Technology and Change: The Role of Technology in Knowledge Civilization

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ABSTRACT

The paper presents a reflection on the role of technology in the era of knowledge civilization. Diverse perceptions of this era, the concepts of three civilization eras versus three waves, of a conceptual platform versus an episteme of a civilization era, of a big change at the end of industrial civilization era are outlined. The deepening separation of the three spheres of technology, hard science, and social science with humanities is discussed. The contemporary philosophy of technology is shortly reviewed; it is shown that some of its writings represent anti-technological attitudes and disregard the opinions of technologists even in the question of defining technology. An interpretation of technology proposed by M. Heidegger in *Die Technik und die Kehre* leads to a distinction between technology proper and the system of its socio-economic applications. The relation of technology proper to hard science and to socio-economic applications of technology forms two positive feedback loops. The second feedback loop, the one of socio-economic applications, might be more dangerous in cases of social infatuation with technological possibilities. Limiting such dangers is the responsibility of *technology brokers* and those who educate them – social, economic, management sciences. It is shown that the technology of knowledge civilization era will differ from that of industrial era in proposing boundless number of diversified technological possibilities. Thus, the Heideggerian warning against social infatuation with technological possibilities must be modified and strengthened.

Keywords: knowledge civilization era, philosophy of technology, definition of technology, technology proper versus its system of social applications

1. INTRODUCTION

As long as fifty years ago, it was accepted, see, e.g., [1] that humanity developed because of tool-making, thus technology is an intrinsic human faculty; that many old civilizations collapsed because their political leaders (pharaohs, kings, head priests) used the tool-making and the technological abilities of their people for too ambitious goals (changing nature too extensively or building pyramids); that technology is a way of mastering nature but nature often punishes those civilizations which use their technological abilities without restraint. All this simple, basic truth has been, however, questioned during last fifty years, while some representatives of social science directly accused technology for its devastating outcomes. At the same time, technology has brought about the informational revolution that includes also the *dematerialization of work:* automation, computerization and robotization relieved humans from most of heavy work and created conditions for an actual realization of the equality of women. This prepared a new civilization era that can be called *global knowledge civilization* (or simply *knowledge civilization,* since it will last many decades yet before this type of civilization becomes truly global, see [2]). This development solves many old problems and brings many hopes, but also brings new problems and many dangers.

Thus, it is necessary to reflect what will be the future role of technology in the starting era of knowledge civilization. The basic character of temporary civilization changes has induced the author to check also the *philosophy of technology;* and the contemporary state of this field appeared to him deeply disturbing. We need a basic philosophic reflection on the future role of technology in knowledge civilization. But if philosophy is not even willing to listen to the opinion of technologists what they truly do, then it will not be able to understand this apparently distinct sphere of human activity.

Therefore, we must first reflect what has happened in last fifty years that apparently three different cultural spheres or worldviews separated themselves: of social sciences with humanities, versus hard sciences, versus technologists; how these spheres view each other; how does this influence the philosophy of technology; what is and what is not the definition of technology acceptable to its practitioners. First upon clearing this background we can discuss the future role of technology in knowledge civilization, its promises and chances versus its problems and dangers. We must start, however, with a review of some basic features of the starting era of knowledge civilization.

2. THE ERA OF KNOWLEDGE CIVILIZATION

2.1 Diverse perceptions of a new era

There is a voluminous literature on the subject of *information society* and *informational revolution,* see [3], [4], [5], [6], [7], [8], [9], [10] with diverse views, diagnoses, prognoses – and a universally accepted opinion that we are living in times of *informational revolution* and this revolution leads to a new civilization era. In this era, knowledge plays even more important role than just information as the essential productive resource, thus we might call the new epoch *knowledge civilization era.*

Concerning the date marking the beginning of new era, we shall follow F. Braudel [11]. Braudel defined the *preindustrial era* of the beginnings of capitalism, of print and geographic discoveries, as starting in 1440 with the improvement of printing technology by Gutenberg and ending in 1760 with the improvement of steam engine technology by Watt, which started the *industrial era*. Similarly, we can take the date 1980, related to the improvements of computer technology (personal computers) and network technology (new protocols of computer networks), which made possible broad social use of informational technology, as the beginning date of the *knowledge civilization era*. Instead of speaking broadly about *three waves of agricultural, industrial, information civilization* such as discussed in [6], we might thus discuss– see [2] – more precisely *three recent civilization eras:* of *preindustrial civilization* (print, banking and geographic discoveries), *industrial civilization* (steam, electricity and mobile transportation); *informational and knowledge civilization* (networks and mobile communication, knowledge engineering).

