5
Science for governance
THE IMPLICATIONS OF THE COMPLEXITY REVOLUTION

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The revolution associated with complexity provides a set of theoretical insights that meet the demand from society at large for an urgently needed paradigm change in science. The paradigm shift is particularly needed for sustainability science, i.e. when science is used in governance processes.

The revolution implied by complexity puts the focus back on very old discussions about epistemology. One of the most important results of this revolution is an awareness of the distinction between perception and representation of the experience derived from interaction with the external world. That is, any representation of a given perception of reality—for instance, a scientific analysis—unavoidably reflects a pre-analytical decision of selecting just one scale and one narrative. Both the narrative and

the relative scaling have to be considered as relevant and desirable by the storyteller (equals the entity capable of legitimising the definition of what should be observed and why). The problem is that, for the same reality, it is always possible to find multiple legitimate scales and narratives for sharing useful experience. Therefore, especially when dealing with science for governance, it is crucial to establish a process of quality assurance on the generation of scientific analyses. That is, it is necessary to guarantee a semiotic check in terms of a correspondence between:

1. The relevance of perceptions within which the scientific analysis has been performed (according to the choices of the storyteller)
2. The pertinence of representation (according to the choices of the analyst)

The definition of relevance has to do with the chosen selection of scales and narratives to explain a perceived relation of causality. Such relevance is associated with the characteristics of the observer/storyteller. By representation, we mean a given selection of descriptive domains and observable qualities associated with the observed. Such a representation is associated with the characteristics of an observation space. Scientific models, in fact, require an observation space to exist in the first place. These issues of standards and choices cannot be ignored because it is impossible to provide ‘once and for all’ and ‘one size fits all’ semiotic check on scientific knowledge. Each scientific activity is tailored to the specifics of the situation, so there is no grand universal narrative under which science operates when applied at different problems in different points in time and space. The specifics of a given situation become especially important when we are dealing with the issue of sustainability and science for governance. In these cases, the complexity revolution calls for the semiotic check to be made case by case. All real situations are special, meaning that the involved social actors must agree on the definition of perceptions, narratives, models, data and indicators that are selected by the scientists.

In relation to this predicament, we discuss five points relevant for the quality of the process of scientific analysis in relation to the post-normal science paradigm:

- **Point 1**—the reasons for the impasse experienced by normal science
- **Point 2**—the required quality check on the pre-analytical selection of narratives using, as a case study, the limits to the application of neoclassical economic analysis to the issue of sustainability
- **Point 3**—a view of post-normal science from within the framework of hierarchy theory
- **Point 4**—a taxonomy of definitions of knowledge (with new entries)
- **Point 5**—the spectre haunting science for policy: replicant knowledge

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Point 1: post-normal science

Current trends in environmental degradation are linked to a groundswell of social unrest in many developing countries. This indicates that in the third millennium ‘humanity is challenged to learn how to build a sustainable future’ (Caldwell 1999). The degree of concern shared by many in this regard is related to the fact that there are critical things that humanity has to learn fast. In particular, change should be focused on improving the efficacy of two crucial components of society:

1. Scientific capability for generating useful representations to frame sustainability problems

2. Political will to provide adequate mechanisms of governance to deal with the predicaments encountered in the arena of the discourse for sustainability

Globalisation makes it harder to perform governance well. The very scale of globalisation increases the challenge of dealing simultaneously with definable and workable problems at different scales. It is becoming increasingly important to detect, characterise and handle problems occurring at scales much smaller and much larger than those typical of the space-time domain at which national governments wield influence. This mismatch makes it harder to develop mechanisms of control able to detect, react to, and keep co-ordinated processes operating in parallel on various spatial and temporal scales. It is clear that such challenges force the development of new procedures of scientific analysis and new analytical tools.

An indicator of crisis is a mismatch between the vision possessed by the general public compared with the insights of the community of scientists or politicians giving them advice. We suspect that the general public often has a better grasp of the situation than the experts and officials. In this light, it is not surprising that sustainability as an issue is ignored, or even denied, in the analyses provided by many academic disciplines and in the strategic planning of large national and international institutions. The lay public, who are supposed to use these scientific analyses and will be affected by these strategic plans, are feeling ever more uncomfortable with what scientists and politicians are offering. Often in the news, there are reports of growing and widespread disintegration of ecological and social fabrics all over the planet. For those living in developing countries it is worse, because they have direct experience in their daily lives in real time of the planetary unravelling. People have every reason to feel disconcerted, but they are receiving little reassurance from the power brokers as to the likely outcomes of permanent and dangerous trends.

