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Not an Ordinary Tipping Point

Introduction

It is clear that we are hitting a tipping point, but it is no ordinary tipping point. I will argue in this chapter that this moment of crisis is a mega-mega-tipping point. Actually, taking a long-term perspective, it is one of the three most consequential tipping points in human history. The other two were the mastery of matter (which took, as we saw in Chapter 8, a couple of million years to achieve) and the harnessing of fossil energy (which took about two centuries). This raises a question about how leaders can plan in a system where unintended consequences and extreme nonlinear events become increasingly frequent.

One of the themes of this book is to show how the organization and functioning of human societies has always been shaped by challenges in information processing. An interesting role was played in this process in around 300 BCE in Europe, possibly earlier in China, by tokens and (later) coinage and money, whereby the transmission of information through the mechanism of price indicated a combination of values. In Europe, this became especially relevant in the Renaissance, when a variety of fiduciary financial instruments was developed. Financial values became important indicators of the wellbeing of princes and nations as well as individuals, of the desirability of goods, and the risk involved in acquiring them. Another important early phenomenon that played a major role in this process in Europe and China was the introduction of printing, and the huge transformation that this engendered in spreading information much wider (see Bonifati 2008).

But until very recently human societies have never been confronted with the isolation of information as one of the three basic commodities of life (alongside matter and energy). Nor have societies found ways in which to divorce information from most of the material and energetic substrates and channels through which it was transmitted. This process began in the late nineteenth century (see Gleick 2011) and has accelerated in the last sixty years or so. It is only some twenty-five years old as a mass, global phenomenon.

This is not the kind of transition that we will be able to cope with by simply becoming more resilient as individuals or as societies, all the while remaining more or less organized as we have been. If you do not believe this, I refer you to the overview of the ongoing changes by Thomas Friedman (2016). In this book, he sketches the changes that are currently being wrought by acceleration in several domains. Of these, the environmental domain is best known. But other accelerations are playing into the same process, and together they are wreaking the kind of destabilization of our societies that may lead to chaos – in the strict and scientific sense of the word – a drift toward total unpredictability of the behavior of our societal (and therefore our socioenvironmental) systems. The main drivers that Friedman outlines are among those I mentioned in Chapter 16, notably demography, technology, finance, and environment. No doubt governance should be added to these (see Haass 2017). I will deal with each of these in turn. But this is not all. The fact is that the interactions between the accelerations in these domains are only beginning to be perceived; they are beyond our collective control, and so far we have no idea how to deal with the second order changes they may be triggering.

Of course it will not surprise any reader when I emphasize that these changes are intimately related and part of one and the same dynamic that seems to be getting out of hand: unintended consequences of earlier actions and decisions that are being reinforced by the acceleration of information processing, driven by increasing interactivity between more and more people who are in possession of more and more complex and effective tools for thought and action. Several centuries of reductionist thought have both linearized complex phenomena to make them more accessible, and compartmentalized knowledge within disciplinary systems. This in turn has reduced the frequency of intuitive insights into such complex, nonlinear systems. While thinking that they gained more knowledge, people have lost an understanding of the socioenvironmental systems they had modified in their attempt to bring parts of them under

control. But before I look in some detail at these changes, I would like to put them in perspective.

The Acceleration of Invention and Innovation

For most of human history, inventions by individuals were only transformed into innovations at the societal level if there was, whether consciously or unconsciously, a need for them (and such a need was not necessarily owing to a challenge; it could be an emotional need, such as in the case of jewelry and similar objects) and if there was enough free energy and matter (wealth, in the sense of human, social, and natural capital) available to implement them. The pace of societal change was limited by these two requirements for societal innovation, and so was the change in value differential between society "insiders" who were part of the innovating community and "outsiders" who were not.

We have seen that this changed from around 1800 with the introduction of ways in which to use fossil energy on a massive scale, and the Industrial Revolution that this enabled. As the energy constraint was relaxed and collective human information processing was favored by new innovations (as in transport, communication, finance, urbanization), the last two centuries saw a rapid acceleration in which information processing ultimately replaced energy as the main constraint, and marketing enabled innovators to create demand for their products. In the process, this fostered an important increase in wealth differentials, the exponential growth of cities, our dependency on the fossil energy industry, and globalization driven by the consumption society. On the other hand, it also fostered the emergence of improved education as a fundamental societal need. The acceleration of information processing is accentuating, at least for the moment, these tendencies. This shift has hugely reduced the chances that outsiders become insiders, creating an extraction-to-waste economy (in terms of raw environmental limits (Steffen et al. 2015).

We saw in Chapter 15 how, because of the territorial limitations of national governance, this system's spread around the globe has enabled – but has also been driven by – growth of the large multinational corporations. Their impact outside the core of the western world has slowly but surely, since 1950, incorporated regions that were culturally and socially fundamentally different into that extraction-to-waste economy and made it truly global. By adopting certain decision criteria in both the economic and the social sphere, they drove individuals, groups, and

countries to gradually adopt wealth-directed mindsets, activities, and institutions that are compatible with globalization's wealth-based urban logic.

In the last thirty years, this process has accelerated, and it is now reaching the conurbations of China, Indonesia, India, and Nigeria, for example. This will not only accelerate global warming, resource shortage, and the material basis of our world's social systems, but it will also become more accident-prone because more and more of the dynamics of the system are becoming interconnected, ultimately leading to hyper-connectivity and thus becoming unduly sensitive to minor disturbances in one place or one sector or another (Helbing 2013). This will (inevitably and differentially) impact the vulnerability, resilience, and adaptability of different scales of the system (Young et al. 2006).

