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Adaptation and Maladaptation in the Past

A Case Study and Some Implications

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Abstract

Adaptation and maladaptation are best viewed as different phases in the relationship between a society and its (social and natural) environment. This chapter looks at that relationship over two scales (millennial and centennial) and attributes the transitions (“tipping points”) between adaptation and maladaptation to the unintended consequences of human actions. These, in turn, are due to the difference in dimensionality between the environment and humans’ perception of it. Transitions between adaptation and maladaptation occur when a society’s “value space” (i.e., the total set of values that the society knows, which keep that society functionally together) does not expand at a sufficient pace to keep up with the growth of the society’s population. This seems to be linked to a second-order dynamic that develops as societies are overwhelmed by the consequences of their own (earlier) actions; their focus turns inward and becomes short term (i.e., tactical instead of strategic). This chapter argues that this is the case in the current, Western-dominated global system, and suggests that an inversion of global information flows (i.e., spreading information rather than concentrating it in the West) has the potential to reenergize the global economic system. This needs to be achieved while respecting the environment, hence the term *green growth*. It implies rephrasing the current economic and political debates from “burden sharing” to “opportunity creation,” both for the developing and for the developed world.

Introduction

Many, if not all, human societies on Earth have experienced at times a “crisis.” In a wide range of environments throughout history, crises in simple societies have manifested themselves, for example, as famines. In complex societies,

they may have taken the form of economic depressions, social conflicts or wars of some kind between groups, or even the collapse of complete empires such as the Persian, Egyptian, Roman, and Byzantine empires (Tainter 1988).

In the lead up to a crisis, societies become increasingly maladapted to address the dynamics impacting them. During and shortly after the crisis, more or less drastic changes are implemented to overcome it, and society readapts itself to the dynamics of its (social and natural) environment. In due time, without the slightest doubt, maladaptation will reoccur and precipitate the next crisis.

Adaptation and maladaptation need to be studied together. One of the most interesting aspects of such a study is how a successful adaptation evolves into a maladaptation, time and time again. Here, two issues are important.

The first concerns our perception of *adaptation* and *maladaptation*. These concepts stem from a research tradition which views human societies (or, in a wider sense, the subjects of a study) as *reacting* to their environment; that is, human societies can be *well*-adapted or *mal*-adapted to their (social and natural) environments. In sustainability studies, ecology, and related fields, there has been a shift in how these concepts are understood: we now study the *interaction* between the system under study and its wider environment. Hence, the dynamics involved are now viewed as reciprocal rather than unidirectional (see Table 13.1). This shift makes it easier to study the transition between adequate and inadequate adaptation from the same perspective, as it removes an opposition (between “good” and “bad”), which only served to emphasize the distinctness of the two while deemphasizing their interaction.

Table 13.1 Relationship between society and its environment: the transition from a reactive to a proactive to an interactive perspective. This shift has changed conceptual terms as well as other attendant aspects (e.g., the cause of crises, the role of technology).

Pre-1970s	1970s and 1980s	1990s and Later
Culture is natural		Environment perspective dominates
Humans <i>react</i> to the environment	Nature is cultural	Nature and culture have a reciprocal relationship
The environment is dangerous for humans	Humans are <i>proactive</i> with the environment	Humans <i>interact</i> with the environment
Environmental crises hit humans	Humans are dangerous for the environment	Neither are dangerous if handled carefully; both are if that is not the case
Adaptation	Environmental crises are caused by humans	Environmental crises are caused by socionatural interactions
Apply technofixes	Sustainability	Resilience
“Milieu” perspective dominates	No new technology	Minimalist, balanced use of technology

The second concerns the definition and scale of the phenomena under study. In investigating the transition between adapted and maladapted dynamics, in the archaeological past or in the present, a major methodological difficulty is presented by the desire to draw a boundary between the adapting system and its environment so that the dynamics of the two may be contrasted. The need to draw such boundaries is in effect a vestige of our traditional entity-based thinking, which will no doubt be replaced in time by a conceptualization of relationships. For the moment, however, I do not have such a vocabulary and toolkit at my disposal. Thus for clarity's sake, I have to distinguish between the adapting system and its environment, and hence between internal and external system perturbations. I ask the reader emphatically to remember that this distinction is artificial—that in the hyperconnected world such as ours, “inside” and “outside” are not really distinguishable. External perturbations are simply internal ones when the system is conceived at a larger scale.

Which Past?

I have been asked to discuss adaptation and maladaptation from the perspective of the long-term past, which is my province as an archaeologist and historian. However, the “very long-term time” perspective has a distinct disadvantage: as one removes oneself in time from events, the details of the dynamics involved tend to become less clear to the observer. This impacts a historian, but is even more poignant for the archaeologist, who does not have the help of causal or dynamical observations, since they are only able to observe the *results* of the dynamics involved in the evolution of material culture. Archaeological observations are essentially static. They are snapshots in time. Even the sequential assembly of such snapshots only results in describing an evolution without being able to infer the dynamics behind it. For instance, consider two photographs in which the same actors are positioned differently in each. Which process caused the rearrangement of the group to occur? On the basis of the photos alone, it is essentially impossible to determine the sequence of changes, let alone what motivated the group to change.

My initial description of a series of adaptation–maladaptation–readaptation phases in Western European history, based on a combination of archaeological and historical information, will be followed by a recent example of a major transition in Epirus (northern Greece) that occurred between AD 1850 and AD 2000. In between, I present theoretical ideas aimed at designing a conceptual framework for the study of such transitions and conclude with ideas about the present that have emerged from my involvement in sustainability research, looking at the question: Can we redirect the path upon which our global society is traveling and, if so, what might be needed to achieve this?

The “Long-Term-Time” Perspective: 600 BC–AD 1950

To develop a longer-term perspective, let us look at the history of Western Europe from about 600 BC to the very recent past, beginning with the Roman Republic and Empire (Tainter 1988; van der Leeuw and de Vries 2002). Roman expansion was enabled by the spread of Greco-Mediterranean culture northward from the Mediterranean. For centuries, this structured societies in Italy, France, Spain, and elsewhere, spreading inventions (e.g., money, crops, the plough), building infrastructure (towns, roads), creating administrative and military institutions, and collecting wealth. Profiting from this situation, the Romans used an ingenious policy of stepwise assimilation and organization of indigenous political entities (Meyer 1961), making them subservient to their needs (i.e., to the uninterrupted growth of wealth, raw materials, foodstuffs, and slaves from the conquered territories to Rome). This flow linked societies across the Empire to its capital for as long as there were preorganized societies to be conquered and wealth to be gathered (Tainter 1988).

During this period, until about AD 100, a feedback loop between innovation, wealth creation, and institutional change drove Roman society to increase its size both demographically and geographically, while at the same time increasing wealth differentials, both locally and between Rome and the periphery. However, once Roman armies came to the Rhine, the Danube, and the Sahara in the first century AD, the inflow of preaccumulated wealth came to an end. Rome became dependent on wealth generated annually by solar energy (in the form of agricultural products). In the second century AD, this led to major internal investment in the infrastructure (highways, *villae*, industries) of conquered territories, and resulted in a precursor to what we would currently call “agroindustry,” with large-scale production of foodstuffs such as cereals, olive oil, and wine.

By circa AD 250, the Empire became less efficient in addressing many challenges that resulted from its earlier actions. As of that point, the Empire became increasingly maladapted to the circumstances it needed to confront. The wealth gradient between the center and the periphery leveled out as the living standard in the periphery rose. This increased the relative cost of maintaining a military and an administrative establishment to ensure the inward flows of resources needed to feed the population of Rome and to maintain its infrastructure (Tainter 2000; Tainter and Crumley 2007). The emperors responded by repeatedly devaluing their money to address immediate needs, and, several centuries later, ended up splitting the Empire into four parts to reduce administrative and military overhead. *Subsequently, the coherence of the Western Empire decreased to such an extent that it ceased to exist.* People focused increasingly on their local environment rather than on the central system. Much smaller, dynamic socioenvironmental structures emerged at the edges of the Empire, from which the process of extending a core began anew, based on different ways of information processing. In other words, the cultural, social, and

economic alignment between different parts of the overall system broke down, and new alignments emerged that were only relevant locally. To summarize:

- Social formation expanded by incorporating preaccumulated resources.
- Limits to its adaptive capacity were reached due to a shortage of resources.
- A period of maladaptation followed once those limits were reached.
- Society readapted by reorganizing its agriculture based on new infrastructure.
- A few centuries later, society nevertheless collapsed.