The paradigm shift implied by the concept of post-normal science is due to:

- Existence of different perceptions of the reality. These perceptions are associated with legitimate but contrasting definitions of who is ‘us’ as concerned agents and observers of the problem situation

- The unavoidable presence of great uncertainty and genuine ignorance. This compromises analytical explanations of the existing situation as well as the analytical models used to forecast the future

In the field of sustainability science this means that:

- There is no consensus among the scientists in scientific terms as to issue definition and problem structuring of the sustainability predicament

- There is no consensus in the society on how to define what should be considered an improvement or a deterioration of the existing situation

- There is not enough scientific evidence that could make it possible to achieve a distinction between facts and hypotheses

- Future scenarios are definitely covered by a thick cloud of genuine ignorance

If we accept these points, then what should be changed in the way we do science?

The validation of information in the social process that generates knowledge is based on the ability to guarantee a ‘semiotic check’ on the congruence of two sets of decisions. The first decision is about the relevance of the perception of the reality used as basis for analysis. Such a decision requires that a given identity be assigned to the observer/storyteller/agent in terms of goals, fears and rules, useful experience and legitimised institutions. The second decision is about the pertinence and rigour of the relative analysis. Such a decision translates into the assignment of an identity to the observed. This second check, by default, must come after having decided a semiotic perception of the observed. In addition, it also requires that the chosen representation of the reality has to produce a result compatible with the codified knowledge already available. This is a requirement that makes it possible for the observer/storyteller/agent to take advantage of past experiences.

Such a ‘semiotic check’, therefore, requires the existence of a knowledge system, which must have a preliminary agreement on a set of procedures/protocols to be used to guarantee a quality assurance process on the selection of both narratives and scientific analyses used for guiding action. At the end of this check the scientific analysis and the selected narrative must be:

- Compatible with each other (the belief about a causal relation associated with the chosen narrative can be validated using an empirical analysis based on the model)

- Relevant and pertinent for the specific problem and for the specific observer/storyteller/agent (they must result in something useful for guiding action)

Normal science (Kuhn 1962) pertains when the society has in place a set of procedures that are considered reliable to guarantee a ‘semiotic check’ over scientific analyses. The adjective ‘post-normal’ indicates situations where the standard validity check of ‘normal science’ is impossible. The concept of post-normal science was introduced by Silvio Funtowicz and Jerry Ravetz during the 1990s (Funtowicz and Ravetz 1990, 1991, 1992; Ravetz and Funtowicz 1999). It characterises a situation of crisis for the reductionist paradigm, which is increasingly evident in the third millennium ‘where facts are uncertain, values in dispute, stakes high and decisions urgent’ (Funtowicz and Ravetz 1993: 744). Situations in which is not easy to obtain a ‘semiotic check’ over a given analysis are becoming more and more frequent.
Point 2: the required quality check on the pre-analytical selection of narratives—limits to the application of neoclassical economic analysis to the issue of sustainability

Two quotations are used here to introduce the subject matter of this unit:

I shall argue that the postulates of the [neo]classical theory are applicable to a special case only and not to the general case, the situation which it assumes being a limiting point of the possible positions of equilibrium. Moreover, the characteristics of the special case assumed by the [neo]classical theory happen not to be those of the economic society in which we actually live, with the result that its teaching is misleading and disastrous if we attempt to apply it to the facts of experience (Keynes 1936: 1).

analytical work begins with material provided by our vision of things, and this vision is ideological almost by definition (Schumpeter 1954: 42).

The validity of scientific knowledge depends on the perception embodied in selection of a relevant narrative. There is also a corresponding pertinent analysis that gives a representation. The perception and representation must be coupled wisely. This implies that, for scientific analyses, there is something that is worse than being wrong: being irrelevant. A scientific analysis may be wrong, but it may still use the right set of categories relative to an appropriate narrative. In such a situation, sooner or later practitioners in the field will learn and produce better models. On the contrary, in the worse case, where the selection of narrative is wrong, the problem lies outside the realm of technical choices. Things do not work even superficially in the way they are supposed to. The problem is a systemic lack of meaning for the analytical tools applied in relation to the situation at hand. There is insufficiency in the semiotic check. In this chapter, we make the point that, when applying environmental economics to the sustainability issue at the global level, we are dealing with the application of analytical tools based on an irrelevant narrative.

