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Analysis

Revocability and reversibility in societal decision-making

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ABSTRACT

Reversibility and irreversibility are poorly defined in the decision-making literature. Defining reversibility as "the ability to maintain and to restore the functional performance of a system" is consistent with thermodynamics; specification of its crucial terms is case dependent. Reversibility is coming in degrees from flexibility, over rigidity to preclusion, with irreversibility as an absolute end. Further substantiating reversibility considers three variables: duration of impacts, revoking costs, and substitutability. Substitutability depends on weights assigned to the strict identity or to the functional performance of something valued. For given degrees of substitutability, revocability of an action is measurable in time-dependent revoking costs. Together with future time and doubt, reversibility sets a three-dimensional context for societal decision-making, revealing domes of expanding complexity. Cost–benefit analysis is a useful decision tool at lower complexity but falters at high complexity because there prevail non-monetary trade-offs. A revival and proper use of the concept reversibility are recommended for improved dialog on major societal issues, with climate change outstanding as the case where reversibility could turn into absolute irreversibility. Also shown is the correspondence between reversibility and ecological concepts like resilience, lock-in, tipping points, and others.

1. Introduction

In sciences like physics, cosmology, biology, ecology, and medicine, reversibility is a commonly used term, theoretically explored and practically applied (Denbigh, 1989; Reynolds and Perkins, 1977). Ecological economics uses reversibility concepts and metabolism laws for describing the thriving of economic systems within the natural environment (Ayres and Warr, 2009; Georgescu-Roegen, 1971), delivering a frame for arguing limits to growth (Daly, 1973; Krysiak, 2006). However, the framework is no breeding ground for operational models (Baumgärtner, 2004; Dasgupta and Heal, 1979). In ecology, reversibility is related to phenomena like resilience, hysteresis, collapse, and similar concepts (Ludwig et al., 1997; Scheffer et al., 2001).

Irreversible impacts on local or global environments are largely triggered or occasioned by inappropriate demands by human societies on the sources and sinks of the environment. This has been documented extensively in cases such as loss in biodiversity and climate change, not amenable to mitigation after they have occurred (Chapin et al., 2000; IPCC, 2007). In this article most examples and literature are related to climate change.

Human decision-making is recognized to be the main difference between the functioning of ecological-physical and of social-ecological systems (Perrings and Brock, 2009). "Humans are unique in having the capacity for foresight and deliberative action… Their capacity to manage resilience with intent determines whether they can successfully avoid crossing into an undesirable system regime or succeed in crossing into a desirable one" (Walker et al., 2006).

Reversibility is not seen as a foundational concept in economics or in other social sciences (Manson, 2007), although implicitly marginal analysis, which is the foundation of neo-classical economics, assumes smooth reversibility. The term reversibility acquired some explicit popularity in for example ecological economics (Georgescu-Roegen, 1971), environmental economics (Arrow and Fisher, 1974), and investment theory (Dixit and Pindyck, 1994). These strands were joined in debating optimal timing of climate policy but without establishing terminological clarity during that debate (Caron and Ohndorf, 2010; Kolstad, 1996; Manne and Richels, 1991; Nordhaus, 1994). The social sciences lack clarity in defining and using the term irreversibility (Manson, 2007; Perrings and Brock, 2009). The practice of citing irreversibility as coming in degrees is widespread, although proper vocabulary preserves the term for the absolute impossibility of reversal.[1]

The principal goals of this inquiry are a workable definition and a substantiated description of reversibility for policy-making processes. The search does not start at the kaleidoscope of reversibility and irreversibility terms scattered in the literature, but by outlining a framework of societal decision-making (Section 2). A stylized description of

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[1] One reviewer pointed this out. Aligning the article on standard vocabulary for terms beginning with "im-" and "ir-" prefixes assigning absoluteness, I avoided describing the actual confusion in the literature that quotes irreversibility as coming in degrees or uses the concept as such. At some occasions (e.g., Section 4), literal quotes from the literature do not align with standard vocabulary.

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decision components and decision context is provided. The literature relates irreversibility on the one hand to irrevocable spending of resources by undertaking actions, and on the other hand, to undesirable evolutions in the environment. In societal decisions actions generally affect environmental evolutions but mechanisms and ultimate impacts are susceptible to high degrees of uncertainty. This reflects the multiple interactions between system (where the own actions belong to) and environment (impacts on third parties, society at large, nature). Societal decision-making aims at balancing attention for both sides, but proper distinction and separate terminology are helpful. Revocability puts the focus on revoking costs when one would like to recall an action and it is limited to economics. Reversibility relates to impacts governed by laws of physical sciences with economics in a secondary role. Reversibility is – or should be – one of the three main dimensions of a societal decision context, next to (future) time and doubt (used here as a more encompassing term than the commonly used "uncertainty", in Section 2.2 described as one of the phases of doubt). Section 3 offers a definition of reversibility, with necessary guidance on its interpretation. It is compatible with the thermodynamic reversibility concept widely applied in the life sciences. Section 4 develops a substantiated description of reversibility based on three variables: duration of impacts, revoking costs, and substitutability. With duration and revoking costs, revocability is defined; by adding substitutability revocability is enriched to reversibility, or seen from the other side: substitutability is extended with duration and revoking costs to obtain reversibility. The constituent variables and their interactions are illustrated with diagrams. The conclusion (Section 5) recaps the main results for societal decision-making. The performance of cost–benefit analysis is dubious when a decision and its context are unwieldy complex with a high likelihood of stranding in irreversibility.