The Acceleration in Information Processing

I have used a dissipative flow structure model that is based on feedback and feedforward loops between perception, knowledge, information processing, growth of communities, increased use of energy, and accumulation of unintended consequences to describe the evolution of societal structures through time in dynamic terms. In this long-term development, increases in human information-processing capacity have been central.

Until the middle of the nineteenth century, matter, energy, and information were closely embedded in each other while being transmitted orally, in language, in writing, in the shape and qualities of artifacts, but also in the structure of organizations and institutions. Oral communication between people embedded information in language and gestures, blinks of an eye, or a smile. Artifacts informed substance and simultaneously substantiated information into tools for action, which thus became essential parts of the information-processing systems of societies.

Writing was a major step in disembedding information by substantiating symbols with informational meaning onto different material substrates, and thus facilitating communication beyond immediate interaction between people and beyond unity in time and space. Printing popularized this means of communication. With the telegraph and telephone, other steps on this trajectory were set, transmitting information in the form of pure (electrical) energy, and thereby hugely reducing the cost of communication. But this electrification did not extend to the processing of information.

At the root of the current tipping point is the fact that presently information is processed in the digital form of 1 or 0 (on or off) in electrical circuits. This fundamental difference from earlier tipping points is profound, as it has enabled the emergence of computing, the Internet, artificial intelligence, and all that has come with it.

This disembedding of information processing is (for the moment) the last stage in the story of societal information processing. For the first time in the development of human societies on Earth it has enabled the (semi-) independent processing of information by machines, and this in turn is the major driver of the transition that current human societies are facing. We all know that this digitization of information processing has changed the world, but looking in more detail at *how* it has changed the world is worthwhile.

The Information Explosion

In sustainability science, the term "the great acceleration" captures the fact that since the beginnings of the eighteenth century resource use and pollution of the Earth system have exploded. But in the context that we are talking about here, I want to draw attention to the fact that the great acceleration has, since about 1970, been further speeded up by electronic information processing.

Recall for a moment the information-processing feedback loop that is driving societal dynamics and the transformations in them (see Chapter 8):

> Problem-solving structures knowledge —> more knowledge increases the information-processing capacity —> that in turn allows the cognition of new problems —> creates new knowledge —> knowledge creation involves more and more people in processing information —> increases the size of the group involved and its degree of aggregation —> creates more problems —> increases need for problem solving —> problem-solving structures more knowledge . . . etc.

Until the information and communications technology (ICT) revolution, this feedback was relatively slow – initially it took a very long time to master the processing of matter, then less time to master the use of fossil energy, and lastly even less time to master aspects of information processing by developing electrical and electronic communication

systems. But dealing with these tipping points is not the only way in which human information processing has set a limit on the speed with which societies could adapt to change. All our means of information processing, including institutions, economies, languages, and ways of life have all coevolved with information processing over considerable periods of time in which humans were able to change their behavior, adapting to innovations and novel circumstances. In that interaction, information flow and information processing have until recently been the main constraint on the speed of coevolution. Human individual learning, and especially collective learning of groups, accelerated only slowly as long as information processing and communication were constrained by human cognition, which also required domestication of resources, innovation, cultural alignment, building institutions, education, and much more, so that larger and larger groups could become interactive. Interestingly, the groups in society that have generally been more receptive to the importance of accelerated information processing were the Church, some of the nation-states, finance, and the military. The Roman Catholic Church had Europe's first efficient information acquisition and transmission network, and this was followed by those of the major financiers of European princes and kings (e.g., the Fuggers and later the Rothschilds, who made a fortune by being the first to transmit to London the news of the defeat of Napoleon at Waterloo).

But now technology is reducing the temporal dimension of (digital) information processing to (near) zero by disembedding it from humans, transferring it to machines, and collapsing the change in information processing from a slow long-term process into a nearly instantaneous one. This in turn has created the potential for accelerated change, and because more information is processed, an increase in the overall information diversity, which in turn might lead to more change. This is part of the impact of the forty-odd years of exponential technological acceleration in information processing that is summarized in Moore's law, which states that computer information-processing power doubles on average every eighteen months (Figure 17.1).

The result is, on a linear scale, an explosion in electronic processing power (Figure 17.2; for details see Brynjolfsson & McAfee 2011).

But over and beyond this accelerating hardware evolution, the last forty years or so have also seen a very quickly accelerating algorithmic software evolution that has further accelerated our capacity for information processing. Human information processing is no longer able to deal with this acceleration. As roughly calculated by Friedman (2016),