2.2 The *conceptual platform* and the *episteme* of a civilization era

Each of these eras started basing on a definite *conceptual platform*[1] of new concepts and ideas formed even before the beginning of the era, see [5], which after some time was followed by the formation of an *episteme* characteristic for the era, see M. Foucalt in [12]. *Episteme* denotes the way of constructing knowledge in a given era, is specific for the era and emerges some time after the beginning of the era.[2] But before Gutenberg we had the beginnings of Renaissance, before Watt we had Newton and French encyclopedists; thus, a *conceptual platform* precedes the beginning of an era. *The episteme of knowledge civilization is not formed yet,* but the destruction of the *industrial episteme* and the construction of a new *conceptual* or *cultural platform* started with relativism of Einstein, indeterminism of Heisenberg, with the concept of feedback and that of deterministic chaos, of order emerging out of chaos, complexity theories, finally – with the *emergence principle*.

The study of mathematical models of nonlinear dynamic systems, see, e.g., [13], resulted in a *rational justification of the emergence principle: of new systemic properties emerging on new levels of complexity.* This emergence principle was *justified empirically* by biology in its concept of *punctuated evolution,* see, e.g., [14]; but the *rational justification* has shown the emptiness of diverse ideological attacks on the concept of evolution. This change of perception was additionally supported by a *pragmatic justification* given by technology, in particular – telecommunications and information science. An example is the ISO/OSI model of seven layers of a computer network. The functions of such complex network are fully independent of the functions of its *lowest, physical layer,* of the way electronic switching elements work, repeat and process signals. On each higher layer, new functions and properties of the network emerge. The functions of the *highest, application layer,* are responsible for application software and they would be the same even if the switching in the lowest layer would become fully optical or even quantum mechanics driven. The theory of hierarchical systems, consistent with the emergence principle, was developed some time earlier by control system theorists [15].

The *industrial episteme* believed in *reduction principle – that the behavior of a complex system can be explained by the reduction to the behavior of its parts* – which is valid only if the level of complexity of the system is rather low.

> With very complex systems today, mathematical modeling, technical and information sciences adhere rather to *emergence principle – the emergence of new properties of a system with increased level of complexity, qualitatively different than and irreducible to the properties of its parts.*

[1] Called also sometimes *cultural platform.* See [2], [5].

[2] *Episteme* of previous eras has not been consciously recognized by people living at these times; but after Foucault has created this concept, we have not only the right, but also the duty to use it consciously in the coming era.

It should be noted, see [2], that *the emergence principle expresses the essence of complexity* (in the Heidegerrian sense which will be discussed later) and means much more than the *principle of synergy* or *holism* (that *the whole is more than the sum of its parts*) which was noted already by [16], [17], see also [2].

2.3 What happened at the end of industrial civilization era

The technology of industrial civilization era was developed to such a degree that, for the first time in the history of human civilizations, on one hand it promised the possibility of freeing people from hard work, on the other hand has shown also the possibility of a total destruction of life on Earth. Entire societies or social systems have become blinded by their seemingly unlimited power over nature given to them by the industrial technology, what has led to the large overexploitation of natural resources and many degradations of natural environment. This has occurred especially in the communist system, where the official ideology stressed the social power of transforming the nature; this is occurring even today in the capitalist system, where the trust in the role of free market induces the belief that market should also determine the use of technology (e.g., in the issue of climate changes). In face of such controversies, it is no wonder that *the ideological and intellectual crisis at the end of industrial civilization era has been very deep indeed.*

The end of the *industrial era episteme* was marked already in 1953 by the paper of W.V. Quine [18] which has shown that the logical empiricism is logically inconsistent itself, that all human knowledge *"is a man-made fabric that impinges on existence only along the edges"*. For diverse reasons, a part of social science went much further to maintain that all knowledge is *subjective* – results from a discourse, is constructed, negotiated, relativist. This general belief has many versions: radical biological constructivism [19], [20]; radical relativism; the strong program of the Edinburgh school [21], [22]; *post-existentialism* and *postmodernism* [12], [23], [24]. Opposite was a further development of humanistic rationalism [25]; however, precisely from humanistic sociology soon came also an anti-technological position, initiated by H. Marcuse [26] with his concept of the single-dimensional man enslaved by the autonomous, dehumanizing force of technology and followed by treating technological (or *technocratic*) thinking as equivalent to a functionalist worldview, see J. Habermas [27] (e.g., pp. 72-3), M.C. Jackson [28] (pp. 107-210).