2. Policy Decision-making: Components and Context

One property that made mankind the dominant species on earth is its capacity to explore the future for taking considered decisions (Walker et al., 2006). That capacity has developed over time; it is not perfect and never will be. Since World War II scientific methods for supporting decision-making made the human planning capacity more consistent and robust. Wartime operational challenges were tackled with scientific methods, giving birth to an extensive field of research and applications, today known as operations research, decision science or management science. For strategic decision-making by large corporations, organizations and governments, the sub-discipline decision analysis emerged (Raiffa, 1970; SRI, 1977). Cost–benefit analysis added a public (also called: welfare) economics perspective when large-scale infrastructure projects were investigated in the USA, in Europe and in developing countries (Harberger, 1972; Layard, 1972; Lesourne, 1975).

Decisions are made for a future characterized by doubt. Scientifically proven methods are warranted for long-term, complex, unique actions with persistent effects and impacts (Lempert and Collins, 2007). Climate governance deals with issues stretching into the far future with aspects of doubt being immense, being complex and unique, and mattering to entire societies (IPCC, 2007). Emphasis on comprehensiveness and integration does not thwart that "it is critical to distinguish between the governance of the *ecosystems* that may be harmed by negative Earth system interactions and governance of the *drivers* behind those negative interactions" (Nilsson and Persson, 2012). For clarifying the differences between revocability and reversibility, decisions and their components are discussed separately from their context.

2.1. Decision Components

Decision-making is interplaying three sets of variables: possible events, alternative actions, and expected outcomes conditional on previous actions and on events that happened (Matheson and Howard, 1968). Events occur beyond the control of decision-makers, but affect outcomes and generally also future action opportunities. Actions (also named alternatives, options, or elaborated strategies) are the objects of decision-making. Decision analysis aims at finding actions with outcomes optimal according to encoded preferences, and by systematically processing information. Encoded risk and time preferences are a reduced way of considering decision-makers' values about doubt and about future time. Iterative and time-sequential processing weights the net value of additional information. Outcomes (effects, impacts, consequences, results) can be measured as distances to targets. Decision-makers react on the course of events to avoid or minimize negative outcomes and to obtain and maximize positive outcomes, subject to constraints faced.

Three comments on the components and their interplay in societal decision-making are due. First, coverage of events, actions and outcomes has to be comprehensive, complete (sufficient detail about diverse components within the comprehensive scope), and consistent (recognize interdependencies, mutually exclusive or contradictory options, etc.). If not, the dangers of too narrow scopes and biased decisions lurk, wasting analytical and political resources on local or false optima far from real overall optima. Especially a good catalog of outcomes is important, because disruptive decisions bring winners and losers. Losers are generally the poorer people without influential voice or unborn people without direct voice by definition, climate change being an example in case (UNDP, 2007).

Second, dynamic and complex interplaying between components is a spiraling time-sequential process of conditional deployments of actions, events, outcomes, actions, events, outcomes, and so on. Modeling this reality of interlaced facts and policies is an intellectually challenging effort. It differs from single vantage point scenario projections delivered by most integrated assessment and economic models that in one bow cover time spans of 30, 40 or 100 years (Nordhaus, 2007). One-bow projections stifle crucial conditionality among the components, with constant-rate discounting reducing the weight of values according their rank on the bow. Complexity theory recommends time-sequential modeling that "concentrates on the significant issues which need to be handled in the short-term, and ensure that the debate about their long-term consequences is lively and engaged." It does "not justify short-termism, but points towards a more practicable way of taking the future into account" (Rosenhead, 1998). Time-sequential cycles match adaptation management in allowing flexible and reversible policy designs, learning, knowledge integration and experimentation (Voss and Bornemann, 2011).

Third, distinguishing between actions and outcomes in a time-sequential process helps in anchoring reversibility terminology used in the literature. Irreversibility is named as an inherent attribute of spending resources by taking actions (Dixit and Pindyck, 1994; Kolstad, 1996), but also of outcome impacts that one cannot undo (Arrow and Fisher, 1974; Pindyck, 2000). While expenses of actions are well inventoried, outcomes considered are mostly limited to the ones falling within the decision-makers' accountability. Important external effects are rolled off to the environment and to the distant future. Climate change is beset by external effects some with low degrees of reversibility, such as melt of the Greenland ice sheet, dieback of the Amazon rainforest and shift of the West African monsoon (Lenton, 2011; Schneider, 2003; Solomon et al., 2009). Next to the dichotomy internalized/externalized, the distinction between desirable and undesirable outcomes is important. In principle concerns about reversibility only apply to undesirable outcomes, with the understanding that preferences shift over time regarding what is desirable or undesirable.

2.2. Decision Context

With higher complexity, drawing boundaries between systems and their environments is very difficult and largely arbitrary (Homer-Dixon, 2011). Yet it remains helpful to see actions, events, and outcomes as