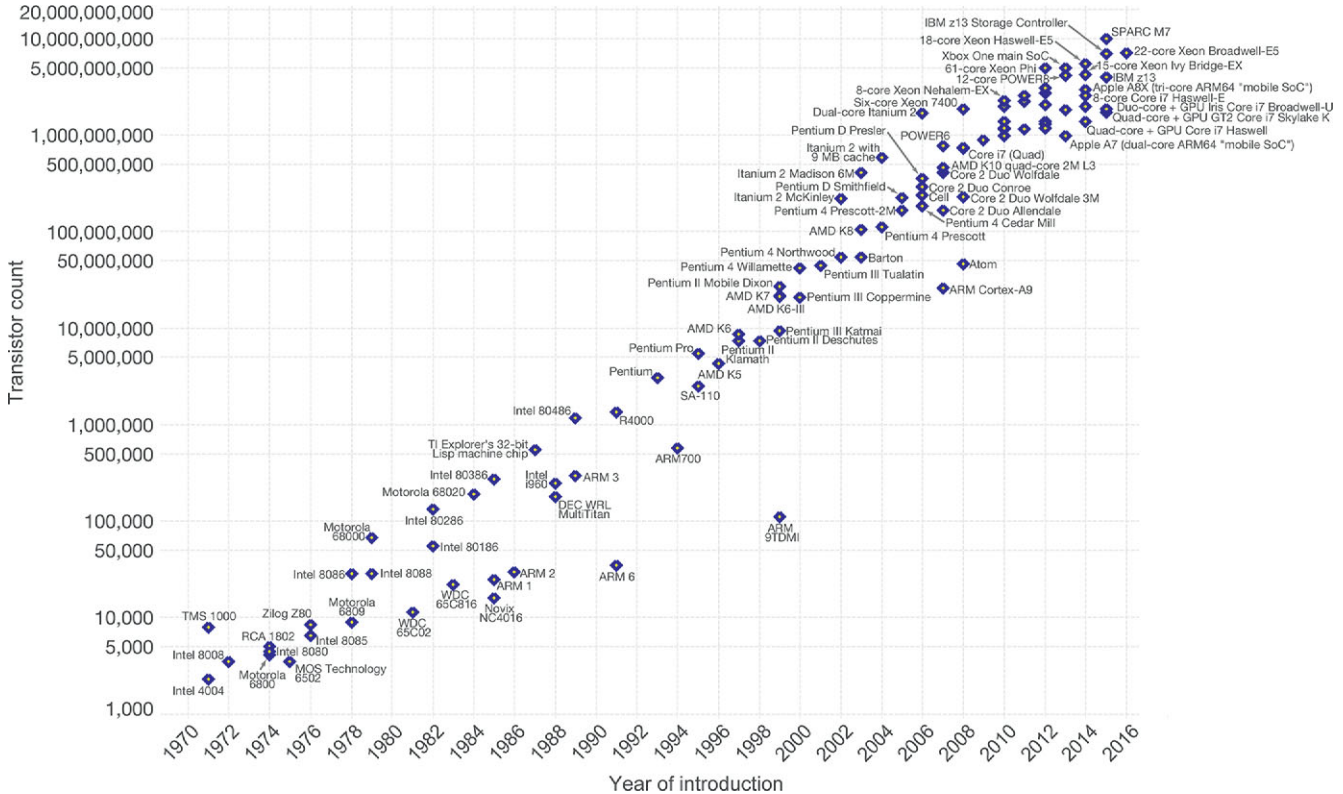

FIGURE 17.1 Moore's law: logarithmic representation of the increase in computer information-processing power 1970–2016. (Source: Wikipedia under CC-BY-SA from *Our World in Data* by Max Roser)

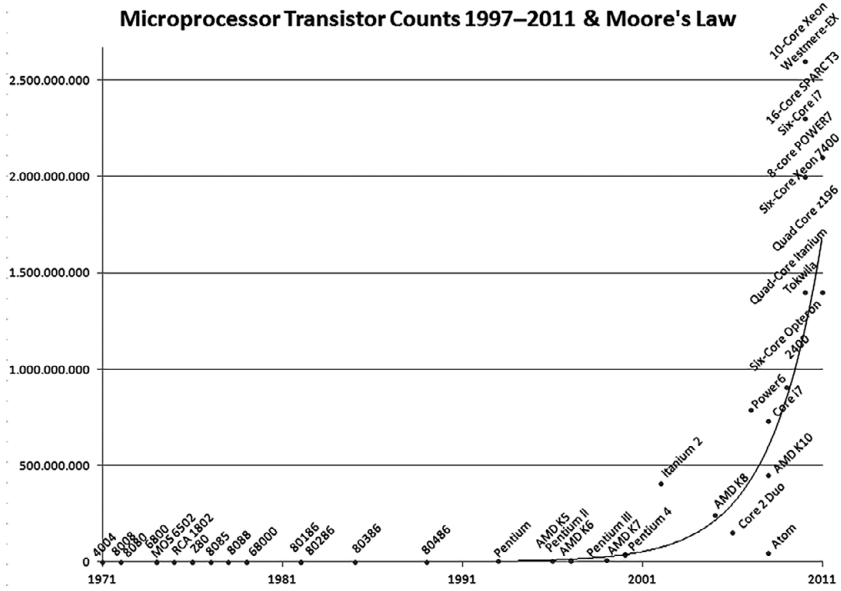

FIGURE 17.2 Linear representation of Moore's law – a very rapid explosion of computer information-processing power since around 2006. (Source: Wikimedia under CC-BY-SA)

technological generations (periods of relative stability between major changes) last some five to six years, while human information processing takes up to fifteen years to deal with such major changes.