In the second part of the period we are considering, we encounter (in roughly the same space) a situation in which a new social formation readapted itself several times in a row, each time managing to maintain its coherence. In Western Europe, between c. 600 and c. 1950 AD, at least three major readaptations can be distinguished:¹ (a) after the Black Death in the fourteenth century, (b) after the discovery and trade-based colonization of new continents, and (c) after the invention of ways to use fossil energy.

After the western Roman Empire collapsed in the fifth to eighth century AD, several centuries of cultural, institutional, and technological “decay” followed. This can be observed, for example, in the spatial organization of settlement, which, apart from a few ancient roman cities, changed completely and discontinuously. New settlements were mostly located in different places, indicating that they depended on different resources and/or different ways of exploiting them. The social principles upon which the society was based also changed profoundly: from a commercial system driven by long-distance interaction in a monetized economy to a feudal agricultural system in which most local units were self-sufficient. The art of reading and writing survived within the Catholic Church, but even Charlemagne could only sign with an elaborate cross. Many advanced arts and crafts were forgotten in large stretches of Europe, such as thrown pottery making and glassblowing, only to be rediscovered or reinvented centuries later.

The period AD 1000–1200 saw the emergence from the ground up of a fundamentally new structure of European society. Small principalities warred (Duby 1953/1971), eventually some conquered others, and larger entities emerged. This led to an increase in courtly wealth (cf. the twelfth century Renaissance), as well as innovation in crafts, arts, and technology, and to the reemergence of long-distance trade (Pirenne 1927/2014, 1937/2012; Lopez 1967, 1971; Spufford 2003). The wealth discrepancy between the courts and the rest of the population, as well as between cities and the countryside,

¹ Depending on the scale of observation, many more readaptations can be observed. Further transitions include during the Industrial Revolution, in particular those driven by the introduction of steam, electricity, and cars. The three examples which I have chosen distinguish themselves by the fact that in each case, major social upheaval, and possibly the collapse of existing structures, could have resulted if the transition had not succeeded.

increased and commerce became increasingly important, leading in the thirteenth and fourteenth centuries to numerous technical, institutional, and cultural innovations, particularly in northern Italy (Padgett 2001; Padgett and Powell 2012) and the Low Countries. Had this process continued unchecked, we might possibly have seen another phase of social upheaval. However external perturbation, in the form of the Black Death, intervened in the fourteenth century AD by killing, in three waves, a large proportion of the European urban (denser, wealthier) population. After much unrest, society readapted as the marginal rural population moved into the cities and gained in wealth (Wunderli 1992). Thus, the cycle did reboot. As a result of dynastic policies and multiple wars, Europe continued its structuration in ever larger and more solid political units, particularly in the westernmost part of the continent (France, Britain, Spain). This was accompanied by more innovation, more intensive commerce, more urbanization, and a general increase in mutual dependency between different regions and sectors.

By the end of the fifteenth century AD in Portugal, Spain, the Netherlands, and Britain, population pressure and growing wealth differentials limited room for further expansion, thus threatening the overall adaptedness of Western European societies. With the appearance of new scientific (the Earth as a globe) and technical (mapmaking, shipbuilding) ideas, adventurers were pushed and enabled to discover new riches on other continents, thus inaugurating yet again a new dynamic, driven by intercontinental trade in commodities (e.g., spices, precious metals), not unlike the expansion of the Roman Empire into the Mediterranean. Out of this readaptation process, transnational commercial (e.g., the East Indies Companies in the Netherlands and in Britain) and financial institutions (e.g., the Fugger Banking House; see Häberlein 2006) emerged. It should be noted that the contacts with extra-European areas were generally limited to trade and managed through the installation of emporia and/or the collaboration of indigenous populations. The Iberian colonies in the Americas were the exception: mining and the establishment of large agricultural domains involved greater local investment of Spain and Portugal than did the trade favored by the Dutch, British, and French. This phase, called the *rise of the modern world system* (Wallerstein 1974), drew enough new wealth from all around the world to maintain the coherence of European society until the second half of the eighteenth century AD.²

After AD 1750, Europe came to a point where wealth differentials were so important that social unrest was rife, as evidenced by the French Revolution (1789), unrest in Germany (1848–1876), and the American War

² These developments played out with considerable temporal and qualitative differences between the countries involved, due to their own historical path dependencies. It is interesting to note that smaller societies (Italian cities, Portugal, the Netherlands) were the first to innovate in the domain of exploration, commerce, and finance, and were then overtaken (in particular by England), whereas larger entities (Spain and France) transitioned more slowly and thus suffered greater tensions.

of Independence (1775–1783). It is my contention that European society was given a third lease on life through the discovery of ways to harness fossil energy (Landes 1969; Mokyr 2009). This enabled numerous other mechanical inventions (e.g., railroads, steamships, mechanized spinning and weaving, mass production of many utensils and artifacts) which were relatively rapidly introduced; the relaxation of the energy constraint on innovation greatly facilitated the introduction of novelties by reducing the energy cost of adapting society to their use. These readaptations also affected the colonies of European countries, where the need for raw materials in Europe led to increasingly intensive exploitation of all kinds of resources through mass mining and agriculture. In exchange, the colonies became the scene of mass marketing of goods produced in Europe. Together, these two trends bound the colonies more closely to the colonizing powers and generated a continuous stream of wealth for the latter.

This drove an acceleration in the process of change itself, which has become truly evident in the twentieth century. Information processing has replaced energy as the main constraint on innovation, and marketing has enabled innovators to “create” demand for their products. As a result, we have witnessed a shift from “demand-driven” to “supply-driven” innovation, so that we are currently engaged in a “Red Queen” innovation race: Western societies need to keep accelerating innovation and value creation to keep their societies together (van der Leeuw and Zhang 2014). This has fundamentally transformed the societies of Europe again, fostering the emergence of ever more education as a fundamental societal need, causing the exponential growth of (and our dependency on) fossil energy, leading to globalization driven and controlled by multinationals, increasing overall wealth but also the wealth differentials between core and periphery, leading to the current extreme form of unbridled capitalism and its corrosive effects on trust between social strata.

From the *ex ante* perspective adopted here, at each of three transition moments, post-Roman European societies could potentially have engaged in different trajectories, and this continues to be true for the present. *History is not inevitable*. There are times when processes dominated by strong drivers make change very unlikely, and there are moments when unexpected events or people can change the course of history. In the former, it seems as if the society is so closely attuned to the dynamics of its environment that one could argue that it controls them to the extent that is necessary for the society to function well. In the latter, the reduced adaptedness of the society’s dynamics to those of its environment seems to open the door for important structural changes.

Looking at this historical example from a different perspective, one could also interpret it as an indication that societies which undergo a maladaptation crisis—in these cases an excessive wealth discrepancy coupled with a slowdown in the creation of new wealth—can survive such a period if they manage, in time, to find solutions to their problems. In each of these cases, that hinged on finding new ways to create value for society’s members. Whether

challenges emerge, and whether they can be addressed in time is partly dependent on the context as well as on the path-dependent trajectory of the society.

A Framework for the Study of Socioenvironmental Dynamics

Humans differ from most other species³ in that they can learn and learn how to learn. Their capacity to process information is genetically encoded, but the information they process, and the ways in which they do so, is socioculturally and self-referentially developed and maintained. Humans can categorize, make abstractions, and hierarchically organize objects, and they communicate with others using various types of symbolic means. Human learning involves the recognition of patterns of all kinds, whether temporal, spatial, semantic, syntactic or yet other. By identifying such patterns, we organize the world around us, infuse it with structure and meaning, make it possible for us to understand it and/or know things about it, intervene in it, etc. As part of that process, human beings have the capacity to transform their natural and material environment in many different ways, and at many spatial and temporal scales. At any time, our relations with our (social as well as natural) environment are part of an uninterrupted process of human learning. This may be seen as a positive feedback loop that creates order out of our experiences of the world, by isolating patterns, defining them in terms of a limited number of dimensions, and storing the latter in the form of knowledge. The greater number of cognitive dimensions that exist, the more problems can be tackled, and the more quickly knowledge is accumulated, roughly speaking according to a feedback loop (Figure 13.1) (van der Leeuw 2007).

The result of this process is the continued accumulation of information-processing capacity, which enables a concomitant increase in matter, energy, and information flow through the society, thus enabling society to grow. That information-processing capacity includes the sum total of understanding, know-how, and skills of the people involved, including their technical and organizational means of solving problems, their means to maintain group cohesion, etc.