This chapter provides three examples—typical of environmental economics—of analytical tools developed within narratives that are meaningless at the global level:

Example A: at the global level, the concept of externalities is no longer useful

Example B: at the global level, contingent valuation methods do not provide a rigorous analytical tool, since there is an issue of scale as to how to aggregate preferences across levels

Example C: at the global level, the issue of sustainability is at odds with the hypothesis of moderate scarcity

Example A: different definitions at different levels of the same term—'externality'

The possibility of different legitimate perceptions and definitions of the same concept does not sit easily on reductionism. An example of different legitimate perceptions and definitions arises in the field of economics where there are different definitions of a central term 'externality'. For example:

- Externality a = A consequence of an action that affects someone other than the agent undertaking that action. The agent is neither compensated nor penalised through the market by that externality. Externality can be positive or negative
- Externality b = A successful shifting cost strategy (reflecting the strategy typical of 'cowboy economics')
- Externality c = An indicator of market failure, because the price was not right (deep economic theory)

These three definitions notwithstanding, the very concept of externality at the global level loses its meaning. Waltner-Toews and Lang (2000) observe that the scale of human activity on this planet reached a point that leaves no room for 'externalisations' relative to the global economy. What are often called externalisations may in fact be short cuts providing temporary comparative advantage to those deciding to use them (definition b), but they are still within the global system and so are not external to the system on which all depends. In terms of pollution, the term 'globalisation' means that 'what goes around comes around.' In terms of international development, the term 'globalisation' means that increasing profit because of favourable terms of trade for one party implies impoverishing someone else (definition c). That someone else will, sooner or later, require assistance—which puts pressure on the original protagonist. Ignoring negative side-effects on the environment no longer pays because, in the long term, the bad actor pays (this goes against definition a). The environment will sooner or later present the bill. The term 'globalisation' should prudently include acknowledging the return of the ancient practice of integrating the goal of economic growth with a set of additional goals such as equity, environmental compatibility and respect for diversity of cultures and values. This will require looking for wise solutions at a global scale assuming an open and expanding universe of discourse (becoming a reality), rather than for optimal solutions in a smaller universe of discourse (a finite set of indicators).

Example B: aggregating a formal representation of preferences across hierarchical level entails a scale issue and therefore the need to address in semiotic terms the unavoidable existence of legitimate but contrasting perceptions

Contingent valuation methods (CVM) are based on interviews to identify individual preferences. This information is then used to assign numerical values (in monetary units) to the encoding variable 'market price' in those situations in which there are no
market mechanisms available to determine market prices. The quantification here is an attempt to escape the metaphorical nature of cost–benefit analyses when dealing with assessments of economic values of goods and services (e.g. biodiversity) in situations in which there are no functioning markets. In this way, fictitious markets (e.g. willingness to pay measured via interview) are claimed to provide the missing experimental input. Contingent valuation methods invite questions as to the validity of the CVM measurement scheme, which is supposed to provide a formal representation of preferences in quantitative terms. Such questions apply particularly when CVM researchers generate numerical assessments of the willingness to pay in relation to the preservation of environmental services. The issue is particularly pressing at the global level as the scale of analysis.

That is, the neoclassical disciplinary approach is based on:

- Expected relations and behaviours of types useful for representing events
- A given narrative about a relevant reality
- A formal problem structuring for scientific analysis (how to formalise in an alternative way goals, costs and benefits)

This creates a big problem when science is asked to deal with sustainability. For example, let's imagine that we want to define in numerical terms (e.g. price expressed in a given currency) the value of a drug able to retard the process of ageing using the willingness to pay approach. Then, the chosen method has to face the unavoidable existence of different storytellers having different goals since they perceive a different relevant reality. That is, the willingness to pay for such a drug expressed by a young girl would be a negative one. She wants to grow; therefore she would not pay anything for such a drug. Actually, she drinks as much milk as possible. On the contrary, the willingness to pay expressed by her adult mother would be a positive one since she does not like ageing.

The same problem is found when asking different social actors about their willingness to pay for preserving biodiversity. Rich people living in developed countries are willing to pay to preserve biodiversity. On the contrary, desperate people living in developing countries are willing to pay to get rid of biodiversity (e.g. by bribing the guards of a natural park to allow illegal hunting or tree-cutting). This example illustrates why, in the field of sustainability, it is not possible to define an optimal policy based on a given formalisation of its performance. Different storytellers adopt their own perception and representation of costs and benefits and, therefore, they require the adoption of non-equivalent formalisations.