In all these disputes, the emergence principle was unnoticed and disregarded, while clearly reductionist arguments were used to deconstruct the concepts of truth and objectivity, trying to deny the importance of such more complex concepts by the analysis of more primitive ones. Seen from the perspective of the emergence principle, truth and objectivity are concepts of a different layer of complexity; they might be unattainable, but serve very clear purposes as ideals. Without trying to pursue objectivity, technology could not be successful, e.g. when trying to increase the reliability of transportation vehicles. Thus, these reductionist deconstruction attempts were in a sense *signs of the end of a civilization era, when a general uncertainty of values results in a universal, playful anarchy.*

A deep cultural cleft emerged between social sciences and technology towards the end of industrial civilization era. We can quote here also the opinion of H. Kozakiewicz – a known Polish philosopher of sociology – who diagnoses [29] a crisis in sociology. She asks: *in what sense sociology is a science?* It is a science by tradition, since it started from positivistic beliefs of Comte using scientific methodology. However, sociology itself revised these beliefs, today the formulation that somebody uses "positivistic" or "scientific methodology" means for a postmodernist a strongly negative epithet. Postmodernist sociology treats science as a social discourse. What happens if we apply this to sociology itself? A paradox: *sociology is a social discourse about itself.*

3. THE THREE SEPARATE SPHERES OF TECHNOLOGY, HARD SCIENCE AND SOCIAL SCIENCE WITH HUMANITIES

3.1 Why separate spheres?

We indicated above that the sphere of social sciences with humanities is different than the sphere of technology, because they adhere to different values, have different *episteme,* use different concepts and language. The same obviously concerns also social sciences and humanities versus basic, hard sciences; similar distinction concerns hard sciences versus technology. Some (social science) writers, e.g. [30], speak about *technoscience.* However, *this is a great error* resulting from the lack of understanding of technology: while science and technology are obviously related, they differ essentially in their values and *episteme.*

The anthropology of 20th century created a very useful principle of dealing with separate cultures: *you should never judge a foreign culture without fully understanding it.* We can extend the same principle to the three spheres of hard science, technology, social science and humanities. But then, what does postmodern sociology of science (represented, e.g., by B. Latour in [30])? By telling a hard scientist that he does not value objectivity, only power and money, it behaves like a communist activist coming to a priest and telling him that he does not value God, only power and money. By telling a technologist that his products enslave people, it behaves like telling an artist that his religious paintings enslave people. By the principle mentioned above, the *episteme* of hard sciences should be discussed, criticized and further developed by hard sciences themselves; the same concerns technology. The same concerns social sciences: until they overcome their own internal crisis, they should not expect that their opinions about other spheres will be seriously attended to.

3.2 The dominant *episteme* of a sphere and its limitations

If we adhered too closely to the principle described above, these three spheres would become completely separated, which is neither possible nor desirable. Intercultural understanding should be promoted; with this aim, we indicate here the limitations of each *episteme,* using metaphors to describe the differences between them.

Even if a hard scientist knows that all knowledge is constructed and there are no absolute truth and objectivity, he believes that scientific theories are *laws of nature discovered by humans* rather than *models of knowledge created by humans*. He values truth and objectivity as ultimate ideals; metaphorically, *hard scientist resembles a priest.*

A technologist is much more relativist in his *episteme,* he readily agrees that scientific theories are models of knowledge – because if he has several competing theories, he simply compares their usefulness. If he does not have scientific theories to rely upon, he will not agree to wait until such theories are created, but will try to solve the problem anyway using his own creativity. Metaphorically, a *technologist resembles an artist.* He also values tradition like an artist does, much more than a scientist: an old car is beautiful and, if well cared about, can become a classic.