But there is a catch: All interaction between humans and their surroundings passes through the combined interface of cognition and action. Understanding the nature of that interface is fundamental to our comprehension of the transition between adaptation and maladaptation. As human beings, we are limited in the number of dimensions that we can simultaneously handle in our short-term working memory (Read and van der Leeuw 2008, 2015). Our perception of our surroundings is therefore heavily simplified. Such simplified perceptions govern our interactions with those surroundings, even though the dynamics of the surroundings are much more complicated than we perceive. As a result,

³ The extent to which other species possess these capacities is a matter of ongoing research. My focus here is that humans have these capacities, not on whether other species may also have them.

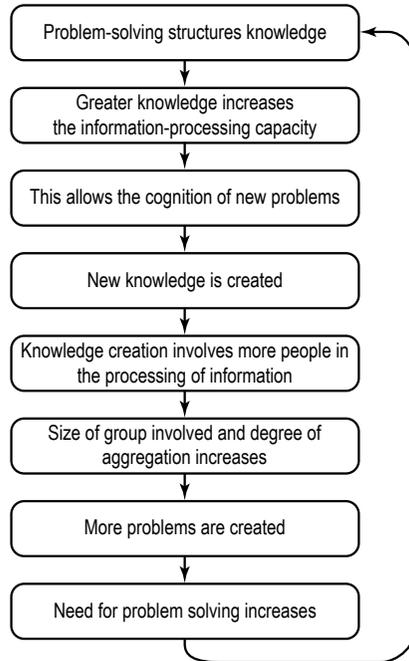


Figure 13.1 Feedback loop of human learning.

all of our interactions with our surroundings have unintended consequences. The knowledge, insights, and experience that we acquire by interacting with our surroundings is (heavily) outstripped by the (unknown) changes that our interactions are triggering. In other words, the human cognition–action interface is asymmetrical because there is a mismatch in dimensionality between humans’ perception of their surroundings and the nature of those surroundings, and this mismatch grows throughout the interaction. The more we think we have learned about our surroundings, the less we know about their actual state! If at the beginning we knew relatively little about the complex dynamics playing out in our surroundings, after a while we know more, but in the meantime the (un)intended consequences of our actions have transformed those surroundings beyond recognition, and our (expensively) acquired knowledge has become ineffective in dealing with the present.

Moreover, our ideas (theories, etc.) are underdetermined by our observations. This is most easily understood by referring to the example Atlan gives (1992): Take five traffic lights, each with three states (red, orange, green). The “system” of these traffic lights can assume 3^5 ($= 243$) states. But the number of possible configurations of the connections between the lights that could explain them is much higher, 3^{25} , which amounts to about a thousand billion. That is also the number of random observations we would need to decide logically between these configurations, but evidently we never have anywhere near that

number of observations.⁴ Hence, we must assume that our theories and ideas are indeed underdetermined by our observations, and (an important corollary) *overdetermined by preexisting ideas*, patterns of thinking that we apply to each new data set which shape our interpretation of it. That overdetermination is the principal factor that causes intellectual traditions to be difficult to change, especially after they have existed sufficiently long to have been applied in many different domains, and have led to many investments in institutions and infrastructure based on them. Changing these would demand a very large restructuring effort, and therefore a long period of uncertainty.

These two aspects of how we cognitively address the dynamics in which we are involved reinforce each other over time because the more we intervene in our environment the less adequate our knowledge of that environment actually is. This makes it increasingly difficult to change our interpretation of what is going on because we have fewer and fewer data points concerning the “new” environment which we have ourselves brought into existence.

How does this process proceed in practice? Existing, well-adapted sociocultural and economic structures are elaborated over time in an interactive process of problem solving, generation of new (unanticipated) problems, solving these problems, encountering new problems, etc. Accordingly, new elements (institutions, measures, objects, routines, techniques) are grafted onto existing societal (i.e., cognitive, institutional, material) structures whenever it is necessary to address a new challenge. In the course of such grafting, certain aspects of the society’s functioning are smoothed or rendered more efficient, but because every intervention has unintended consequences, such actions also cause unintended, unanticipated (and often unperceived) inefficiencies which emerge over time, in turn hindering any efforts to address efficiently the dynamics in which the system is involved. In the longer term, this causes the structure to become increasingly less efficient from the perspective of the use of human, environmental, financial, technical, and other forms of capital, and thus more costly to operate; this situation leads to maladaptation. One sees this clearly in the development of bureaucracies, legal and institutional systems, as well as in technologies. In reality, this process permeates all we do as humans (other examples include tax codes, the cables on poles that disfigure many cities, professional and academic divisions of labor, technologies).

But this is only part of the story. Simultaneously, as the structure evolves, it merges functions or otherwise simplifies its structure. The effect of that tendency is that the structure becomes more focused on fulfilling a precise, well-defined set of functions, and resistant to change. As all societal structures operate in a permanently changing environment, and they themselves “fossilize,” I would argue that the “pincer movement” between a narrower focus and a wider

⁴ The number of sequential observations would be considerably smaller, as one could extrapolate from them toward “trends,” but it would still have to be much larger than is in effect practicable with traditional scientific means.

range of unintended consequences is what ultimately drives social systems toward maladaptation and, in the end, toward a tipping point and a structural phase change—a readaptation.

Observing This Process in the Real World

What kind of phenomena can we observe that might tentatively corroborate this assertion? Is there a slow but certain transformation that can be observed where societies move from being externally focused, innovative, looking toward the future and taking risks, toward being inwardly focused, avoiding innovation and risk under the impact of the unanticipated consequences of its own actions? In other words, does existing knowledge weigh down on our actions, blocking ways to finding “out of the box” solutions to our challenges?

The kind of transformation that we are looking for is a very slow one; it is generally only observable over very long periods. In effect, it is a second-order transformation in the dynamics between a society and its environment, a transformation of the process of change itself. Is such a second-order transformation observable in examples given above, concerning the period 600 BC to AD 1950, even though the second-order transformation was interrupted (except that of the collapse of the Roman Empire)? We have roughly tested a number of proxies against the evolution of European society to clarify whether the perspective presented here is actually helpful (van der Leeuw 2012). The proxies chosen were based on two characteristics that seem to derive directly from *innovativeness* and information-processing efficiency: (a) societal cohesion and (b) the size of the flows of matter and energy that depend on the information-processing gradient from the center to the periphery of the system concerned.

This choice requires a few words of explanation. Allometric scaling (Bettencourt 2013) shows that innovation scales superlinearly with the size of cities, emphasizing that most novel value is created wherever the information-processing capacity is greatest. Such innovations are the most difficult to get, at least initially, in the (spatial and/or social) periphery. As long as the society innovates, there is a value gradient across a society: the periphery accords the highest value to what is created at the center, exchanging its plentiful resources for the products of that center. That gradient keeps the periphery interested in being part of the society, and thus impacts on societal cohesion. Over time, as innovations spread throughout the society, the gradient levels out unless the rate of innovation is maintained or increased. If the gradient levels off, the flow of matter and energy changes, because the center will have more difficulty getting the energy and matter it needs. Hence, this is an appropriate measure of the coherence of the system and its degree of innovativeness.

The proxies that I have tentatively derived to indicate the way I am thinking about this are:

- Trade volumes and the spatial extent of trade flows are the most direct conceivable measure of energy and matter flows, and thus of the information-processing potential between the center and the periphery.
- Demographic evolution of the system: As systems become more coherent, they are able to align more people, and this enables more people to depend on them. Births rates and migrations tend toward population growth, as do improvements in sanitary and health conditions.
- The density and density gradient of population aggregation across the system, and in particular the evolution of city sizes: the larger the number of people who interact frequently, the larger the set of values they respond to, and the more occasion there is for innovation.
- The complexity of the internal administrative organization of individual entities in the system (cities, territories, nations).
- The spatial extent of the territory pertaining to a system, relative to the territories of other such systems, as a measure of the area that the system can coherently organize.
- The density and extent of road, railroad, and other transportation systems as a proxy for the density of information flows. For later periods, this is to be replaced by the density and extent of telephone and other communication networks.
- The degree of internal cohesion of the society as measured by the extent and uniformity of monetization of its economy, its education system, its language and customs.
- The degree and gradient of wealth accumulation in the system as measured, for example, by the overall infrastructure level of the society, and the relative level of it in each town.
- The innovativeness of particular towns, regions, and periods (e.g., the Italian Renaissance).
- The relative proportions of the financial, trade, and industry sectors. There seems to be a regularity in the evolution of such systems, from an emphasis on trade to an emphasis on industry and then to an emphasis on finance (e.g., Amsterdam 1500–1800; London 1600–2000).