These different perceptions of costs and benefits are in fact developed within non-equivalent definitions of a relevant reality. Whenever we find a situation in which there are legitimate contrasting definitions of relevant reality and non-equivalent semiotic identities are adopted by different storytellers, quantitative analyses clash against the problem of how to select the right formal identity for the 'observer-observation complex'. If we insist on adopting a single formalisation of this semiotic identity (e.g. using the willingness to pay), then the existence of a diversity of storytellers would move the problem on the decision on how to stratify the sample. Going back to the example of willingness to pay for a drug retarding ageing, the final assessment will be determined not by the substantive value of the drug but rather by the relative number of girls and mature women that the analyst decided to include in the sample.

At the global level, it is impossible to aggregate in a substantive, neutral, objective way the different views about costs and benefits associated with sustainability. This is reflected in the existence of different preferences in face of the same choice. In fact, 'willingness to pay' across the population to be aggregated is expressed:

- At different scales
- In different contexts in relation to ecological processes that are nested and occurring at different scales

There are no universal procedures or units to aggregate in a substantive way when some clients refer to full market regulated activities, while others look to issues of subsistence. Formal analysis is therefore unattainable, but negotiation may well be possible.

**Example C: using formalisms associated with unrealistic narratives can be a way out of confronting unpleasant situations**

Narratives of the type 'when the market is able to internalise the full cost' and 'when the price is finally right' are wishful thinking with little relationship to the reality of a planet in continuous evolution subject to biophysical constraints. 'The price is right' only works in the television game show of that name. What if full cost cannot be fully internalised? What if the price is always right in relation to a given definition, but always wrong in a relation to another legitimate perspective? What if prices are irrelevant for deep issues of sustainability: for instance, when the scarcity is such that nations go to war? In that case, it is better to have the right weapons.

**Point 3: over-connectedness across levels and scales**

There are several reasons for the difficulties in achieving a semiotic check of scientific information in the third millennium.

The first arises from globalisation, which shortens functional, social, cultural and geographic distances. There is a huge flow of people, information, goods and ideas across different systems of knowledge, which is removing the traditional barriers used in the past to preserve their peculiar identities. As a result, different knowledge systems are forced to interact and adjust to each other at unprecedented levels. These strong fluxes cause contamination of values, traditions, indicators, symbols and taboos within local societies. Within individual countries and within other well-established social entities, modernity also offers a dramatic increase in the diversity of legitimate and accepted behaviours and beliefs. The diffusion of ICT challenges the established hier-
architectural control over the flow of useful information. Anyone on the internet has access to an enormous amount of information in the form of reported problems, facts claimed, studies and scientific controversies about interpretation. The scientific community is losing its monopoly as 'official experts'. Someone affected by a rare disease can spend a couple of weeks on the internet and then be in a position to dispute the opinion expressed by the consulting medical expert. The internet produces an overload of information beyond the capacity of experts, whatever the discourse. In the same way, marginal communities in developing countries are able to contest the technical advice received from Food and Agriculture Organisation (FAO) experts. These lay people can readily receive supporting information received from non-governmental organisations (NGOs) or alternative experts. Alternative information makes it possible for marginal groups to challenge the quality of the information they are receiving. Furthermore, marginal social groups can reach a critical size so that their distinctive values, perspectives and narratives cannot be ignored by the existing power structure. By operating in large-scale networks, it becomes possible to legitimise their perception of what should be considered as relevant.

Beyond globalisation, the second reason for the difficulties in achieving a semiotic check of scientific information is the technology issue. Human activity can now generate huge changes on a large scale in very short periods of time. Rapid change introduces uncertainties and ignorance, so that it becomes even more difficult to reach the required consensus to achieve semiotic closure. On top of the difficulties in obtaining a quality check on the reliability of the narratives, there are also problems in performing on the reliability of models and data. Very often new measurement schemes, developed to gather empirical evidence required to characterise an innovation, become reliable only when the relative observable quality is already obsolete. At that time the relative innovation has already been replaced by another one or the critical issue may have been shifted to another observable quality.

Point 4: taxonomy of different types of knowledge and reasons for their interaction

Polanyi's famous line 'we know more than we can tell' (Polanyi 1966: 4) indicates that perceptions of the reality based on semiotic identities are richer than our ability to represent it by sharing with others the meaning of epistemic categories used in formal identities. The large number of Eskimo words for snow or Italian expressions for ordering coffee at a bar are both limited labels for an even richer set of concepts and perceptions. In his book The Science of Culture, L.A. White (1949: 3) says:

science deals with particulars in terms of universals: Uncle Tom disappears in the mass of Negro slaves. Art deals with universals in terms of particulars: the whole gamut of Negro slavery confronts us in the person of Uncle Tom.