A postmodern social scientist or a soft scientist believes that all knowledge is subjective, constructed, negotiated, relativist. There are traps in such *episteme,* it would not stand up against a serious Kantian-type critique, as indicated by Kozakiewicz; but this is a sign of an internal crisis that must be overcome by social and soft sciences themselves. Metaphorically, a *postmodern social scientist resembles a journalist:* anything goes as long it is interesting. He also does not much value tradition.

4. THE VIEWS OF PHILOSOPHY OF TECHNOLOGY

4.1 The general impression of a technologist

It is just too dangerous not to understand technology, if it gives us today not only the power to transform totally our lives, but also to destroy life on Earth – not only by an inappropriate use of nuclear energy, but also e.g. by an inappropriate use of genetic, or even of robotic technology. Postmodern social sciences will not able to understand technology until they overcome their internal crisis. Hard sciences will continue to see technology as a mere application of their theories. All this creates a dangerous situation; and the perception of this danger only deepens when we study the contemporary philosophy of technology.

There are serious writings on philosophy of technology, e.g. [31] edited by R. Laudan, addressing the question whether the concept of a Kuhnian revolution in science is applicable also to technology; but even they do not ask the question what would be a definition of technology acceptable to a technologist. Beside other definitions, there is in [31] an attempt to define technology as a practical problem-solving activity, which is certainly correct if still not fully essential.

However, a recent and excellent – at least, in its breadth – review of old and current writings on philosophy of technology [32] edited by R.C. Scharff and V. Dusek includes 55 papers, of which many introductory are on philosophy of science and the paper starting the actual discussion on philosophy of technology by M. Bunge [33] is based on the assumption that technology is just an application of the theories of hard science. The question of ethics of technology is addressed by K. Schrader-Frechette [34] where technology itself (not its applications) is seen as misevaluating technological risks, thus unethical. Such anti-technological flavor can be seen in many of remaining papers; of the final seven papers, only one by E.G. Mesthene [35] is free of such flavor, but it is immediately followed by a paper criticizing the previous one and presenting technology as the opiate of intellectuals by J. McDermont [36]. The writings from [31] are notably absent. And in all 55 papers, *there is no paper written by a technologist.*

4.2 A few acceptable views

Nevertheless, a few papers present views that are acceptable to technologists; notably, they are the ones most discussed or criticized by other papers.

The most close to the perception of a technologist what he truly does is the fundamental analysis of M. Heidegger in

Die Technik und die Kehre [37], repeated in [32] in somewhat unfortunate translation *The Question Concerning Technology* (we use somewhat more adequate translation as a part of the title of this paper). *The Question Concerning Technology* is commented upon in [32] by a number of other papers, mostly trying to show either that Heidegger perceived technology as an autonomous, dangerous force or that he was not enough critical of technology. The problem of the difficulty and diversity of interpretations relates to the fact that Heidegger was a poet at heart, playing with words to achieve empathy and *essential truth* as opposed to a *correct understanding.*

Another important paper in [32] showing the understanding of the (Heideggerian) *essence* of technology is that of E.G. Mesthene [35] on the subject of social impact of technological change. We quote here some of his sentences important for further analysis:

> *"At its best, then, technology is nothing if not liberating. Yet many fear it increasingly as enslaving, degrading, and destructive of man's most cherished values. It is important to note that this is so, and to try to understand why."*

Unfortunately, further analysis given by Mesthene is not conclusive, because he does not make a clear enough distinction between technology proper and the socio-economic system exploiting technology.

4.3 The dangers of misunderstandings

There is, however, a grave danger in the mistaken diagnosis that technology is an autonomous, enslaving and degrading force: *a wrong diagnosis cannot help to cure the illness.* Technologists disregard the diagnosis as a sign of misunderstanding; postmodern social scientists have a scapegoat to put the blame on, thus do not reflect on their own responsibility. But both sides should feel responsible.

Technologists perceive this type of misunderstanding by social sciences also in other cases. In systems research, there is the debate between *soft systems thinking* and *hard systems thinking,* e.g., the issue of *Soft Systems Methodology (SSM)* [38]. SSM stresses listing diverse perspectives, so-called *Weltanschauungen, problem owners,* and following open debate representing these diverse perspectives. Actually, when seen from a different perspective, that of hard mathematical model building, SSM – if limited to its systemic core – is an excellent approach, consistent with the lessons derived earlier from the art of modeling engineering systems. More doubts arise when we consider the paradigmatic motivation of SSM. SSM is presented by P. Checkland in [38] as a general method, applicable in interdisciplinary situations; but a sign of misunderstanding is his opinion that *soft systems thinking* is broader and includes *hard system thinking* as defined there.