Most of these proxies cannot be measured in comparable ways for each and every historical period and region. They constitute measures derived from different kinds of dynamics (although they all seem to fit within the overall dynamic outlined). They operate at different temporal rates of change. However, these proxies are for the moment all we have. The next step is to see whether they can deliver a coherent, overall picture.

Epirus 1850–1995

To fill in some of the details that are unavailable for past transitions, the recent history of Epirus, Greece, will be used as a case study to examine the effects of adaptation and maladaptation.⁵

Adaptedness and Stability

The starting point actually lies in a relatively distant past, during the centuries-long occupation of Epirus by the Ottoman Empire. During that period, the inhabitants of any Epirote village formed an isolated and closed, small group in a very isolated rural area where people lived off the land and the herds it sustained. The technical, social, and economic differences between the inhabitants were relatively small, and the information pool was very homogeneous (everyone knew everything about everyone else); most decisions were made on a consensual basis. This socioenvironmental system had been functioning for centuries; the people knew the area intimately, and their way of dealing with the environment was closely matched with local circumstance. In effect, over the centuries, a long-term well-adapted strategy had evolved in which society and environment interacted more or less in harmony. That strategy was anchored around subsistence activities:

1. *Mixed animal husbandry and small-scale farming*, in which mixed short-range pastoral transhumance (i.e., the seasonal movement of people with their livestock between fixed summer and winter pastures) between valleys and adjacent hilltops was combined with household cultivation for subsistence use, carried out by the women and a few poor shepherds. The few sheep and goats provided a little cash through the sale of wool and goat hair, skins, milk, and cheese.
2. *Long-distance, long-term (3–5 years) travel to urban centers*, particularly to Constantinople (Istanbul) and Rumania, but also to Egypt. The men often practiced traveling trades and craftsmanship (e.g., stone masonry, leather work, smithing, barrel making). These activities could produce (relatively) high incomes, which were brought back home during short return periods (of a few months) between long absences.
3. *Transhumant and semi-transhumant pastoralism* was traditionally (and still is to a small degree today) the mode of life of peoples who were culturally and socially distinct from the villagers, the Vlachs and

⁵ This discussion is based on an in-depth study that was carried out under the direction of S. F. Green (University of Manchester, U.K.), V. Papapetrou and V. Nitsiakos (University of Ioannina, Greece), with the help of G. P. C. King (Institut du Physique du Globe, Paris, France). For a more encompassing, semiquantitative description of these events, see Green (1995), Green and van der Leeuw (1998), and van der Leeuw and Green (2004). The perspective that I present is complementary to one offered in van der Leeuw (2000). The interpretation offered here, and any errors it might contain, are mine and mine alone.

Sarakatsani. Most often, transhumant groups returned to the same summer grazing areas but varied their winter destinations according to grazing agreements made with lowland villages. Full transhumance, relatively rare, meant that the group had no village anywhere, whereas semi-transhumance meant they had a summer village and lived in temporary huts during the winter.

4. *Commercial cultivation* was prevalent in fertile plains, but large portions of the plain were also left fallow for use by wintering transhumant pastoralists, for grazing or for household crops.

Of course, these activities had their consequences for the spatial organization of the area. Predominantly ethnically Greek villages, during the Turkish period, were most often located in rather remote hilly or mountainous areas because (a) of threats from bandits, irregular militias and the security forces; (b) villages were dependent on animal husbandry, villages were often located half way between lower winter grazing land and higher summer grazing land; and (c) the plains were most often controlled by Turkish landlords who prevented that land from being used for settlements in order to rent it seasonally to transhumant pastoralists—a guaranteed income requiring little work.

On the other hand, those villages which were predominantly “Turkish” were often located much nearer the plains. Some concentrated more on cultivation than animal husbandry. Others, located in more mountainous areas, specialized in trade or certain crafts (e.g., barrel making) rather than pastoralism.

Greek village structure had two main forms: (a) a closely packed village with a central public square, surrounded by fields and/or grazing land; (b) a widely dispersed set of houses, with grazing and fields interspersed between the houses, and a central public area that also often acted as grazing land. The first pattern was associated with permanent or semipermanent mixed farming subsistence communities, and the second with predominantly pastoral communities. Relations between neighboring villages were based on kinship links and spatial proximity. Groups of villages, often numbering between twenty and thirty, formed what were regarded as single communities (“us” rather than “them”).

Before the end of Turkish rule, few Greeks held titles to land. In the low and medium altitudes, land was owned and/or managed by a local *agha*; in contrast, at higher altitudes and in more remote areas, which were virtually all summer transhumance grazing areas, land was independently managed by making agreements with the Ottoman rulers on noninterference in return for self-regulation. In this case, some people developed a personal attachment to parcels of land, in the absence of external landlords. In general, however, as very little cultivation was carried out for anything except household use, and because the major source of food and income was animal husbandry, there was in most cases only a low level of individual attachment to particular areas of productive land.

During Turkish rule, the transhumant groups living off the higher slopes made arrangements with the Turkish government to be essentially self-governing, collecting their own taxes and maintaining their own security. This was probably somewhat of a relief to the Turkish tax collecting and security forces, because these regions were almost impossible to control anyway. The various Muslim ethnic groups, generally on good terms with the administration, tended to dominate the best plains land and southerly grazing areas. The Greek villagers, sandwiched in the areas between these two, experienced the most control and restriction of their lives, with resident landlords, heavy taxation, and frequent incursions from both mountain-based bandits and irregular militias. For this reason, many men from these villages traveled abroad for long periods to work: it was better to produce little at home (which was heavily taxed) and instead bring back income from abroad.

Disruption

The end of Turkish rule in 1913 initiated the fundamental social, political, and economic changes to be discussed. The 1923 exchange of populations between Turkey and Greece, to achieve “ethnic adjustment,” involved the massive transfer of Muslim populations from Greece to Turkey, and the equally large transfer of Greeks from Turkey in the other direction. In Epirus, this particularly affected the large ethnic Albanian Muslim population, though many managed to stay due to confusion over their status. However, Greek expulsions from Turkey, particularly from Constantinople, caused considerable hardship for families dependent on the income from long-distance travelers.

The Second World War (1941–1945) involved both Italian and German invasions into Epirus, and fierce battles in the hinterlands. Two separate sets of resistance fighters were formed: one communist and one allied with the (then right-wing) Greek government forces. They generally worked together as long as the war against a common enemy lasted. As the common enemy was defeated, ideological disagreements led to a civil war soon thereafter. This civil war was in many ways more destructive to the society than the Second World War itself. It triggered widespread emigration among a population that had always been very mobile, often spending many years away from home only to come back to retire among relatives and friends. Around the same time, the imposition of a boundary between Greece and Albania by the superpowers led to the construction of paved roads in the area. *As a result of these two processes, the existing, older, well-adapted way of life became maladapted to the circumstances under which it was now functioning.* That led, inevitably, to a process of readaptation involving a series of complex transformations in the society, its relationship to the landscape, the spatial structuring of the latter, and the means of existence of the population.

Further external dynamics kept the way of life for the Epirus population under pressure. The first of these was a phase of major emigration from

impoverished Epirus to those regions and countries that were rebuilding or industrializing after the war: Athens and southern Greece, Germany, the United States, Canada, and Australia. Successive governments in the late 1950s and 1960s tried to stem that flow by modernizing the rural areas and offering subventions to stay on the land. Numerous projects were implemented in Epirus, such as the draining of areas that had always had problems with flooding and the beginning of land redistribution projects. The Papadopoulos regime (1967–1974) had the most dramatic effect on the infrastructure in Epirus. During this period, electricity, asphalt, and mechanized irrigation systems were introduced to the rural villages, large numbers of locals' debts to the agricultural bank cancelled, and grants given to improve farming facilities.

Together, these major events had a number of effects. First, they confronted the population with social and political instability—the feeling that nothing stays the same for very long in Epirus before some major upheaval causes chaos. As a result, local communities have tended more recently to adopt a readiness for change, in the expectation that this would be necessary. Second, these events highlighted, for the population, the interweaving of local, national, and international factors in the structuration of their environment and the way it is perceived.

Transformation

The paving of roads triggered increasing contact between many of the isolated villages. As people started moving along the roads, information from the outside began to influence village life: stories and observations on how things could also be done. Because not everyone shared the urge to visit, the information pool began to differentiate. At the same time, the roads brought increased contact between the countryside and the provincial capital, Ioannina. This linked villages to a whole range of different administrative hierarchies and facilitated the meddling of regional and supra-regional institutions into village affairs. The appointment of village headmen, for example, gave the authorities in Ioannina some influence over village activities, and simultaneously gave the headman a status of his own and a communication channel to the outside. Ultimately, this process transformed the spatial macrostructure from one based on tribal territories to one based on roads and promoted, along the way, the “seeding” of nodes linked to the urban system, further and further into the countryside.