There is tension between the need to introduce new epistemic categories and maintaining a sound level of ambiguity on the meaning of terms. The term knowledge itself is loaded with ambiguity. It is often used to indicate simply information: for instance,

Tentative glossary of labels associated with the concept of knowledge

- **System of knowledge** = the ability to implement an organised process through which it is possible to generate useful information for sharing experience, and developing predictive models and mechanism of controls within a set of relevant perceptions/representations of the external world, which has been validated by 'the' storyteller.
- **Indigenous knowledge** = developed by a system of knowledge which was able to preserve its individuality for a long period of time. Its characteristic is a universal claim (a cosmological view) in which the identity of observer/storyteller/agent is clearly at the centre of the semiotic check (from a definition given by Silvio Funtowicz).
- **Traditional knowledge** = developed by a system of knowledge operating a process of semiotic check with a very large time differential. This is typical of pre-industrial societies, in which the definition of the semiotic identity of the observer/storyteller/agent included characteristics of local ecosystems, i.e. this is a form of knowledge in which there is no clear dichotomy between humans and nature. The relative narratives tend to focus more on a long-term view of harmony with nature, rather than on a short-term view of improvement for human material standard of living.
- **Local knowledge** = the ability to provide 'fine-grain' perceptions, narratives and analyses in relation to a location specific context. This distinction has nothing to do with the level of development of the social system within which such knowledge is expressed. Local knowledge can be found just as well in Manhattan as in Peru or in Amsterdam as in Papua New Guinea.
- **Objective knowledge (or substantive knowledge)** = a mythical assumption about the existence of narratives and relative analyses whose validity remain invariant across scales, places, special situations, dimensions of analysis and knowledge systems (different storytellings).
- **Scientific knowledge** = the ability to perform a pertinent analysis within a set of standard narratives about a relevant reality, which are considered to be valid by default.
- **Replicant knowledge** = a pseudo-form of knowledge leading to the application of policies indicated by rigorous scientific analyses, which are based on narratives that may be irrelevant for stakeholders. In this case, these policies have to be imposed from the outside, thanks to the existence of power asymmetry, and against the will of stakeholders belonging to a different knowledge system. See Point 5 for more on this concept.
Reasons for interaction among different knowledge systems
(after Martin O'Connor and Ângela Martins da Guimarães Pereira)

**Reason 1.** Communicating to the public what the powers that be have already decided to do, in order to facilitate the acceptance of such a decision (e.g. a rugby referee explaining the reasons for a call).

**Reason 2.** Extracting useful information from local knowledge in the form of useful narratives and effective analytical tools. Such information would be more difficult and expensive to extract in a different way (e.g. asking the locals for a typical restaurant with decent prices). In the long term, this can result in the establishment of an effective mechanism of monitoring.

**Reason 3.** Establishing a process of interaction among social actors able to provide a semiotic check over a given production of knowledge (e.g. organising a process of participatory integrated assessment). In the long term, this can lead to the establishment of permanent platforms of negotiations among social actors about how to: generate and evaluate scenarios; and select and implement policies.

**Reason 4.** Learning how to produce knowledge better (e.g. meta-analysis of the process of social learning how to build a better future together).

These analyses that determine policies have normative value, and are determined by the choice of an economic narrative that assumes that the level of gross domestic product (GDP) is an uncontested indicator of economic development. These choices may drive a larger cash flow through the economy of developing countries to no advantage for local people, but still cause environmental degradation.

In these scenarios, investment and jobs come from outside, and salaries and profits go back outside the country. The GDP narrative invokes the 'wrong' for the communities living close to the mining sites because a larger GDP may not coincide with 'better' for the country or its communities. It may be that the only thing remaining in the country associated with this boom in the flow of GDP is ecological and social disturbance. Such a problem is not limited to economic policies made for developing countries. For example, within the European Union, the introduction of the euro as a common currency has been associated with a pact that imposes stability on national budgets. Strict limits to national deficits and inflation rates were fixed for the countries participating in this process. Less powerful countries such as Portugal, Spain and Italy all made sacrifices to meet these criteria. However, as soon as the rich economies of France and Germany found themselves in trouble, these two governments simply decided that the narratives supporting the implementation of the existing rules may be challenged by other narratives (social concern) whenever they should imply economic decisions that would be too detrimental to the welfare of their citizens. The sound, rigorous scientific analyses used at the outset to mandate the existing rules obviously remain unchanged, but, as soon as underlying narrative became politically inconvenient for the big power brokers, a way out was generated by challenging the priority given to the original narrative in preference to alternative ones.