This has resulted in a quickly growing gap between the rapid acceleration in the technology of information processing and the capability of the very large majority (99 percent or more) of human beings to deal with this acceleration. Among the people and machines directly engaged in the coupled information-processing system, we see an explosion in the number of dimensional combinations, and thus of their invention space. The elite group able to cope with this is getting smaller and will continue to decrease as machines overtake specialist knowledge that is based on the mastery of data sets, such as routine legal and medical processes. Those who are not part of this small community will be left behind. The elite group has a greatly enhanced opportunity to accelerate invention, but the adaptation of society as a whole to these inventions is much slower. This situation is profoundly affecting our societies in their capability to absorb change – in ways that have never been observed before. I will come back to the social consequences of that acceleration in Chapter 18. Here I want

to outline some of the ways in which the ICT revolution seems to be changing basic assumptions about our social and societal dynamics.

Changing Relationships between Society and Space

To begin with, the ICT revolution is rapidly and fundamentally changing our individual and societal relationships to space and time. Many authors have been noting, for a considerable time, that the world is "getting smaller." What is going on? On the one hand, since around 1800 the acceleration of our transportation methods (trains, cars, airplanes) has reduced the temporal investment in going to other places and has increased the frequency of such displacements. But the ICT revolution has very rapidly accelerated this development by enabling anyone to share any information immediately all across the world. Cyberwarfare is one way in which this is manifesting itself: interference in the internal dynamics of foreign nation-states at a level until now impossible.

But the consequences of the changing relationship between humans and space go much further. The first anthropologist I know to dedicate some of his work to the profoundly changing role of space and place in the modern world is Marc Augé (1992), whose study is significantly titled *Non-lieux: Introduction à une anthropologie de la surmodernité* (which may be freely translated as "The absence of place: introduction to the anthropology of hypermodernity"). In particular, Augé focuses on those places where all sense of particularity has been removed so that people move anonymously in them: train stations, airports, etc. One could add many shopping malls in the USA to this category. But Augé draws in part on a more long-standing debate in geography, of which one of the clearest expressions is found in the work of Tuan (1977) who drills down into how human perception and action create a "place," a location created by human experience in a wider, non-experienced, space. In emphasizing that in the current world there are locations where that dimension of human experience has been removed to facilitate movement, flow, and anonymity, Augé in my opinion hits on a core aspect of the impact that ICT will have on our lives.

At a very different level, this development is what I think might ultimately undermine the current reliance on defined territories, such as municipalities, provinces, states, and nations. All of these are in effect administrative entities created to deal with localized, multipurpose information processing. They grew from the bottom up, as political and economic power was spatially extended by subsuming smaller entities

into larger ones. This is easiest to follow in France, Germany, and Italy, where unification happened as described in Chapter 14. This led, in France in the seventeenth century and in Germany and Italy in the nineteenth, to the creation of the current European nation-states.

Not all power has always been territorially distributed and limited. In Europe, in the Carolingian era, in case of conflict people were not judged by the rules of the location where they found themselves, but by the laws and customs that were traditional for the tribe or people to which they belonged (Faulkner 2013). The rules and customs of these tribes survive to this day, such as the *Lex Baiuwariorum* (concerning the Bavarians) and the *Lex Francorum* (concerning the Franks). For a long time, well into the Renaissance, foreigners visiting or living in one of the Italian cities were subject to the oversight of the head of their "Fondaco" the entrepôt in which they had to store their wares and which they used as a basis for their trading. All members of a nation were required to reside in the Fondaco allotted to them. Thus, again, they were judged not according to the place where they were, but according to the customs of their nation or tribe. The same is true of the concessions established in Shanghai (China) after the Opium Wars (1830–60): these were extraterritorial colonies granted by the Chinese authorities to groups of foreigners belonging to one of the western colonial powers. Territoriality is not a natural state of affairs, but one created by specific circumstances. It is interesting to note in this respect that the USA is one of the few developed countries that maintains some extraterritorial aspects in its legal system, in particular in taxation (US citizens pay tax on their worldwide income), financial transactions (when they are in US dollars, anywhere in the world, the USA assumes that they are subject to US laws), and the fight against corruption (forbidden by US law wherever it occurs).

The question facing us now is whether, as distance is shrunk to the extreme by the ICT revolution and people are increasingly placeless, other, non-territorial modes of organization might emerge. An interesting example of this is the current policy of Estonia, which accepts applications for e-residency from anywhere in the world. E-residency creates an information technological identity in Estonia, which is valid for any transaction in the world but is governed by Estonian rules, without the need for the parties concerned to be resident in the country. Thus, a global virtual entity and community are being created for transactional purposes, in which location no longer plays any role. Were other countries to follow the Estonian example, location would no longer define the laws and statutes governing a person or firm's transactions; instead, the

organization that guarantees the transactions, wherever in the world it is based, would do so. One can imagine many other examples that would give individuals the facility to work globally, not unlike the way in which multinationals have done for a long time, enabled by their financial and legal firepower.