Simultaneously, emigration contributed to the reduction and aging of the rural population, and led to fundamental changes in lifestyle and in perspective on society and its future (for details, see van der Leeuw and Green 2004). Notably, it accelerated the social and economic differentiation of the population, so that not everybody knew everything about everybody else any longer, engendering occasional conflicts of interest between people and/or groups.

Changes in perspective on the landscape also occurred. Seasonally transhumant people who used to consider their hilltop village as their “real” home and the valley as a temporary (winter) abode, now generally considered themselves as living in the valley, with their hilltop houses temporary (summer) places of residence. As a result, residence in the valley became longer, and grazing more localized. When the administration prohibited the regular burning of the hillsides to provide grass for the animals, this would not have had any particular spatial effects if the herds had continued to graze the same grounds every year, because they would have kept all non-grass vegetation short. Under the changed circumstances, however, thorny bushes in the uplands saw their chance, and an important part of the uplands became inaccessible almost overnight, even to goats. This forced herdsmen to bring their animals ever closer together in other areas, which were thus overgrazed—leading to erosion on the very vulnerable (tectonically highly active) slopes. Thus, outside authority and local changes in perception colluded to allow *garrigue* growth and increased gully erosion (because traditional brushwood barriers were no longer maintained). Ultimately, the abandoned uplands were colonized by various species of trees. One of the interesting consequences nowadays is that the upland villages in Epirus frequently have a shortage of drinking water, as the increase in vegetation cover reduced the amount of water that ends up in the karstic aquifers.

The increased dependency of the population on valley cultivation wrought changes in the economy. Cash became increasingly important as “urban” ways, norms, and ideals penetrated the countryside, thus stimulating people to acquire other material goods. The (transhumance) herding economy of the hills and mountains transformed into an (sedentary) agricultural economy based on fodder production and consumption in the valleys. This, in turn, created increased dependency on the commercial aspects of the regional (national, supranational) economic system, and the vulnerability that such dependency entails.

Local traditions were rapidly transformed. Young people abandoned the rural lifestyle. The increasing symbiosis between the region and the outside world multiplied risks for farmers. It became easier to protect oneself against natural calamities, but more difficult to escape the consequences of imported economic crises, or of the European Union’s system of agricultural subsidies.

Emigration had important consequences for the local economy and lifestyle, as the lack of competent laborers led the Epirotes to reduce their dependence on goats and sheep, and increase the number of pigs, which did not require close supervision. To increase their income, certain villages tried to promote tourism by building the necessary infrastructure with European Union money. With or without European subsidies, the region got locked into pursuing this developmental trajectory. A tertiary sector developed in Ioannina and along the paved roads. The region became increasingly dependent on money coming from outside, notably the contributions of the émigrés who amassed a

degree of wealth elsewhere. This, in turn, changed the equilibrium between the different powers in the villages, and in the region as a whole. Altogether, the Epirotes lost most of their autonomy.

Readaptation

In the post-WWII period, the four historical economic options changed considerably. The first—subsistence production—has been virtually abandoned, with the resulting overgrowth of hill fields and depopulation of the small mountain villages. The second—transhumant pastoralism—has also diminished considerably, replaced by more sedentary pastoralism and animal husbandry (with a steep increase in pig farming and beef cattle breeding), alongside the development of commercial animal fodder production. The third—seasonal migrant work—has been largely replaced by the permanent emigration of whole families to cities in Greece and abroad. The economic history of the area is still reflected in current economic patterns, but its organization has changed considerably.

The mountains have essentially been abandoned, due to a steep reduction in transhumant pastoralism and the virtual abandonment of subsistence farming. Periodic labor migration has been replaced by permanent emigration. Mountainous areas have been overgrown with oak scrub, brambles, and young trees, while commercial agriculture on the major plains has developed considerably since the 1960s, with mechanized irrigation systems, chemical fertilizers, agricultural machinery, paved agricultural roads, and compulsory allotment of holdings into contiguous parcels. There has been a considerable increase in sedentary animal husbandry with purpose-built stables in mechanized animal farms, allowing pastoralists to live in the plains all year long, raising beef cattle, chickens, and pigs alongside traditional sheep-goat herds.

A physical environment, in which almost every type of landscape, climate, and altitude was used for economic purposes, is now used almost solely in and around the major plains for large-scale farming. One of the potential dangers is that by underusing large parts of the landscape, other parts will be overused. The land-use pattern, therefore, lost resilience as well as diversity. This trend is not easily reversed as the required know-how is getting lost.

A concomitant change from kinship-based to function-based networks has also affected the resilience of the system. Individual relations in function-based networks are more short term and brittle; they encourage a selective flow of particular kinds of information, rather than communicating a wide range of information. Hence, they reduce the flexibility of the system by compartmentalizing know-how and decrease the span of collective memory.

These changes have fundamentally altered settlement patterns and local perceptions of the environment. Many villages were relocated from rather inaccessible higher areas to the valleys for three reasons: (a) the security risk was gone, (b) the increase in commercial cultivation on the plains made proximity

to the plain more attractive, and (c) most of the large *agha* estates were distributed among the local population.

With road construction and improved agricultural practices, settlements along main roads and on the plains grew. They are more accessible and have better facilities than “old” villages, and while they lack cultural heritage, they are often economically dominant in the area. They also have a higher proportion of “strangers” and more mixed cultural backgrounds than older villages. Although the old web of interrelated and bounded community groups is still maintained, it is increasingly based on memory rather than structural necessity. An increasingly formalized network of relations through agricultural cooperatives, local government administrative organization, and cultural organizations is replacing it. These are increasingly structured with reference to urban centers. The creation of a road network has thus removed a major constraint that kept a dense and elaborate network of social relations in place that covered the whole landscape. It has triggered a cascade of self-amplifying processes that led to bifurcations in spatial and temporal organization. The resulting transformation from a locally based, matter- and energy-constrained system to an urban-based system, and hence mainly information-constrained occupation of the landscape, created a “pioneer front” in its own right, with major consequences for the spatial structure of the landscape. Cultivated fields were equally shared among resident families, while most grazing land became commonly owned by the village, administered by an elected headman and council, which became the bottom tier of the new state’s administration. Large or mature forests became public land.

An important aspect is that the “fixing” of landholdings actually replaced a uniformly shared, very fuzzy and mobile perception of the landscape with a less fuzzy, multiform one, in which there are as many perceived “landscapes” as there are uses of the landscape, and which is sedentary. This fundamentally transformed people’s worldview, with implications for their sense of identity. Past cultural entities were still remembered, but they no longer had practical relevance; rather, they became relevant to the disagreements between nations. The political center of Epirus continues to be Ioannina, but the city is no longer in competition with powerful rural groups. Different regions are defined by their urban center and its characteristics, which in turn are linked to other urban centers in Greece and to international political and economic relations.

Summary

A relatively stable and well-adapted mode of life was disturbed when the area was drawn into wider, supra-regional conflicts after the demise of the Ottoman Empire. The region lost the relative independence that enabled its mode of life to continue for a substantial amount of time because of its spatial isolation. One may debate whether its subsequent maladaptation to the changed external circumstances is due to external or internal dynamics; I would argue that this

distinction is not really very helpful when we address the transition from a closed to an open system, as in this case. However that may be, the growing discrepancy between the local way of life and the (supra-)regional dynamics that Epirus faced in and after the Second World War led to a state of maladaptation in the region. Growing awareness of that maladaptation fed tensions that forced a profound transformation of Epirotes' way of life, economy, village and regional organization, communication and perception of themselves and their land. These tensions were clearly manifest during the Second World War and the ensuing civil war, when the population was divided over the way in which the area should go after the common enemy was defeated. Many of those who had adhered to the losing faction, and many others who were "dislodged" by the events, then emigrated. At the same time, the closure of the Albanian border and the concomitant need to build roads for the military set in motion entirely novel information flows that introduced new ways of thinking from the outside world through connectivity with the urban way of life. Ultimately, this transformed the economy and the landscape as well as the perception the Epirotes had of it. Indeed, a transition such as this one between a long-established, well-adapted mode of life and a novel, profoundly different new context is not limited to the material and energetic aspects of the subsistence system involved, but fundamentally touches on the perceptions and values of the population.