But then, should not SSM be also applicable to itself? It includes two *Weltanschauungen: hard and soft;* thus *the problem owners of hard Weltanschauung should have the right to define their own perspective.* However, hard systems practitioners never agreed with the definition of hard systems thinking given by Checkland. He defines hard systems thinking as the belief in the statement of [39] that *all problems ultimately reduce to the evaluation of the efficiency of alternative means for a designated set of objectives.* On the other hand, hard system technological practitioners say *no, they are hard because they use hard mathematical modelling and computations, but for diverse aims, including technology creation, when they often do not know what objectives they will achieve.* As a result, hard and soft systems researchers simply do not understand each other.

5. WHAT TECHNOLOGY IS AND WHAT IT IS NOT

5.1 The definition of technology by Heidegger as understood by a technologist

Heidegger came closest to the *essence* of technology by stressing several essential facts:

- Technology is obviously means of transforming nature and also obviously a human activity;
- *Technology is an art of solving practical problems,* not an application of abstract theory;
- In its *essence,* the technological act of creation is an act of *revealing the truth* out of many possibilities offered by nature.

We can thus interpret Heidegger that *humans cannot escape creating technology,* similarly as a child cannot escape playing with blocks. It is thus our basic, even defining characteristics, an intrinsic human faculty.

> *No matter how we define humanity, we would stop to be human if we stopped technology creation.*

5.2 The warnings of Heidegger as understood by a technologist

Heidegger perceived that technology in industrial civilization changed essentially when compared to older times by offering humans an almost complete control over nature. However, such control, when exercised without reflection and restraint, might threaten the very essence of human being. This warning was correct, we learned later that our control over nature is never complete and that unrestrained control over nature is very dangerous for us. But Heidegger never condemned technology in itself as an autonomous, alienating and enslaving force. This condemnation came later, started in social sciences by Marcuse [26]. Heidegger writes (about the results of perception of a complete control over nature) explicitly: *"Meanwhile ... man exalts himself and postures as the lord of the earth".* Thus, though Heidegger did not make a precise distinction here, *his warning concerns not technology proper, but the social use of technology.* Nevertheless, a technologist must read a lesson from these controversies: *he must be careful what technologies he creates, because the socio-economic system might use them without restraints and the blame will be put later not on the system and social scientists apparently responsible for such systems, only on technology.*

5.3 The sovereign though not autonomous position of technology

We start with proposing a definition of technology derived from Heidegger but amended, acceptable to technologists, distinguishing *technology proper* from *the system of socio-economic applications of technology*:

Technology proper is a basic human faculty that concentrates on the creation of artifacts needed for humanity in dealing with nature. It presupposes some human intervention in nature, but can also serve the goal of limiting such intervention to the necessary scale. It is essentially a truth revealing, creative activity, thus it is similar to arts. It is also, for the most part, a problem solving activity, concentrating on solving practical problems.
Thus, it uses the results of basic sciences, if they are available; if they are not, technology proposes its own solutions, often promoting this way quite new concepts assimilated later with delay by hard or social sciences. It is not an autonomous force, because it depends on all other human activities and influences them in return. It is, however, sovereign, in a similar sense as arts are sovereign human activities. Autonomous forces can be found in the socio-economic system of applications of technology proper.

5.4 The reverse relation of science and technology

It happens very often that technological solutions precede the developments of science. The first obvious example is the technological development of a wheel. The mathematical concepts of a circle and that of actual infinity stem from this technological development: a wheelwright constructs a wheel as a polygonal structure, slowly increasing the number of sides of the polygon by cutting consecutive angles, until an approximate circle and an (approximately) smooth wheel is achieved. Another example, well known in the philosophy of science, see [31], is the impact of the development of a telescope on astronomy and Galileo's findings.