The Impact of ICT on Time and Its Societal Management

The concept of time and its perception constitute a booming research field in psychology, philosophy, and related disciplines, as is clear from the remarkable publications of the International Society for the Study of Time (www.studyoftime.org/), which since 1966 has met once every three years, often in very exclusive locations, but also from numerous papers in a wide range of journals. An interesting summary is presented in Wikipedia (https://en.wikipedia.org/wiki/Time_perception, consulted June 3, 2019). I do not want to explore the many theories and explanations proffered, beyond accepting that time perception is subjective and individual. What interests me here is the evolution of the relationship between the subjective and relative individual perception of time and the societal management of that perception, which requires that people to some extent share, at least for certain purposes such as meeting each other, a sense of time as well as location (but not place in the sense used above). In our society, that is the role of clocks – external, mechanical devices that offer an objective measurement of time, and in doing so control to some extent human behavior. Among the simplest of such devices are sundials, in which a stick projecting a shadow on a calibrated surface indicates time as a function of the path of the sun. It indicates time relatively roughly, at intervals of one hour between calibrations. Another such simple device is the hourglass, in which the flow of water or fine sand between the upper and lower half of the glass is regulated (by defining the size of the hole through which the sand or water moves) so as to empty one half (and fill the other) within a specified amount of time. Its advantage is that it also works at night, which is important on ships, for example. Moreover, the length of the interval can be varied, so that such a device can measure very different units of time. But its disadvantage is that one has to turn the glass every time the flow has stopped, so that the process can begin again.

How have we, in our society, come from such relatively simple, local devices to clocks that measure time in milliseconds or even finer, such as the atomic clocks that now regulate time across the world? Mechanical

clocks, introduced in fourteenth-century Europe, had the advantage that they worked day and night, had to be reset less frequently than hourglasses, but initially also had only one indicator calibrating hours. Over the centuries, clock- and watchmakers managed to calibrate time measurement in finer and finer units (minutes, seconds), and related their time measurement also to the motion of the sun, the moon, and certain planets. The core process seems to be that larger and larger communities have delegated their time management to mechanical devices of increasing precision, so that transactions can be managed more and more precisely. In that context, individuals voluntarily suppress their personal, internal experience of time to the societally agreed external time management metrics.

How is the ICT revolution likely to affect this long-term trend? We can imagine this by placing the evolution of time management precision in the context of the wider evolution of our information-processing systems, and in particular the growth of the volume of information that we, as humans, process. The rapid increase in knowledge and the increasing size of networks of interactive people that is concomitant with this increase point to the fact that the amount of information processed by each individual in our societies has grown very rapidly, as has the overall information flow that is managed societally. One wonders whether there might be a dynamic relationship between the size of the flow of information processed by an individual and that individual's time perception on the other. This would seem to be confirmed by everyday experience: the fact that when an individual is very busy (processing a lot of information) time seems to be flying, whereas if information processing falls below a certain level, time is perceived to be moving very slowly. If we adopt such a relationship as a working hypothesis, then the growing volume of information processed by each individual in society would seem to relate to the increasing subdivision of temporal intervals in individual time perception and in societal temporal management. As the ICT revolution is likely to further increase the volume of information processed individually and societally, this would further reduce the size of units of human time management, possibly to the point that only closer integration between people and computers can deal with it.

Exploding Connectivity among Tools for Thought and Action

The acceleration in digital information processing has changed our relationship to information itself in many ways. To begin with, it becomes

much easier to deal with very large volumes of information. This has been captured under the term "big data," which has been closely tied to the fact that more and cheaper sensors, increased processing capacity, and cloud memory have exponentially inflated the total volume of information that we can collectively process. But a closer look at this increase also shows that the ICT revolution has engendered an even more rapid increase in the connectivity between different dimensions of the information processed and different information signals.

In the technological domain, for example, the number of recombinant innovations (innovations that link existing novelties in different domains) has been increasing for at least forty years (Strumsky & Lobo 2015). But the ubiquitous availability of information from across the globe, and the improvement in ways to search for, and identify, complementary components is accelerating this process even further. It has enabled an important shift in the economics of innovation in our societies, from reliance on originating (rare) innovations that open up a completely new technology) toward reliance on such recombinant innovations (see Brynjolfsson & McAgee 2011).

This also affects our individual and social lives, through such innovations as search engines and social networks. For those who can connect to the Internet, linking disparate pieces of information has become much easier, and this in turn impacts in major ways on our intellectual and social lives. We can keep up with the detail of one another's lives and can trace the whereabouts and history of people with whom we have lost contact as much as forty or more years ago through social media, and we can quickly explore and link diverse intellectual ideas by using search engines, and thus generate (recombinant) intellectual novelty. Moreover, this capacity can recycle existing information that has thus far been ignored or overlooked.

Reduction of Control over Information Processing

We can now communicate instantly with many people in the world (though about 3 billion are still excluded from this), and at an infinitesimal additional cost in energy, even though the investments in human, financial and material capital to achieve this are very considerable. Those investments have completely changed the human interaction model that has driven societal dynamics up to this point. The fact that anyone can instantly transmit information to anyone, whether one on one, one on many or many on many, and that such information can then be processed

individually by all concerned, has created such a huge amount of potential redundancy in the information processing of societies that everyone is instantly informed of everything happening elsewhere on the globe unless they protect themselves against this.

This development is progressively, at least for the moment, transforming information processing without central control (see Chapter 11) into information processing without *any* control. In distributed and heterarchical information-processing systems there have always been nodes that controlled some of the information processed, whether through enforcement, through institutionalization, through incentives, or otherwise. These nodes were the basis on which current nation-states were managing the large numbers of members of these societies, as well as keeping non-members out. Each of these nodes involved only a limited number of people, and there were barriers to the flow of information between them, whether in the form of spatial isolation, differences in culture, identity, or administrative organization and other means. This enabled such nodes to organize themselves, to maintain their (different) organizations over time, and to align their members on certain basic values, procedures, and institutions.