The Role and Importance of a Society's "Value Space"

I would like to introduce here the novel concept of *value space*. Any society is driven by the creation of value. For it to function effectively, a society must accord value to the ideas, institutions, things, and services that it produces. Indeed, societal membership is for those who value the society; these values keep it together as a functioning entity. Values are not only economic; they encompass all that the society shares in thinking about, and doing, things. In effect, these values allow a society to manage itself and to address the dynamics of its environment. They are at the core of the knowledge, understanding, and insights that society has collectively acquired over time. Thus, they constitute an important aspect of its information-processing capacity. In both the long-term example of Europe and in the short-term example of Epirus, the values of these societies profoundly changed due to readaptation, as a result of interplay between external circumstances and adaptive innovation in the society. In each case, such a change was a necessary part of "giving the society a new lease on life."

My emphasis here is on the *total set of values of the society* at any time. Within that value space, individual values may, and will, change. The classic example is the value of the car in the United States, which for several decades was principally an object to signify a certain degree of wealth and fashion, but

has now become a much more utilitarian value. Throughout this change, the object concerned (the car) has retained sufficient value to be bought and appreciated, and the overall value space of the society has not really changed, even though the place of the car within it has.

I contend that in their evolution, due to the second-order dynamics of the societal system driven by the accumulation of unintended consequences, the value space of most societies is transformed to the point that the rate of innovation in the society slows down, and that this affects their expansion (for a different perspective, see Tainter 1988). What kind of observable phenomena might tentatively corroborate this assertion? There seems to be a slow but certain transformation in many societies from being externally focused, looking toward the future and taking risks, toward an inward focus, avoiding innovation and risk. This, I argue, occurs under the impact of the unanticipated consequences of the society's own actions. In other words, existing knowledge weighs increasingly heavily upon a society's actions, blocking ways to find "out of the box" solutions to its challenges.

How might a value space expand? Normally, innovation drives expansion, but this is a complex process. It involves intuition, the observation and querying of challenges, the attempt to define ways to address these questions by "bending collective knowledge," and the correct formulation of questions so that they can be answered through available knowledge.

Yet not all innovation is actually involved in the expansion of an existing value space. As argued by Strumsky et al. (2015), three types of innovation occur *within* the value space: (a) true original novelty, (b) the novel combination of existing knowledge, and (c) the embellishment of existing knowledge. Each type creates, in effect, a "grafting point" where novelty is added to the content of the value space. *But only the first—true original novelty—expands the society's value space.* Examples of true original novelty include electricity or telecommunications, a new religion or philosophy, a novel form of governance (e.g., democracy). As evidenced by everyday life as well as through an analysis of patents in the U.S. Patent and Trademark Organization, true original novelty is extremely rare, essentially because it breaks through the society's cognitive path dependency and the boundaries of its value space.

Due to the "pincer movement" (i.e., the combined effect of a narrowing of societal focus and an increasing number of unintended consequences that must be addressed), a society approaches a "tipping point," and this necessitates the creation of novel values to avoid being stifled by its existing values. At this point, if society has reached the limits of its value space, no novel values can be created to address the unintended consequences of its earlier actions. This conundrum forces the society into a phase of maladaptation and readaptation.

The edges of society's value space are not defined by the values which are contained within it. They are defined by things society has never thought about, by what is unknown to society, what has never been observed, questioned, or

addressed. In effect, *the value space of a society is limited by the cognitive void around it*. Hence, if a society's capacity to invent out-of-the-box innovations slows down enough, such that the value space cannot expand sufficiently at a fast enough rate to keep expanding, society tips into a phase of maladaptation.

Is Our Current “Value Space” a Constraint?

I contend that the Western value space has been transformed, over the past sixty years, to the point that its expansion is slowing down and that this may be affecting the rate of innovation in Western society. In industry, this has led to a reduction in the rate of return on investment in innovation in many different sectors. In finance, it could explain why available funds are increasingly being diverted from the productive to the speculative sector. In macroeconomic terms, it might explain the leveling off of growth of our economies, as argued by Summers (2013).

In asserting this, and in line with our model of human problem solving and learning, the observed growth of interactive populations worldwide (caused by rapid increases in demography, health care, and communication) causes *and* requires a rapid increase in the rate of innovation if our societies are to remain intact. Thus I am not arguing for an absolute decrease in the rate of innovation, but for a decrease relative to the need to keep our quickly expanding society more or less stable.

What kind of phenomena do we observe that might tentatively corroborate this assertion? Is a slow but certain transformation underway in our societies: from externally focused, looking toward the future and taking risks, toward inwardly focused, avoiding innovation and risk under the impact of the unanticipated consequences of its own actions? Is our existing knowledge impacting our actions, blocking the way to finding “out-of-the-box” solutions to our challenges?

Clearly, as a result of the difference in dimensionality between the known and the unknown, our society is becoming increasingly disconnected from the dynamics of the environment with which it is supposed to connect us; hence the looming environmental crisis. Another manifestation of the closure of our value space is the shift in business from long-term strategic thinking to short-term tactical thinking—a consequence of the preference for speculative capital over productive financial investment (see Mazzucato, this volume). This is one result of the accumulation of unintended consequences, which has more widely shifted the focus of our collective efforts to the immediate, thus entrapping us in a kind of historical myopia that biases our understanding of the processes that have driven our societies to this point. Thus we are looking for solutions within our current given structure, rather than stepping out of that structure

and thinking outside the box. This hampers any attempt to find an exit from the current crisis.

This phenomenon is strikingly evident in the international negotiations about global environmental change, which are still predominantly framed in terms of burden sharing: “Who pays for the global cleanup?” Their aim is to maintain societal ways of life by mitigating negative effects, rather than in terms of opportunity creation and the explicit promotion of change. Burden sharing does not really inspire anyone and, in regard to funding greenhouse gas mitigation, has caused deadlock between developed and developing nations. Reformulating the debate in terms of opportunity sharing and creating the conditions to develop (material, procedural, institutional, and social) innovations that will work and therefore become desirable to others would seem to be the correct starting point for more successful negotiations.

Yet another way to observe this slow shift in the dynamics of our society is to look at the increasing weight of particular interest-based lobbies (e.g., large multinational corporations in our current society) and the extent to which these now dominate political and social life. Essentially, they serve to protect the continuity of certain kinds of economic and political dynamics, by adapting the legal and political niches in which these interest groups function, and thus to maintain the status quo.

Another important manifestation is the fact that in economics—with policy the most important lever through which one may currently attempt to change our societal dynamics—there is a similar emphasis on continuity rather than change. Much of the macroeconomics community lacks a conceptual and mathematical tool to conceive of discontinuous change. As became disconcertingly clear at the beginning of the current financial crisis, the dynamic equilibrium models which link supply and demand are formulated in terms of differential equations; thus focus is on marginal changes of aggregate measures. This cannot help us anticipate “tipping points” or think about structural changes in our current socioeconomic system. One potential way to remedy this is to develop a mathematics of discontinuous change, in which supply and demand are not balanced, and the market does not always work best. This would open the way for a less “productivity”- and “efficiency”-based perspective on economics, one which could include value dimensions other than cost and price. This is one of the main arguments put forth in this current volume.

This transformation is also evident in the process of innovation itself. As I have argued, although originating innovations keep occurring, their occurrence does not speed up over time (as it should if the expansion of our value space kept pace with the expansion of our economy). From the perspective of innovators, this has been related to the fact that the very dense network of inventions in many domains of our economy actually makes it much costlier and laborious to be innovative in those domains, and that there are not enough original inventions to open up new “innovation spaces.”

Is There a Way Out?

If the reader has come this far without throwing in the towel, perhaps he or she might be interested in suggestions on how to go about dealing with the current conundrum. As a first step, we need to acknowledge that there are cognitive dynamics which have brought us to this point; these are fundamental to human behavior and therefore unchangeable (for further details, see van der Leeuw 2007, 2012). Instead of trying to change those, we must *focus them in different directions*. Instead of changing mindsets and worldviews, we need to focus on changing behavior. The change in mindset will, I expect, follow.

How do we change behavior? Well, first of all it seems that as we find ourselves in a huge hole, we have to stop digging. In a literal sense, this effectively means finding ways to slow down, and ultimately reverse, globalization in time for us to retain at least part of the cultural diversity that has built up over many millennia, which thus far has limited the growth of the waste-to-extraction economy. That does not imply abolishing the market system, but it does imply a redefinition of the balance between governments and markets, to reenforce governments to put into place checks and balances to contain the markets and large multinational corporations.