These examples illustrate risks in applying mechanically the output of scientific analysis to generate policy indications without adequate semiotic checks on the validity of the narratives within which the analysis was developed. This is particularly important where there is a clear power asymmetry that can imply a distorted negotiation about contrasting legitimate perspectives. Such misuse of models in situations where they do not apply invokes what we call replicant knowledge.

The definition of replicant knowledge given in the box on page 91 gives a label to a form of pseudo-knowledge. Thus explicitly identified replicant knowledge can be exposed as troublesome and expurgated. Replicant knowledge currently corrupts science for governance as a discourse. Those carrying and applying replicant knowledge seem to believe that a given set of narratives and relative formalisations that proved useful in a given context, at a given point in space and time, when the consensus on the validity of the narrative was uncontested, should be considered still useful no matter the context in which they are applied. Replicant knowledge pertains when reductionist science claims objectivity. Possessors of replicant knowledge assert that they have found something out (an indicator, a sound policy, a technical solution, an optimising procedure) without taking a point of view or suggesting a given meaning in a context. There is, of course, still meaning and context, but it is hidden behind sterile and neutral cadence. As suggested earlier in this chapter, objective knowledge is an oxymoron because, assertions of neutrality notwithstanding, it involves a knower (storyteller) who has a point of view that something is worth knowing. Objective knowledge is a myth. We see replicant knowledge as based on this myth. Any form of real knowledge has to be generated through a process of semiotic validation of the narratives, sug-

**Point 5: justifying the introduction of the neologism: 'replicant knowledge'**

As discussed in Point 2, there are cases when an irrelevant narrative can imply the selection of a policy that would be ineffective or perhaps dangerous in a real-life situation. For instance, an international banking institution may impose a policy of subsidising mine extraction on developing countries in order to boost the mining sector of their economy, or to build big dams for hydroelectric generation even though there is no local demand for electricity.
gested meaning and relative formalisations in relation to the specific context in which that knowledge is applied.

The term *replicant* comes from the movie *Blade Runner*, in which ‘replicants’ were pseudo-human forms used for expansion into the extra-terrestrial colonies. They looked and behaved like humans, but they did not have a history, neither as individuals nor a social group. They did not know who they were, and this was their major existential problem. Replicants had no memories, no roots and no future. In order to increase their effectiveness in conquering the extra-galactic colonies, replicants were given a clear and short expiration date. Their lives were without historical meaning or cultural narrative; they could only live in the present. Thus their knowledge would be very close to what we define as replicant knowledge. Replicants would not take a position; they would merely function.

This is exactly the proposition in recommendations to leave market forces free from any controls that organise societies. ‘Nothing personal, guys, it is just the market at work.’ The market does not care, it only functions. Of course, those who advocate the market as an arbiter think that is has value in meaningfully organising society. But such a blind faith is an abdication of responsibility. Belief in the market is a way to excuse heartless disregard for losers in the arena. It is supposed to offer validation of the sort of irresponsibility one might need in expanding into extra-terrestrial colonies. Since replicants live in the present, they are not distracted by a meaningful past or any unfortunate scenarios for the future. This makes replicants winners in the here and now.

But sustainability requires the claims that there is more to human existence on this planet than winning all the time. Sometimes the losers have helpful things to say, particularly if they are to be constructive participants in aftermath of governance. The replicants in *Blade Runner* were not intended to be part of the continuing scheme of things. In this regard, it is useful to mention one of the favourite lines used by Charles Redman to explain the basic idea of sustainability: ‘sustainability is doing what we think we need to do if we were intending to stay here for a long time’.

Reductionism in science is somewhat similar to the generation of replicant knowledge, but it does not share the fatal flaws. On the contrary, reductionism is a very powerful tool for generating scientific knowledge. By focusing only on a small and well-defined view of the reality, it is possible to organise, share and transmit experience better. Reductionists narrow the discourse until only some version of thermodynamic self-organisation clearly applies. At that point ‘how? is pretty much the only question. In this way, it is possible to create better formalisations and models, and it is the basis of disciplinary scientific knowledge.

