrete insights: first, it strengthens the capacity to speak to and with the rationalist scientific programs that are also needed to address the domain complexity of just sustainability, and second, it introduces a contemporary perspective of judgment and decision-making.

CHAPTER 10

1. This understanding is also supported by many in the *requirements engineering* field. See for example widely used textbooks such as Robertson and Robertson (2012), Alexander and Beus-Dukic (2009), and Pohl (2010). Within the context of software development, Mohanani and Ralph have criticized the framing of "requirements" as an "illusion" and highlighted that a fixation on perceived requirements can reduce the creativity and quality of software development (Ralph 2013; Mohanani, Ralph, and Shreeve 2014). But their study refers to the narrow traditional concept of requirements statements in the second sense, as documented in requirements specification standards. For example, IEEE Std. 610.12 and later ISO 24765 define a *requirement* as "(1) A condition or capability needed by a user to solve a problem or achieve an objective; (2) A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents; (3) A documented representation of a condition or capability as in (1) or (2)" (ISO 2010).

2. In fact, well known work in RE on stakeholders and onion models (Alexander 2005; Alexander and Beus-Dukic 2009) draws from literature that considers only those *with influence* as stakeholders and severely misrepresents Midgley's argument (e.g., Coakes and Elliman 1999).

3. Most writers' interpretation of soft systems approaches is rooted in hard systems thinking, reflecting the assumptions corresponding to the left column in table 8.1. For example, one classic textbook states that "[in] the early stages of analysis . . . the application domain, the problem, and the organisational requirements must be understood . . . 'hard' models . . . are inflexible" (Kotonya and Sommerville 1998). While the authors recommend "soft" systems approaches instead, they imply that domain, problem, and requirements exist prior to requirements work. A more recent book explains that "'Soft' here means that the work is ill-defined, involving many partially known concerns, not susceptible to deterministic approaches" (Alexander and Beus-Dukic 2009, 13), neglecting to embrace the epistemological shift from hard to soft systems thinking represented in table 8.1. This misunderstanding underpins a misinterpretation of techniques, methods, and the role of models: For example, Checkland's "Rich Pictures" are described as models of reality ["a diagram of what is happening in a business . . . an informal but very useful view of a system's context and scope" (Alexander and Beus-Dukic 2009, 77–78)]; Checkland would disagree (Checkland 2000; Checkland and Poulter 2007). Another textbook suggests that one of the

structuring techniques used in SSM called CATWOE means that "you consider the Customers, Actors, Transformation Processes, World view, Owners, and Environment *for the project*" (Robertson and Robertson 2012, 64; emphasis added). In SSM, CATWOE is a set of concepts used to shape a thought model of one of multiple relevant systems (which are *ideas*), with the central aim being that the participants develop multiple such ideas from different world views as an aid to structure a conversation about the situation; it is not a way to specify "the project." Another textbook, finally, makes no mention of SSM at all (Pohl 2010) and instead is firmly grounded in a hard systems view. The adoption of SSM techniques into other types of methods is typical, and one might argue there is nothing inherently wrong with it. (The Robertsons' textbook provides a sophisticated method for carefully scoping out a project and developing useful requirements.) But it changes the nature of the techniques, and these examples illustrate that the writers have not completed the epistemological shift involved in SSM. The myth of objective problems shapes their texts.

4. Note that this definition of stakeholders excludes those who are subsequently affected but unaware. In the world of this textbook, they are not even recognized as stakeholders. Fortunately, others are more sensible (Alexander 2005).

5. The role is rarely labeled "requirements engineer" but more typically "business analyst" or "systems analyst." Very often requirements work is spread across multiple roles and/or done jointly with project management work, software architecture work, etc. (Robertson and Robertson 2012; Rozanski and Woods 2012). This does not affect the argument since all these roles are positioned in that same context. I use the terms "requirements work," "RE professionals," and sometimes "requirements engineer" to refer to this spectrum of work, roles, and people.

6. These questions are adapted from Becker, Betz, et al. (2020).

7. The research team was composed of Leticia Duboc, a researcher at La Salle University in Barcelona, my PhD student Curtis McCord, and myself. Leticia had been involved in conversations with the third-sector company and other stakeholders and had close contact with the technical and business developers of SoundCare but no previous knowledge of CSH. Curtis and I were knowledgeable in CSH. We took a mentoring role and helped to critically reflect on the models created by Leticia.

8. The description of these iterations is adapted from Duboc, McCord, et al. (2020).

9. Midgley reports on a structural parallel in a community project developing housing services for elderly people. The participation of those affected in a key meeting could not be arranged, despite the researchers' attempts, because the project sponsor insisted this was for their managers only (those involved, but not affected). The researchers faced the ethical dilemma of canceling the project or representing, as surrogates, the interests of those affected. Based on a reflection of their own positionality, they configured the meeting such that some of them became dedicated spokespeople for those affected (Midgley, Munlo, and Brown 1998, 472–473).