Currently, that battle involves, in part—and with limited success—governments and the financial system (e.g., elimination of tax havens, changes in tax codes, better information about financial fluxes, investigation into microsecond trading). More importantly, there is engagement between governments and citizens, on one hand, and large energy companies that control much of the world's economies, on the other. This conflict pitches hydrocarbon industries against those who promote the use of renewables. It is occurring at a time when the energy companies have been weakened due to their decreasing return on investment and the limitations this places on the future volume of hydrocarbons they can deliver (Leggett 2014). Moreover, the financial and energy battles are linked because of the “stranded assets” that are curtailing projects in the Arctic as well as some of the “pre-salt” projects in front of the Brazilian coast.⁶ Of course the largest part of the necessary regulatory structure in these domains still needs to be established, and if we are to achieve this, it will demand the utmost from all of those who see the need to do so.

Here a distinction needs to be made between the structures of the three major economic blocs (the United States, Europe, and China) and those of the emerging economies (e.g., Mexico, Brazil, India, Indonesia, South Africa, Nigeria, Turkey). Among the three major blocs, China may possibly have the best opportunity to create the necessary regulations, as its government has relinquished less control over business and industry than the West. Both Europe and the United States have, at the moment, deep governance challenges, but

⁶ The investigation of sales pitches and techniques in the pharmaceutical industry is another sign on the wall.

it seems that the Euro area may have more control over its industries than the United States, because of the way the European Union was effectively built around the regulation of industry. A challenge of a completely different order of magnitude is no doubt shaping the structure of the emerging economies, which currently have relatively weak executive and judiciary branches, high levels of corruption and cultures that are in a sense halfway between their autochthonous past and the modern *extraction-to-waste economy*.

How could ordinary citizens direct their efforts? Citizens need to reengage their own responsibility in the political process, at all levels. In the West, responsibility for the well-being of society (and its citizens) has effectively been delegated to a small minority; thus citizens have lost (or relinquished) control over what is happening. Fortunately, political engagement is visibly growing, particularly on a local and regional level through citizens' organizations and NGOs. It will take time for this to reach higher levels of government, except where populations have reached a tipping point. There, however, an absence of sufficiently thoughtful leadership or a "revolution of rising expectations" can hamper efforts to move forward.

Regaining the initiative by taking up our responsibilities as citizens is not enough. We have to plan our future differently, and to do so we must ask the question: What kind of future do we actually want? Then we could set out to design a roadmap that might actually get us there. This needs to be done locally, regionally, and nationally, as well as internationally. Calling for "innovation" is not enough, if we do not first consider where such innovation should lead us. After all, the last 250 years of unbridled innovation have led to our supply-driven consumerist innovation culture and our sustainability challenges. If we want to do better, we must learn to focus innovation.

We know quite a bit about the conditions under which inventions and innovations flourish, and the ways they affect the economy, but we have much less scientific, procedural knowledge to help us focus or steer invention and innovation effectively. Both have to do with the *emergence* of novelty, and emergence is insufficiently studied in our predominantly reductionist, *ex post* scientific approach, which focuses on explaining currently observed phenomena by linking them with their past by means of cause-and-effect narratives. If we are to plan our future, we must adopt an *ex ante* perspective, linking learning *from* the past to learning *about* the present to learning *for* the future. We need to focus more directly on the emergence of novel phenomena rather than on explaining existing ones. One way to promote this is to develop the academic discipline of "futuring." Currently, the development of models, scenarios, and forecasts is (presumably for reasons of expense) principally in the hands of major corporations, governments, or supra-governmental institutions. Thus no independent community can critically look at the results of such exercises and help develop such efforts.

Another major barrier to the principal question of our future seems to be that we view the present as the result of a quasi-inevitable "evolution" toward

the present. That is an ancient tradition in our Western culture, but it is a distorting simplification of reality. As discussed, in our history there have been moments in which our societal trajectory was determined by either choice (in the sense of “systemic choice”) or the actions of an individual or small group of individuals. Major structural changes resulted from these events and gave, for example, European society a new lease of life. That said, things could have gone a different way: European societies could have disintegrated. *Choice is important*, whether systemic, local or individual. When facing a tipping point, we must not succumb to an incremental (or even a passive) perspective, but rather actively stimulate collective, conscious choice.

What about our role as scientists? Over the past century or so, in some of our Western societies, science has to some extent lost the most precious gift of all—its trust—to its unchecked instrumentation by industry and government. Science has been a willing partner in this process, as it is dependent on both for funding. In certain regions and certain domains, therefore, scientists are either seen as too distant from the concerns of civil society or too much under the influence of government and industry. The loss of trust in science shows in some countries (e.g., the United States and, to a lesser degree, the United Kingdom and European countries) as a reduction in funding for science and/or acceptance of scientific ideas. Hence the relationship between science and society must be transformed into a more open and transparent one: We must be more realistic in the expectations we create and more aware of the potential unintended consequences of our actions. We must listen more, think more broadly in terms of alternatives rather than narrow causal explanations, and rebuild that trust if we are to have an impact on the political debate.

Green Growth

Why choose the label *green growth* for our vision of the future? Climate change has *ab initio* been presented as a threat to be dealt with, potentially limiting growth or even leading to regression. Green growth, however, emphasizes that we need to see this as an opportunity for positive transformation, rather than burden sharing, regression, or danger. Like *sustainability* and *resilience*, green growth has been adopted by different communities, from different perspectives, and is ill defined. For purposes of this discussion, it is much more encompassing than the *green economy*. Green growth implies a fundamental restructuring of society that would affect all our institutions and customs, just like earlier structural changes (e.g., sedentism, urbanization, and the Industrial Revolution). The ongoing information and communications technology (ICT) revolution offers a unique occasion to achieve such a transformation. The ability to process information quasi-independently from any substrate, and to harness processing power that can integrate a near-infinite number of dimensions and transcend the limits of purely human information

processing, is fundamentally transforming humanity's social, economic, and environmental organization. We should use this occasion to transform our society into one based on green growth.

The ICT revolution is leveling the wealth differentials of the "resource-to-waste" economy, by creating horizontal information-processing networks alongside the vertical ones which dominated our society for so long. Rather than accumulation, spreading of information is becoming an important tool to create wealth. The reason for the relatively high valuations of the social networks is that they have discovered a novel way to profit from existing information differentials—by decreasing rather than increasing them. This favors an *inversion from the current, predominantly extraction-to-waste economy* (in terms of natural and human capital) *into an economy of opportunity creation and spreading wealth*. This could substantively enlarge the global "value space."

However important the ICT revolution may be, we need to grasp this opportunity and not let it slip by uncontrolled. Collectively we need to take hold of the way in which the ICT revolution transforms our society, rather than leave this to corporations that steer society in ways profitable to them. The global value space will not expand if the technology is used to spread the current productivity and consumption-focused Western value system already in place. Indeed, we must do the inverse: we must develop many non-Western values from other societies and actively stimulate them to create novelty based upon *their* value systems. Without stimulating cultural diversity to grow our value system, we will not be able to find ways to live peacefully with nine billion people on Earth.

In practice, this implies democratically strengthening the constraints imposed on the ICT industry, as well as individually and collectively focusing it on our green growth goals. This requires gaining insight into foreseeable effects of ICT development, which is now coming into its revolutionary stage as costs bottom out and computing power achieves such complex tasks as self-driving cars, speech recognition, drones, robotic manufacture of complex objects, and automation in the service industries (Avent 2014). ICT is expected to further increase transaction efficiencies, trigger more structural changes in the division of labor, further increase specialization of individuals, groups and institutions, change the configuration of firms and markets, as well as their roles and shapes. As fewer resources are spent on maintaining current institutions, there will be more for innovation. Though there are no limits in sight to what ICT may change, its effects will differ profoundly between developed and developing nations.

In the developed world, ICT favors capital over labor, shifting jobs from (automating, capital intensive) industry to (intellectually complex and labor-intensive) services. But it has not (yet) achieved substantive increases in productivity or wealth for societies as a whole. It accentuates wealth inequalities in favor of those involved in complicated tasks so that, if left unchecked, wealth and power will become more concentrated among a very small minority. On

the other hand, employment and wages are expected to increase for nonautomated menial tasks, not mid-level routine jobs.

ICT will enable developing economies to leapfrog industrial development. The reorganization of industry into dedicated global supply chains overcomes the need for integrated local industrial production. Any stage of a supply chain may be located anywhere in the world. In many places, this will reduce the opportunity to employ large numbers of people at the base of the wage ladder. Developing countries must find other solutions to increase wealth. ICT can enable this by delocalizing production (e.g., 3D printing) and dematerializing products (e.g., services in education, health care), so that they can be produced (almost) without marginal cost.