The fact is that making complex problems simpler, getting rid of taboos and traditions, not looking too far into the future, and focusing on a single aspect of the reality at the time all facilitate dealing with specific problems. This is the root of success of reductionism. The caveat is that this protocol can be used to address only one narrow problem at the time. Reductionism cannot do everything. It has limits in its application. When rich meaning returns to the discourse as the larger contexts entailing diversity are addressed, then reductionist focus is too narrow and reductionism loses power to the point of being counter-productive.

The success of reductionism is the back door through which replicant knowledge was inserted into science for governance. So reductionism is in that sense part of the problem. When there are problems not of how things work, but rather issues of what should be and why, then the focus of a reductionist posture leads to inflexible recommendations which many clients will not buy into. If those clients own part of the solution, they will scuttle the ship. If the success of reductionism is used appropriately to justify its application beyond its ken, then replicant knowledge, not scientific insight, is generated. Narrow focus and single solutions to problems with a strong normative component end up imposing unfair policies that are often also unworkable. Technical solutions, where one size is forced to fit all, are not appropriate because they lack a sufficiently rich narrative and meaning. This is our complaint about the use of replicant knowledge. While understanding based on replicant knowledge is clearly flawed by its lack of meaning, it is a mistake to underestimate the power of such knowledge, or of any facsimiles thereof.

The adoption of replicant knowledge for justifying policy choices happened mainly in the second half of the 20th century in northern Europe, and then spread. The social groups using replicant knowledge for their decisions achieved advantages associated with a cultural lock-in, ‘the survival of the first effect’ (Hopf 1985). Reductionism provided an edge over competing systems of knowledge. By relying heavily on science and technology, Western neocolonialism was able to take over the world—as if the rest of the world were an extra-terrestrial system to be colonised. Decisions were often supported by cost–benefit analysis—an analysis entailing an explicit normative component. That is, scientific knowledge was used to force the best policy. This implies moving the reductionist approach into the arena of policy-making where it has large consequences but is inept. Compared with the values coming from our goal-driven existence, cost and benefit both have different meanings for people playing a role in a barring, subsistence economy and for people operating in an industrial society. This explains why replicant knowledge (and reductionism) can send a few humans for a few hours on the moon, but it cannot be expected to keep 8 billion people in a state of peace on the Earth. The very simplifications that were so useful in making Western culture the first to rule the planet in the fossil energy era are not likely to be so useful in making it last.

We make no apology for our neology, because there is an important centre to replicant knowledge. Many concerned with the sustainability of Western civilisation are wont to confuse replicant knowledge with Western knowledge. This is a serious mistake. Western philosophy is replete with statements against the implementation of policies based on indications provided by replicant knowledge:

- ‘Scientists are those that know about their ignorance’ (Socrates)
- ‘Truth can only be obtained for a reality constructed by humans and not in substantive terms—verum factum convertuntur’ (G.B. Vico)

A lot of wisdom sought by concerned scientists under the label ‘indigenous knowledge’ is already available even in Western culture and science. But purveyors of replicant knowledge do not bother to look at it. So the problem with replicant knowledge is not that indigenous knowledge is unavailable to Western knowledge. Rather, there is more than a touch of autism in reductionist science and it passes this dysfunction over to its unwanted child, replicant knowledge. Clearly we need more reasonable curricula in Western academic programmes with mandatory courses of philosophy and episte-
Paradigm shifts amount to a large change in assumptions, and the shift implied by the concept of post-normal science suggests abandoning assumptions typical of reductionism. The most important assumption to be rejected suggests that it is possible to make substantive models of the reality. This assumption of reductionism says that the same representation remains valid for non-equivalent observers and on different scales. Post-normal science, on the contrary, endorses the new set of principles rediscovered by the science of complexity. These principles include the idea that ‘all models are wrong, but some are useful’ (Box 1979). The influence on what the observer experiences is not limited to the characteristics of the observer, but also the characteristics of the observation space. That space is characterised by the selected scale and the observable qualities detected by the measurement scheme. Life is the interaction of non-equivalent observers, non-equivalent storytellers and non-equivalent agents operating on different scales, adopting logically independent mechanisms of mapping and modelling each other. Every fact entails more than a single, simple explanation. Chicken–egg patterns with their cyclical relations of causality require the introduction of complex time in the analysis. All these notions invite a post-normal approach.