But there are also modern examples. The improvement of a steam engine by Watt was a mechanical control engineering feedback system for stabilizing the rotational speed of the engine (before Watt, the rotational speed was unstable and steam engines tended to explode). This not only started the industrial civilization era, it also motivated several lines of scientific enquiry: the stability of dynamic systems [40], [41], leading eventually to diverse aspects of nonlinear systems dynamics and to the theory of deterministic chaos, thus finally to the emergence principle, see [42], [13], [2]; the extremely important concept of feedback, upon which we comment later, attributed incorrectly to N. Wiener [43], [28], actually developed much earlier [44], [45]; the concept of a system, attributed by social science first to Comte, then to [43], [16]; but practical systems engineering developed in technology much earlier, since Watt, and has lead eventually to the most developed technological systems today – to computer networks.

There are also many examples in information technology: a *quasi-random number generator* in digital computers, preceding the development of the theory of deterministic chaos; the development of *data warehousing,* preceding the needed extensions of existing data base theories; etc.

5.5 Two positive feedback loops

Thus, how do hard, basic science and technology depend on each other? As in many questions of human development, they influence each other through the intellectual heritage of humanity, the *third world* of K. Popper, see [46], [2]. But this influence forms a *positive feedback loop,* see Fig. 1; technological development stimulates basic science, scientific theories are applied technologically.

Recall that *feedback* – the circular impact of the time-stream of results of an action on its time-stream of causes – was used by Watt in a *negative feedback loop*. Feedback can be of two types: *positive feedback* when the results circularly support their causes, which results in a fast development, like a growing avalanche, and *negative feedback* when the results circularly counteract their causes, which leads to an actually positive effect of stabilization (for example, the stabilization of human body temperature is based on negative feedback). The concept of feedback essentially changed our understanding of the cause and effect relationship, resolving paradoxes of circular arguments in logic, though it must be understood that such paradoxes can be resolved only by dynamic, not static reasoning and models.

But the positive feedback loop between technology and science works slowly: technological stimulations are analyzed by science with much delay, technology also does not reply instantly to new scientific theories.

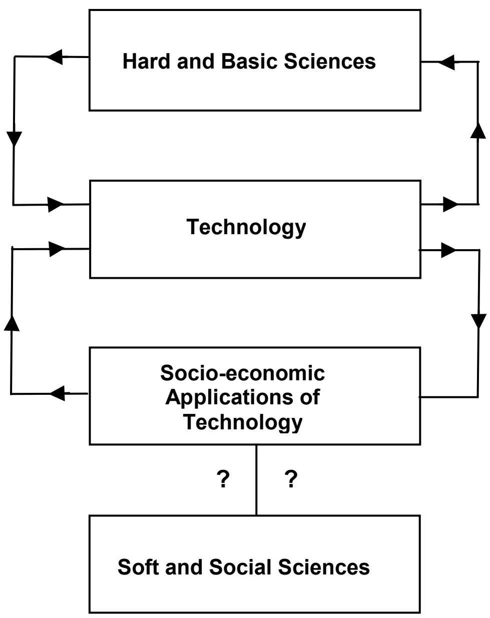

Fig. 1. Two positive feedback loops

The second positive feedback loop is between technology and the systems of its socio-economic applications. The distinction between technology proper and its socio-economic applications is not stressed sufficiently by social sciences, though it should be obvious for at least two reasons. The first is that technologists often work on a technological problem quite long (e.g., almost fifty years in the case of digital television) before their results are broadly socially applied. The second is simple: *technologists do not make much money, technology brokers do,* similarly as art brokers make more money than artists. By *technology brokers* we understand here entrepreneurs, managers, bankers, etc.: all our socio-economic systems turn around applications of technology. If a technological product or service, such as mobile telephony, produces much revenue, then more money is available for its further technological development; this leads to truly *avalanche-like processes of social adoption of technological hits.*

But these processes have also strange dynamic properties, socio-economic acceptance of novelties is slow, there is usually a large delay time between purely technological possibility and the start of an avalanche of its broad socio-economic applications (this delay time amounted also to almost 50 years in the case of cellular telephony). This delay has many causes: the necessity to develop such technological versions that are inexpensive enough for an average customer; an initial social distrust turning into a blind social fascination once a technological hit becomes fashionable. Once it starts to work, the second positive feedback loop is much stronger and faster than the first one.