Currently (the early twenty-first century), the spread in information processing that culminated in the Internet and its many applications is removing such voids and barriers. We are witnessing an explosive increase in horizontal information processing, at all levels of society. This has a wide range of consequences. For example, it has further facilitated the imposition of the values of developed nations on other parts of the world, a process that was (slowly) set in motion in around 1800 CE by the spread of colonial administrations and multinational corporations. In most cases where a preexisting non-western approach to information processing was confronted with the western one, the result has been a fusion at the level of the lowest common denominator – material culture, consumerism, and, even more basically, money. Other domains, and other values, were not so easily integrated, and in many instances differences between cultures have now become a source of friction. This focus on a global lowest common denominator has in many places contributed to the relegation of other values (many of which constitute the deeper meaning of wellbeing) to "noise."

Blurring the Boundary between Information and Noise

On a more fundamental level, the loss of control over information processing has changed the status of information itself, which is of course

dependent on a distinction between signal and noise. Numerous Internet sites that proclaim to provide news can and do launch egregious information that has little or no relationship with commonly experienced social, political, economic, or environmental realities. For many people, it is difficult to separate such information from that provided by trusted institutions that adhere, more or less, to certain collective standards, and at the collective level this is undermining the distinction between signal and noise – and the alignment of people around sets of values as embodied in (sub)cultures at every level.

In due course, this results in changes in the relationship between data and observations on the one hand, and knowledge or understanding on the other. As I emphasized earlier in Chapter 8, information processing is dependent on a reciprocal, interactive, and self-referential relationship between these two (Luhmann 1989). That interaction is responsible for the distinction between signals and noise. Knowledge or understanding enables someone to interpret patterned data and observations, relating them to ideas, but the fact that the data never completely fit the extant ideas exactly allows the person interpreting them to enhance his or her knowledge and understanding. Over time, this has enabled individual societies to develop, path dependently, different relationships between observations and knowledge or understanding, leading to different cultures. But the reciprocity between phenomena and ideas also facilitates the reverse: to use personal insights or opinions to elaborate presumed data and observations.

In our societies (and our sciences) we have thus far generally adopted the first of these interactions, gaining knowledge and understanding by observing patterns in the realm of phenomena. Now, however, there are people and places on the Internet where the reverse is done, whether deliberately or by default. They present data or factoids that are constructed based on their worldview. In itself this is nothing new – the rumor mill has always, in every society, had this effect. But in the global information society it is often much more difficult, or even impossible, to find out how any piece of information has emerged, and what its relationship to the realm of phenomena is. Over time that could fundamentally undermine the existence of all social institutions, and of the societies that have created them, because it obfuscates the boundaries between the dissipative flows that structure our societal interactions (and give meaning to the information processed by them) and the surrounding stochastic chaos. Individuals would lose their alignment and direction, feel lost and immobilized by indecision, or try to create their own dissipative flow

structures based on their own values. Many of these structures are ephemeral, closely aligning insufficient numbers of individuals, and are thus doomed (see Chapter 11), but others gain a wide enough audience to persist and become important in our lives (such as, for example, the Breitbart alt-right website).

A Society's Value Space Determines Signals and Noise

In the relationship between observations, information, and knowledge or understanding, values play an essential role, as they are the basis of what distinguishes between signal and noise. They are, in effect, intangible instantiations of our information-processing structures, and play an essential role in determining or constraining the path dependency of socioevolutionary trajectories. In that sense, they play a role similar to that of artifacts and the technologies underpinning them.

I will now try to delve a little deeper into their importance. My starting point is that a society's values are of fundamental importance for its existence. They align its members around certain information and resource flows, enable them to distinguish between signals and noise, and to communicate, collaborate, and express differing opinions. Communication, collaboration, and differences of opinion are all anchored within a set of – usually partly implicit – values that the members of a society share and the relative priorities they accord them. We could call this the society's value space. I define this neologism as including the total set of dimensions according to which a society attributes value to ideas, actions, institutions, material goods, etc.

Sharing such a value space does not mean that all members of the society have exactly the same conception of these values – it merely means that their conceptions are sufficiently close to facilitate frequent constructive interaction. We could say (with Binford 1965) that people partake in their culture. Their differences are the result of the fact that each person acquires, during his or her lifetime, an individual cognitive system (worldview) that emphasizes certain dimensions of the shared values of a society more than others. Following the extended evolution approach of Laublichler and Renn (2015), one might say that the values of individuals are effectively determined by the socioenvironmental network of which they are a part, and this network, of course, varies for everyone, even if minimally. As a result, all but the smallest social groups that have lived together for a long time in isolation have value differences between their members. (In the term I used in Chapter 11, such societies have more or

less heterogeneous information pools.) Those value differences play important roles in a society. For one, they allow individual members or groups within it to create an identity that distinguishes them from other members or groups in the society. That differentiation also drives continued communication and information exchange between individuals. (In the purely theoretical case that all individuals were identical, there would of course be no reason to exchange information, and thus no reason to interact.) Such exchange of information in turn drives societal change and is thus responsible for societies' coevolution with their environments. Observing value differences between individuals, groups, or societies, for example, can give rise to the desire for change and lead to anticipation, while the exchange of information promotes the emergence of novel ideas and values, and thus stimulates invention and innovation. Partaking in a society's information exchange necessitates acquiring knowledge of the society's language, categories, symbol systems, and other aspects of its tools for thought and action, including its organization, its institutions (again, in the widest sense), and its belief systems. As individuals and groups adopt these, in essence they align their ideas among themselves. The interaction between shared values and value differences within a value space is thus responsible for the coherence of groups of individuals within whole societies.