There is another way that can be used to characterise the difference between the reductionist paradigm and that of post-normal science. Reductionism moves around the concept of ‘discovery’. In this vision, the reality is considered as something which is out there, distinct from and independent of the characteristics of the observer/storyteller/agent, with which it is interacting. Post-normal science, on the contrary, sees the reality as perceived and represented by humans, as an invention. The reality is something to which the observer/storyteller/agent must belong. Therefore, such a post-normal reality, existing or not independently from the observer, is in either case affected by the characteristics and the choices of the observer/storyteller/agent. The choices of the observer/storyteller/agent affect such a reality not just because of the effects associated with the selected actions. There are other effects associated with the selection of how to perceive and represent the observers/storytellers/agents themselves when interacting with post-normal reality. Such nuances of the observer/storyteller/agent are ignored in reductionism.

In relation to science for governance, the paradigm shift implied by post-normal science can be characterised as a substitution of the concept of substantive rationality with the concept of procedural rationality. Substantive rationality is based on the assumption that it is possible to individuate an optimal solution in the passage through semiotic closure. Procedural rationality is based on the acknowledgement that decision-making is about handling:

- Legitimate but contrasting perspectives
- An unavoidable level of uncertainty and ignorance

The distinction between these two types of rationality was suggested at the end of the 1970s by the Nobel Prize winner Herbert Simon (1976, 1983)—one of the fathers of the complexity revolution.

Within the paradigm of post-normal science, decision-making is no longer based on the individuation of optimal solutions, performed by scientists or identified by panels of experts. Rather, decisions should be based on a negotiation among the social actors and they should address the wisest thing to do. In this new process, the role of scien-
tists still remains crucial, although it is somewhat changed. Scientists have to contribute to the definition of acceptable compromises over wise strategies. In this new framework, the solutions to problems or the policies for development are not found but created (invented). Negotiation among social actors can generate options not available before. In that sense, negotiation creates new knowledge, since it makes it possible for the social system to do things that access viable states that were not accessible before. The universe of what is feasible for a society is certainly bound and constrained by biophysical constraints. At the same time, however, the option space for a society remains always an open space. This tolerant, outward-looking posture arises thanks to the continuous updating of the definition of the semiotic identity of the observer/storyteller/agent and the observation space. These constant updates create flexibility in the base of the system of knowledge. As soon as constraints are identified as such, they become no longer relevant. The ability of social negotiation to open new opportunities is associated to its ability to redefine the identities on the observer/storyteller/agent side. Notice that such flexibility sidelines the notion of the single optimal solution that characterises reductionist thinking.

In their new role, scientists have to contribute to society by learning as quickly as possible instead of seeking deep ultimate knowledge of an external world. The learning is achieved by better perception, representation and definition of goals, with regard to options, problems and constraints. The concept of post-normal science implies a scientific process in which there is a strong two-way dialogue with society. This open dialogue is at odds with the one-way flow of information that experts give to the public in a normal science posture. By learning fast and remaining open, scientists can return the fold of the society. They can become just another category of social actors, rather than consider themselves as a special class of social actors above the rest of society. With such connection back to the arena in which the problems arise, scientists become suddenly more relevant.

There is a price to pay for becoming thus engaged, but the benefit of paying that price is a new and enlivened trust of society. Scientists have to accept losing their special status of referees above different sides. By posturing as neutral, reductionist science has achieved a special standing but there is a price for that too. In a situation of post-normal science, scientists are no longer guaranteed the privileges associated with their status, their academic titles and their achievements. Rather, their privileges must be earned by real-time action and success in the field.

In a post-normal world, scientists still have to guarantee the quality of their work. For this reason, the definition of ‘quality’ for post-normal science has to include many more criteria of performance than those required for normal science. In fact, the conventional criteria of quality of normal science include personal preparation, rigour, application and recognised competence. Post-normal science goes beyond even this standard. Additional criteria have to be added to this list. Scientists must yield to a special check on the ‘semiotic closure’ in relation to the application of the scientific output. Such a check can no longer be achieved una tautom (once and for all) and urbe et orbis (here and everywhere). Rather, the check has to be tailored each time to the special situation.

This new set of quality criteria refers to aspects of scientific activity that were never considered explicitly as relevant before:

- Moral integrity (e.g. whenever economic or career interests overlap with scientific findings)
- Transparency in the research process (who pays or who decided the research agenda?)
- Awareness of the responsibility associated with the pre-analytical choice of a given narrative, and therefore willingness to take responsibility for it
- Willingness to accept a review of the scientific work from scientists of different disciplines and/or social actors operating outside the academic world
- Fairness of the procedures of decision-making to which the scientist is supplying the scientific input
- A level of attentive craftsmanship that puts together a specific blend of formal analyses, intuitions, common sense, mathematical models, feelings and metaphors—all applied to adequate procedures of processing and handling data sets

References