This blind social fascination is actually the autonomous force incorrectly attributed by social philosophy to technology proper, it is precisely the source of the Heideggerian danger that *man exalts himself and postures as the lord of the earth.*

For example: how many people are aware that mobile telephony makes it very difficult to practice radio-astronomy from Earth surface, that it is the reason of moving radio-telescopes into cosmic space? And this is a relatively modest adverse effect; what if an avalanche-like adoption of a technological hit would result in truly disastrous effects? After all, a nuclear power station is also based on avalanche-like processes that must be carefully controlled – by negative feedback systems of control engineering – to be safe; but if such systems fail (or are tampered with for fun by irresponsible people, like in the Chernobyl case), the disaster can have no limits.

The answer to the question of Mesthene: *why it is so that many people perceive technology as an alienating force, enslaving, degrading, and destructive of man's most cherished values,* might be the following: *the essential reason of it is the intuitive perception of such danger of a social infatuation with technology leading to avalanche-like process of adoption of technological hits with diverse resulting threats and possible catastrophic results.*

Being intuitive, the perception needs not be rationally correct and the diagnosis can be wrong, see the discussion of a rational theory of intuition in [2]; we must analyze it critically. Thus, we encounter here crucial questions:

1) What mechanisms limit and stabilize the avalanche-like processes of socio-economic adoption of technological hits?
2) Who is responsible for overseeing that these mechanisms work effectively?

The one mechanism that at least safely prevents any economic excesses is the market economy; people tried to replace market by human intervention in the communist system without success. However, it is only a robust mechanism, it does not solve many problems. For example, because knowledge-based economy sharply decreases marginal production costs, prices on high technology markets have today no relation to (actually, are over hundred times higher than) marginal production costs; an ideal, free market simply does not work in knowledge-based economy, an monopolistic or oligopolistic behavior is typical, see, e.g., [47]. Who will oversee such globalized markets?

As to the responsibility, obviously it should be borne first by the *technology brokers*. However, to be effective on the market, they must be motivated by profit, let us only hope that the motivation will be tempered by ethics. Ethics results from education; *who educates technology brokers?* Not technologists proper, but social, economic, management scientists. They should not only educate well technology brokers ethically, but also help them to understand their future jobs by analyzing the mechanisms of social demand for technology, of infatuation with technological hits, together with their dangers.

> Thus, *the responsibility for socio-economic applications of technology, for overseeing the effective limitations of blind social fascination with technological hits lies also at social sciences.*

Unfortunately, they do not perform well in this respect. This is indicated by the question marks in Fig. 1: while the role of hard, basic sciences and technology proper versus its socio-economic applications is clear, social sciences do not seem to even understand their role.

This does not mean that technology proper is not co-responsible and should not at least try to work together with social scientists on limiting such dangers. However, a technologist usually considers carefully possible future impacts of technology developed by him; moreover, he must be careful because he knows that the blame for any possible misapplications will be put on him. On the other hand, the responsibility of technologists will not prevent all misapplications of technology. Human creativity of misapplications is boundless (*against stupidity, the gods themselves contend in vain*).

6. WHAT WILL BE THE TECHNOLOGY OF THE KNOWLEDGE ERA

6.1 The character of technology in the knowledge era

We must ask today a renewed version of Heidegger's question: *in what qualitative aspect will the technology of knowledge civilization era differ from the technology of industrial civilization era?* A tentative answer proposed as the main conclusion of the paper is:

> *The technology of knowledge civilization era will differ in complexity, by proposing an unlimited number of diversified technological possibilities, oriented toward not only products, but also services, including such services as creativity support, and only a small part of these possibilities will be actually accepted for economic and social use.*

6.2 Some examples of technology of the knowledge era

One of the most important possibilities brought by the technology of the knowledge era will *be the change of the character of recording of the intellectual heritage of humanity.* In the last two civilization eras – the pre-industrial and the industrial – the dominant medium of recording the human heritage were printed books. Informational technology will make soon possible *fully multimedial recording of human heritage;* in other words, instead of a book we will have an electronic record including film, music, interactive exercises and virtual laboratories. This change will have impacts exceeding the impacts of Gutenberg printing technology; the nature of our civilization will change, multimedia recording will stronger support the intergenerational transmission of intuitive knowledge and of humanity intuitive heritage, will enable more effective distant and electronic education, see [2] for more detailed discussions.