Value differences are also the drivers of material exchanges. Among other things, they can be due to individual or group preferences, to local environmental conditions, to the availability of certain resources, or to the cost (in energy terms) of acquiring them, adapting them to one or more particular (desired) functions, or transporting them. The differences will prompt people to interact, and to exchange both information and material resources and objects. This is the basis of trade, and of our economies.

The Dynamics of Value Spaces

In all societies, values are given according to a wide range of criteria and in a wide range of dimensions, dependent on the networks in which individuals and groups partake. Anthropology can be seen as the study of the different values of different groups, communities, or societies. As such, it focuses on their diversity, and thus on the diversity of worldviews, and has established the fact that, indeed, different societies have very different value spaces. Economic anthropology studies how these different value systems (or value spaces) categorize and accord different values to

resources, materials, objects, institutions, and customs, and has developed approaches to explain exchange systems in terms of their value spaces. It has thus emphasized the diversity of exchange systems that results from different worldviews.

When a society is engaged in a growth process, and therefore appropriates more and more matter and energy, it does so by extending its information-processing capacity to more and more people and resources, aligning them but also incorporating in the value space of the society more and more knowledge, so that it can access the necessary matter and energy. It is a corollary, therefore, of any growing society that it expands its value space by innovating, generating new ideas and ways to do things, and thus transforming its organization. Such innovation is fundamental to the survival and growth of any society, path dependently building upon and developing, the core values that anchor the development.

But there are limits to the extent to which the organization can be transformed because another particular aspect of human cognitive systems eventually comes to play a major role. This is the fact that our theories (including our categories and the perceived relations between phenomena) are in effect under-determined by our observations. This is nicely illustrated by Atlan (1992). He takes as example a set of five traffic lights that can each assume three states (red, orange, green). The total number of states of this system is 3^5 or 243. But the number of potential connections between these states, which could explain their dynamics, is actually 3^{25}, or 847,288,609,443. To decide which of these is the "right" one would require a number of observations close to the number of possibilities – something humans never achieve in real life. The corollary of this phenomenon is that our theories and actions are generally over-determined by those among our prior experiences that we consider relevant. As a result, the trajectories our socioenvironmental systems follow are path dependent in the sense that 'change is hard': it is very difficult to deviate from a particular trajectory once one has invested substantive thought and material, institutional, or financial means or efforts in it (let alone emotions). In times of crisis this affects both the speed and the extent of changes that may be implemented.

As I argued in Chapter 9, our current sociocultural and economic structure has been elaborated over time in an interactive process of problem-solving, generating new (unanticipated) problems, solving these problems, encountering new problems, etc.. Structurally, those new elements have been grafted onto an existing information-processing structure every time it was necessary to deal with a challenge.

One sees this most clearly in the inherent development of bureaucracies, but this process is not limited to such organizations – it permeates all we do as humans, including our mental structures. In the course of this process of grafting, certain aspects of our society's mental and practical functioning are smoothed or rendered more efficient, but because every intervention has unintended consequences, such actions also cause unintended (and often unperceived) inefficiencies that emerge with time, again hindering any efforts to deal efficiently with the dynamics that the system is involved in. The accumulation of such maladaptations causes the structure to become less and less efficient, and thus more and more costly to operate.

Simultaneously, as the structure evolves, it merges functions or otherwise simplifies certain parts of its structure to deal with the most frequently occurring kind of information processing that it is called upon to undertake. The combined effect of these two tendencies is that the information-processing structure becomes more and more robust, focused on fulfilling a precise, well-defined set of functions, and resistant to change. Inevitably, in that process, the mental and organizational structure becomes more and more coherent and narrowly path dependent, and it becomes more and more difficult to add new values to the value space. More and more dimensions that are compatible with the structure of the value space will be discovered and exploited by innovation, but ultimately there comes a moment that this becomes increasingly difficult.

To put it differently, a core value system will inevitably lead to the construction of a set of utility functions. Initially these may be relatively loose, representing diversity within a group. Over time, experience and complexity will expand them but also harden them to increase their efficiency. Continued hardening leads to the dominance of a few terms and an effective loss of dimensionality. Eventually the functions can no longer adequately adapt and become brittle. This is what I mean by reaching the limits of a value space. It results in an important increase in unintended consequences of earlier actions (see Chapter 15), and in a reduction of the potential of the value space to facilitate the implementation of new inventions.

This in turn creates an increasing incompatibility of the value space with the environment it is created to deal with. This leads to a tipping point, when the existing value space is opened up, so that the definitions of categories and theories, but also of institutions and customs, are weakened by the reduction of their dimensionalities. They can thus ultimately be destroyed or replaced by other structures that constitute a novel value space.[1]

Wealth as the Predominant Global Metric

From my anthropological perspective, it is astonishing to see the extent to which in our own western culture the dimensionality of the value space has shrunk, leading to an increasing focus on productivity, gross domestic product (GDP), and technology. This has emerged since World War II under the impact of the growing power and influence of free market economics worldwide.