10. The presence of surrogacy is mostly implicitly accepted. Some discuss it at length (Alexander 2005), but it is worth pointing out that in his reliance on Coakes's flawed

interpretation of Midgley, Alexander, despite his sensitivity to stakeholder surrogacy, misses Midgley's substantive contributions on marginalization and boundary critique.

11. Of course, professional fields such as medicine and social work have a history in contesting and reflecting on the nature of professional expertise and the ethical and political nature of such knowledge (Hoffman 1989).

12. In a different project, we used CSH in polemic form to contest the process of marginalization. Sidewalk Toronto was a flagship project for Alphabet Sidewalk Labs to design and build (and operate) a prime waterfront district in Toronto as a "sustainable Smart City." The consultation processes sounded participatory enough, the shiny brochure had wooed many, but civic advocates rightfully criticized the corporate urban land grab as a project that would benefit Alphabet, but not Torontonians (Wylie 2020; Editorial 2018). We used CSH to "explore how the professed values guiding the project were contentiously enacted, and we showed how key stakeholders and beneficiaries in the planning process significantly constrained the emancipatory and transformative potential of the project by marginalizing the role of residents in determining project purposes" (McCord and Becker 2019).

13. You can read the result of this struggle in the *Communications of the ACM* (Kienzle et al. 2020).

CHAPTER 11

1. For overview texts, see (Frederick, Loewenstein, and O'Donoghue 2002; Loewenstein, Read, and Baumeister 2003; Loewenstein, Rick, and Cohen 2008; Soman et al. 2005). My coauthors and I review these and others and explain their relevance for decision-making in SE (Becker, Walker, and McCord 2017; Becker et al. 2018).

2. Figure © 2019 IEEE. Reprinted, with permission, from Fagerholm et al. 2019, "Temporal Discounting in Software Engineering: A Replication Study," ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM), 1-12, 10.1109/ESEM.2019.8870161.

3. More detail about the method is reported in Fagerholm et al. (2022).

4. And this is before we have spent time embedded with teams, ethnographically studying decision-making in practice. How much could we learn doing this? I hope to find out.

5. This may have been due to many factors. Maybe it was because in our study, the situation was hypothetical, or because the design already construed a high-level view of the question, while in the mentioned study, the situation was real and full of incidental detail.

6. The definitions of these five elements are adapted and broadened from (Fagerholm et al. 2022).

7. Hypotheticality in practice is a direct function of uncertainty and ambiguity, but in research designs, matters are complicated by the question of how real the situation appears to the participants.

CHAPTER 12

1. See https://twitter.com/ChriBecker/status/1014938612746551296 and https://twitter.com/ACM_Ethics/status/1015280727137705984.

2. Recent decades have added tax evasion to that history (Fair Tax Mark 2019; Schaake 2020). The pandemic of 2020 has raised broader awareness of the erosion of public goods that comes with this history (S. Noble 2020).

3. Software engineering is often not recognized as a “true” engineering discipline. The graduates of SE programs are not chartered engineers—a source of much soul searching in the discipline’s community and scholarship. Nevertheless, the term “engineering” is often used. I use it here to emphasize commonalities across a range of professionalized work in which specialized technical expertise is applied in evolving collaborations in a spectrum between independent contracting and employed labor to shape the material environment, including IT. In Noble’s (1977) account of the early emergence of professional engineers, he focuses on mechanical, chemical, mining, and civil engineers (33–49). Accounts of later developments naturally include newer engineering disciplines such as electrical engineering (Wisnioski 2012). The structural similarities of this work across “technical” fields far outweigh the differences in certification status, and many of the struggles of IT professionals today with technical rationality and its limitations, as well as grappling with issues of equity, mirror earlier struggles (Wisnioski 2012; Tarnoff 2020).

The MIT Press would like to thank the anonymous peer reviewers who provided comments on drafts of this book. The generous work of academic experts is essential for establishing the authority and quality of our publications. We acknowledge with gratitude the contributions of these otherwise uncredited readers.

This book was set in Stone Serif by Westchester Publishing Services.

Library of Congress Cataloging-in-Publication Data

Names: Becker, Christoph (Director of the Digital Curation Institute), author.
Title: Insolvent : how to reorient computing for just sustainability / Christoph Becker.
Description: Cambridge, Massachusetts : The MIT Press, [2023] | Includes bibliographical references and index.
Identifiers: LCCN 2022038283 (print) | LCCN 2022038284 (ebook) | ISBN 9780262545600 | ISBN 9780262374651 (epub) | ISBN 9780262374668 (pdf)
Subjects: LCSH: Electronic data processing—Social aspects. | Computer systems—Environmental aspects. | Information technology—Social aspects. | Sustainable development.
Classification: LCC QA76.9.C66 B435 2023 (print) | LCC QA76.9.C66 (ebook) | DDC 303.48/34—dc23/eng/20221121
LC record available at https://lccn.loc.gov/2022038283
LC ebook record available at https://lccn.loc.gov/2022038284