Another possibility concerns *ambient intelligence,* called also *AmI* in Europe, either *ubiquitous* (omnipresent) *computing* or *wireless sensor network* in the United States, *intelligent home* or *building* or *yaoyorozu* in Japan. There is no doubt that the number of possible ways of helping people by using computer intelligence dispersed in our ambient habitat is endless; people will buy such technology once it is truly ubiquitous and inexpensive. However, there are also grave social threats: AmI requires electronic identification of a person entering a room. What would constrain too ambitious police from realizing the idea of a *Big Brother?* AmI means also ubiquitous robotization; what would constrain too inventive criminals from using robotic squads to break into banks or as invincible bodyguards?

We will mention here only one additional from the endless possibilities of future technology of the knowledge civilization era. *Computerized decision support*, developed towards the end of industrial civilization, can be developed further into *computerized creativity support,* helping in the creation of knowledge and technology. For this purpose, we must understand better knowledge creation processes – not on a macro historical scale, such as in the theories of T.S. Kuhn [48] and many philosophers following his example, but on a micro scale, for today and tomorrow. There are many such micro-theories of knowledge creation emerging in the last decade of the 20^{th} century and in the first decade of the 21^{st}; the book *Creative Space* [2] was motivated precisely by the need of integrating such theories.

6.3 New warnings: what we must be careful about

In all these possibilities, complexity and diversity, there is also a general danger and we must thus also repeat a renewed version of Heidegger's warning. The danger lies in us, humans fascinated by the possibilities of technology and not understanding the threats of such fascination. In particular, the seemingly unbounded technological possibilities might suggest to people – particularly to *technology brokers* – that human intellectual heritage is rich and boundless enough to privatize it without restraint. However, the unbounded privatization of natural resources in the industrial civilization era led to grave environmental pollution; unbounded privatization of intellectual heritage will lead to a pollution of this heritage – what we already observe, e.g., on medicine drug markets. The modified Heideggerian warning is:

In the industrial civilization era, people have became blinded by their seemingly unlimited power over nature given to them by the industrial technology, what has led to many degradations of natural environment. We must take care in the knowledge civilization era not to become blinded by the seemingly unlimited possibilities of products and services offered by technology, in particular –we must take care to preserve our intellectual environment, the intellectual heritage of humanity.

This warning is essentially different than those presented even by most deep writings of social scientists, e.g. [49].

7. CONCLUSIONS

Technology contributed essentially to the change of civilization eras, from the industrial to informational and knowledge civilization observed now. The change has a social character, but resulted from technology. The related *dematerialization of work* was desired by many social thinkers, but, ironically, they often condemned technology as an autonomous, alienating, de-humanizing force, as a technocratic tool of enslavement or functionalist view of the world. This is still a reason of the lack of understanding of technology by social sciences, in particular by postmodern social philosophy.

An acceptable definition of technology at the beginnings of knowledge civilization era is proposed in the paper; it stresses that technology is a basic human faculty that concentrates on the creation of artifacts needed for humanity in dealing with nature. As suggested by Heidegger, *technology is, in its essence, a truth revealing, creative activity, thus it is similar to arts.* It is also, for the most part, *a problem solving activity.*

The relation of *technology and basic science forms a positive feedback loop:* technology supplies tools and poses new problems and concepts for basic science; basic science produces results later applied in technology. More important is the *second positive feedback loop between technology proper and the system of its socio-economic applications,* which are managed by *technology brokers,* i.e. entrepreneurs, managers, bankers, etc. This second feedback loop brings about most social and economic results of technology, but at the same time it might result in grave dangers, because processes of socio-economic adoption of technological novelties in this feedback loop are avalanche-like. Such processes are known e.g. in nuclear reactors, where they must be controlled and stabilized by additional negative feedbacks. If this additional stabilization does not work properly, disasters might occur. *An intuitive perception of the threat of such disasters is the essential reason of the condemnation of technology by social sciences.*

In socio-economic adoption of technology, the stabilization of avalanche-like processes is achieved by market mechanism, but this mechanism on high technology markets does not function ideally and, obviously, markets do not resolve ethical issues of technology adoption. Since technology brokers are educated mostly by social, economic, management sciences, *the responsibility for socio-economic applications of technology, for overseeing the effective limitations of blind social fascination with technology lies also at social sciences.*

We also are repeating and strengthening, in new conditions, the Heideggerian warning about human fascination with technological possibilities: *we must take care in the knowledge civilization era not to become blinded by the seemingly unlimited possibilities of products and services offered by technology,* in particular – we must take care to preserve our intellectual environment, the intellectual heritage of humanity.

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