In both the developed and developing world, the hope is that global connectivity will facilitate the growth of local craft-based entrepreneurs and increase the value of objects (including immaterial ones such as games) and services, which until now could only be sold in local markets. Examples abound in health services and online education. Mobile apps and networks are also democratizing capital ownership by moving us toward a sharing economy, crowd-funding, and peer-to-peer lending. Finally, the ICT revolution is changing intellectual property rights.

Further into the future, the ICT revolution will impact our society in ways that one can only glimpse now (Banco Bilbao Vizcaya Argentaria 2013). For instance, ICT offers the opportunity to mitigate some of humanity's cognitive limitations:

1. It will improve the integration between human and electronic information processing, drastically improving the information-processing capacity of our societies. This process is ongoing, exploiting the creation of global horizontal information processing networks.
2. The "Big Data" revolution will enable us to address the bias of human decision making toward successful past responses, inherent in the fact that our ideas are underdetermined by our observations (Atlan 1992), even though techniques to do so are currently still insufficient.
3. It could help us think about the future by harnessing it to generate high-dimensional problem and opportunity spaces from a limited number of observed dimensions, and then test those for feasibility. Initial steps in this direction have been taken by Nuel Belnap (e.g., Belnap and Anderson 1975; Belnap et al. 2001) and Walter Fontana (pers. comm., June 2012).

In the practical domain, only by increasing information-processing capacity, education, and wealth among the underprivileged can our societies continue to enjoy the high standard of living they currently have. At present, two main kinds of uses of the information-processing links can be distinguished between the developed and the developing worlds. The first aims for direct information transfer from the developed to the developing world, getting the latter to adopt

ideas from the former. This does not directly contribute to the expansion of our global value space, even though the confrontation between the ideas spread and local knowledge may generate innovation and new values. The second stimulates the development of local non-Western knowledge and the expansion of local wealth creation, and their transfer to the developed world.

Examples of the first include the facilitation of distant access to information from many different sources initiated by search engines (e.g., Yahoo, Google); this then led to the development of specialized online encyclopedias (e.g., Wikipedia) which not only assemble but also synthesize information. Direct information transfer is now entering a different stage with the emergence of the Massive Open Online Courses (MOOCs): anyone is able to study free of charge anywhere in the world. Although currently experimental, MOOCs are likely to spread if ways can be found to return, to the educating institution, a small percentage of the proceeds ultimately generated by the people thus educated. MOOCs are part of the “online revolution,” which over the next thirty years has the potential to fundamentally transform the worldwide education landscape at all levels. In addition, many e-based tools exist which have important educational functions, although they do not deliberately aim to educate. These range from blogs to social networks to (“serious”) games that promote certain learning skills. Here, further innovations can be expected to transform learning.

Examples of the second kind are numerous. They have been spreading for fifty years led by NGOs who saw that providing local populations in poor countries with Western knowledge or infrastructure was not effective in helping local populations develop their existing talents and gain independence. Stimulating local recycling economies in the developing world is a good example. These are a fundamental part of the local economy, providing jobs, spreading or accumulating knowledge, and reducing waste. Giving them access to world markets has been one way to promote them, as in the case of the South African production of decorative baskets from telephone wire. Another example of promoting local developments has been the spread of cellphone banking and microcredit to provide for the initial investments needed for local enterprises that are doing things not done in the West. Though not a panacea, this has been so successful that microcredit lending has spread more recently to poor areas in the developed world, such as parts of New York City.

Reframing Our Efforts

Current discussions on the future of our planet need to be fundamentally reframed: instead of identifying a threat that must be removed, we need to look for opportunities to be developed. In the process, the debate at the international political level must shift from burden sharing to opportunity sharing—from a “not in my back yard” reaction or attempt to become a free rider who profits

from the efforts (financial and other) of others, to a strong drive to move first and farthest, setting a competition in motion that will propel the whole of the global economic, social and environmental system in a new direction.

At the *individual level*, macroeconomics has, for a long time, invoked the assumption of “rational” choice. This has been studied extensively in the domain of individual preference, both based on literature in cognitive studies, psychology, and sociology (overview in Ng 2003) and on its own experiments in behavioral economics (e.g., Bowles and Gintis 2011).

Two assumptions made in this chapter are to be relevant here. On one hand, I have emphasized the difference in dimensionality between the human short-term working memory and the wider world in which humans operate. Preferences and choices depend on that short-term working memory and can thus only take a very limited number of dimensions into account, even though the contexts in which the decisions are made actually impact on people’s well-being in many more dimensions (and vice versa). Hence, choices and preferences are at best only partly commensurate with an individual’s longer-term well-being, as that depends on many dimensions not being taken into account. Well-being is not only based on people’s aspirations and an evaluation of their own position relative to that of others, but also on a comparison between their own past and present. Hence people’s perception of well-being is relative to their perception of others and to their own trajectory. Finally, comparisons are framed by the cultural and societal dynamics that constitute the complex adaptive system in which people function. Thus, there is a potential discrepancy between people’s short-term choices and longer-term well-being. Current macroeconomics does not capture these complexities.

Reducing the dimensionality of the value space in which decision making is assumed to happen inevitably distorts the perception of the consequences of that decision making. In the short term, this may escape our attention, but in the longer term it contributes to the unintended consequences of our actions. Through its assumption of economic rationality, macroeconomic science has substantively contributed to recent crises, and will continue to do so unless it profoundly changes course.

One of the tenets of the resilience community (Gunderson and Holling 2002) is that longer-term developments (like that of the last sixty years, in which a limited set of values progressively invaded our global world view to the exclusion of novelty based on different values, behaviors, and institutions) will ultimately lead to hypercoherence of a society’s dynamic structure and rapidly increase its vulnerability to shocks. Once such shocks cause cracks to appear, novel values and ideas, which otherwise could not express themselves, emerge. This may be causing our world to fragment from a bipolar into a multipolar one at all levels, as people everywhere begin to assume an increased responsibility for their own actions. As this spreads, it will involve an increasingly wider set of values and deviate from the kind of “rational decisions” that reduce long-term well-being to growing GDP. Current developments seem to

favor the growth of the global value space argued for in this article. Over the long term, such a move toward an *economy* of perceived improvements in well-being is not only desirable but inevitable. To facilitate the transition, an *economics* of well-being and diversity, such as proposed by Ng (2003), must be developed to satisfy the huge needs of global society. Our social and natural environment is ultimately poisoned by the narrowness of our ideas and of the resource spectrum that we exploit.

At the *level of societies*, the traditional macroeconomic calculus (e.g., Stern 2006) to calculate the effects of different pathways to mitigate climate change “excludes the possibility that mitigation might drive the economy into a more competitive structure [characterized by lower carbon emissions] with a utility level even higher than in a utility without climate change scenario” (Zhang 2014:96). This is because the current economic toolkit only calculates incremental change emerging from the current dynamic equilibrium, and does not enable us to calculate the effects of a deviation from the current trajectory that could shape a different organization. Such a new trajectory would not obey the old rules and would call into existence new feedback loops and new interactions with the environment that cannot be taken into account in the calculations. As a result, “...mitigation has become an action that is undertaken to avoid damage or implement burden sharing, rather than to explore new opportunities” (Zhang 2014:96). Moreover, because the predicted benefits of collective actions are primarily global but the cost is local, all countries (regions, groups, etc.) have a strong incentive to be free riders (Zhang and Shi 2013).

In view of these limitations, we need to investigate whether mitigation may lead to local, measurable, new growth opportunities. Infra-marginal economics enable comparison between structurally different organizations and quantification of the efficiency of institutional innovation. With market expansion and improvements in transaction efficiency through institutional innovation, the market structure in a new sector of the economy may jump to greater division of labor through functional reorganization, and therefore generate higher productivity. This is fundamental to the development of any new organizational structure, and will determine which of several organizational forms (such as technologies) will ultimately succeed.

In the context of global economics, this suggests that economies which take tough emission reduction measures and establish sound rule systems to achieve them will be forerunners in transforming to a more innovative economy (Jaeger et al. 2011; Zhang and Shi 2013). By looking at emergent diversity at the individual and group level, and developing the toolkit to compare different organizations from an efficiency perspective, we might get much closer to focusing our societies’ innovative capacities and thus enhance the chances that our investments in innovation will actually help us meet the sustainability challenges we are facing.