I think this development must be emphasized as an important corollary of globalization. The process began at the time of colonization and has intensified in phases. The first of these began in around 1800 when the European trading colonies became occupied territories producing raw materials for their occupying nations. Over the past seventy years, what we now call globalization further reduced the dimensionality of metrics (and awareness) of human wellbeing as the counterpart of the global growth of interaction between groups and populations from different backgrounds, as it reduced the total information-processing capacity needed to align these different populations. Different cultures and populations, with different values and customs, were progressively aligned along one single dimension, their lowest common denominator: wealth.

Without that reduction in dimensionality, globalization would not have been possible. Imagine that we had to implement global information processing based on the many, many dimensions that different cultures considered important before globalization took hold. That would have overwhelmed our global information-processing system completely. We would not have been able to isolate the relevant dimensions on which to base interaction and around which to create alignment.

Instead, as part of globalization, different populations were slowly but surely accustomed to considering a narrowing set of dimensions as important for them, centered around the wealth dimension, this being the one by which they could compare themselves and transact exchanges. The impact of this is nicely illustrated by Maruyama (1963, 1977, 1980): "If," he once told me, "one reduces the dimensionality of a system to one, people's need to differentiate themselves will be reduced to that dimension. That explains why, on a highway, people tend to distinguish themselves in the speed with which they drive."

Wealth and its metrics, notably GDP, have thus become a dominant dimension of interactive information processing between many different individuals, groups, societies, and cultures around the globe. Although other dimensions are still important, such as religion, community

solidarity, art, and culture, there is an increasing tendency toward a reduction in the dimensionality of value sets. Wealth is becoming in certain circles the most important common denominator. In the process, the holistic basis of social interaction is reduced. Fewer and fewer other dimensions of human wellbeing are generally considered worth thinking about, except among smaller, focused subsets of societies. This in turn has moved our global societies toward an increased emphasis on productivity, and led to the over-exploitation of the natural capital of the environment, as well as of the human capital of many regions and groups. The ICT revolution has accelerated and exacerbated this trend by according control over information processing to a smaller and smaller proportion of humanity, giving it the opportunity to accumulate riches and leave the rest of the population behind. The full impact of this development was brought home to me in 2013, when I gave a lecture on sustainability for a business audience in Tempe, Arizona. The speaker after me had only one message: "We need to replace family life with corporate life!"

This trend also has direct implications for the concept of fairness in negotiations. In many societies, in order to count as moral or fair, a reason, principle, or posture toward the world must traditionally reflect a concern with the (multidimensional) wellbeing of the group generally; that is, a concern with the wellbeing of everyone (McMahon 2010). But increasingly, fairness in reciprocal arrangements has become monetized, so that money and wealth are the medium through which equity in reciprocal relations is expressed. As a result, the degree to which monetization of reciprocal concerns – for example, the fact that insurance corporations calculate the value of human life – has impinged on our world is startling.

We saw in Chapter 16 that another negative consequence of this trend is that it has skewed the whole global value system toward increasing wealth differentials between the haves and the have-nots. Initially, this was not very noticeable, because limited communication between these groups constrained the extent to which people could compare themselves with others in these terms. As the growing wealth differences are now more and more effectively communicated (by television, tourism, and now the Internet), this creates new challenges and conflicts. Increasing wealth discrepancy is rapidly becoming a societal planetary boundary alongside the demographic explosion (from 2 to almost 7 billion people in sixty years), and the acceleration of information processing and the changes it entails.

Our Western Value Space seems to Be Reaching a Boundary

Did shrinking the dimensionality of our society's value space contribute to the reduction in the rate of return on investment in innovation that we saw in Chapter 16? That is difficult to determine, but if that is the case it could in turn explain why more and more available funds are being diverted from the productive to the speculative sector. In macroeconomic terms, it might even to some extent explain the leveling off of the growth of our (western) economies that has been reinstated on the scientific agenda by Summers (2016).

Importantly, at a more fundamental level, the progressive closure of our value space and the increase in unanticipated consequences of our actions seems to be related to an observable shift from long-term strategic thinking to short-term tactical thinking. It has shifted the focus of our collective efforts to the immediate, and thus causes us to be caught in a kind of historical myopia that limits and biases our understanding of the second order dynamics that have driven us to this point, as well as our perspective on potential ways to find an exit from the current dilemma. Thus, we are looking for solutions within our current given structure, rather than stepping out of that structure and thinking outside the box.

This is of particular relevance to economics – with policy the most important lever through which one may attempt to change our societal dynamics. In this community there is an emphasis on continuity, rather than the facilitation of change at a time when digital information processing is accelerating change in all aspects of our societies' dynamics. Much of the macroeconomics community in particular lacks a conceptual (and mathematical) tool to conceive of endogenous, discontinuous change. As became disconcertingly clear at the beginning of the recent financial crisis (2007), the dynamic equilibrium models that link supply and demand are traditionally formulated in terms of differential equations and therefore focus on marginal changes of aggregate measures. Therefore they cannot help us to anticipate tipping points or help us think about making structural changes in our current socioeconomic system.

One potential contribution to overcoming this would be to develop the 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, which could include value dimensions other than cost and price, and thereby enable a new expansion of our existing value space.

NOTE

1 I owe a debt to Stéphane Grumbach for pointing out to me that a number of current phenomena, such as the blurring of the distinction between gender roles in our societies, seem to indicate that this process is currently occurring in the West.