IOP Conference Series: Materials Science and Engineering

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To cite this article: N I Petrov *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1031** 012044

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Abstract. In this paper we shall examine the reliability of technological innovation systems as part of human evolution. Briefly explained are the basic definitions of these systems and the prehistory of their dialectics. The aim is to analyze and evaluate the development of certain technological industries in terms of the reliability of information about the structures and processes taking place in them.
Keywords: information, technologies, innovations, reliability.

1. Introduction
The notion of technological innovation system (TIS) arises as an idea related to the innovative research of human society. The introduction of this notion aims to explain the nature and pace of technological information change on planet Earth [1, 2].

The technological innovation system (TIS) could be defined as a "dynamic network of technologies, actors that communicate in a specific industrial/economic environment, situated in a certain institutional infrastructure, and involved in the generation, distribution and usage of new knowledge about nature" [3]. The approach towards implementation of TIS could be used for at least three types of analysis: in terms of knowledge field, tech product or a set of interrelated products, which aim at satisfying a particular social function [4]. Regarding the latter type of analysis, the approach has proven itself in explaining why and how sustainable energy technologies develop and spread in a certain society or why they fail.

2. Prehistory
The idea about technological innovation system (TIS) was initially introduced as part of broader theoretical movement called innovation system. The leading concept behind it is that the determining factors for tech change are not found in concrete entities or scientific research institutes, but also in a broader social network, in which companies as well as institutions are connected [5, 6]. Since 1980 research on innovation systems has marked the influence which social structures exert upon tech change and, respectively, their indirect impact on long-term economic development of countries, sectors and tech industries.

The purpose is to inspect and evaluate the development of certain tech industries in terms of the reliability of information about the structures and processes taking place in them. Apart from this purposeful reason there exist two more motives which are more analytical and which elevate TIS above other innovation approaches.

Firstly: the TIS concept emphasizes that stimulating the flow of knowledge is not enough to foster tech change and economic performance. The need to use this knowledge in order to create new tech and business opportunities is present as well. Thus, the emphasis is on the importance of people as sources of innovation – something which is sometimes missed by macro-oriented, national or industry innovation approaches [7].

Secondly: The technological innovation system focuses on the dynamics of world society [8]. Concentrating on entrepreneurial activities encourages scientists to think about TIS as something to be built over time. This has already been proposed by Carlsson and Stankiewicz. They defined the technological innovation systems on the basis of information about the knowledge flow, and not on the flow of ordinary productions, goods and services**.** They comprise of dynamic networks for scientific knowledge and competences. In the presence of an entrepreneur and a big enough critical mass of scientists, these networks could be transformed into development teams, i.e. synergic aggregations of companies and technologies into an industry or a group of industries [3].

This means that TIS could be analyzed in terms of its components, in terms of its dynamics, in terms of the Ecological balance of the world and in terms of the amount of information it contains and its dialectics, respectively.

3. Ecological balance of the Earth and information

On Earth there exist information energy-biological forms of life that provide the functioning of its flora and fauna, the greenhouse effect, the ozone layer and a number of other conditions in our surroundings (ecology) and its balance. In the information environment on Earth, there are certain forms of life that represent the interaction between light (source of life) and the available forms of matter on the planet. Analogical are also the interactions with field emissions, elementary particles, antiparticles, electrons, atoms, molecules and molecular formations. The auto-information genesis of the Planet is provided by its internal information capacity or at the expense of the auto-correlational relations with the light-bearing space surroundings of the Universe (the Sun and the space from it till the Earth). The function of the different forms of life is procured at the expense of information synthesis that redounds to the corresponding form of life – elementary particles, antiparticles, electrons, atoms, molecules and their compounds, plasma etc. [10-12]. Therefore, on each cosmic formation (dust, asteroid, plasma or gas) the following forms of life are found: light (photon), elementary particles, atomic, molecular, electron-plasma etc. All these forms of life arise via adaptation and functioning in accordance with the law of information unity of the nature on Earth [14, 15], the environment of people, machines, transport, technologies for social interaction (means of communication and surveillance), services (including medical) and, of course, traditional culture [16-19].

4. The amount of reliable information and its measurement

It is well known that information is generally related to entropy (the measure of uncertainty). However, there is also a deep dialectic relation between uncertainty and information:

Information is just the opposite of uncertainty, i.e. it is definiteness with a certain level of reliability [13]**.**

Such an understanding about information incorporates both disorder and arrangement as special cases of uncertainty and definiteness. Here is held the deep philosophical meaning of information reliability in a system. It exists thanks to the eternal shift of uncertainty with definiteness in the system concerned. In this sense, information and its reliability play a special role for the considered as a cybernetic system society, as it objectively accompanies the world social process.

Let us indicate the uncertainty function of a particular system with $f_{UN}(y)$ where y is the number of its outputs. Then, in a system with one possible output $y = 1$ uncertainty will not exist, i.e. the equation will be fulfilled

$$f_{UN}(y) = 0, \qquad (1)$$

From (1) and the famous article of Shannon, Mathematical Theory of Communication, the three attributes of the uncertainty function could be derived [12]:

$$f_{UN}(1) = 0;$$

$$f_{UN}(m) \leq f_{UN}(n);\ m \leq n;$$

$$f_{UN}(mn) = f_{UN}(m) + f_{UN}(n), \quad (2)$$

where m and n are, respectively, the number of outputs of the examined system at different moments of time.

The only function which satisfies the conditions (2) is the logarithmic function where the logarithm base is $a > 0, a \neq 1$. As a result from this, it could be concluded that uncertainty is not any type of function of the number of system outputs, but it is proportional to the logarithmic function. If we mark the uncertainty function $f_{UN}(y) = N$ and the number of outputs of the examined system is n, then the equation will be

$$N = k \log_a n,\ \ a > 0, a \neq 1, \quad (3)$$

where k is defined by the chosen base of the logarithm.

After the specific event comes true and it corresponds with the examined system, the uncertainty N turns into information about the reliability of the event as the probability for flawless realization of the event is $P_{БР}(\Delta t) = 1$ in the examined time intervalΔt. The information amount function is denoted with I resulting in

$$I = N = k \log_a n, \quad (4)$$

A conversion of (4) is undertaken as follows:

$$I = k \log_a n = -k \log_a n^{-1} = -k \sum_{i=1}^{n} {}^{1}/_{i}\ \log_a n^{-1}, \quad (5)$$

From (5) follows the equation

$$I = -k \sum_{i=1}^{n} {}^{1}/_{i}\ \log_a n^{-1}, \quad (6)$$

Equation (6) is fulfilled when the corresponding random logarithm base is $a > 0, a \neq 1$, while the value of the coefficient k depends on the chosen base. Let us thoroughly examine (6). The number of possible cases or the number of possible outputs of the system is marked with n. When all cases are equally probable, then $1/n$ designates the probability of occurrence of each one of them. For instance, when rolling a dice, the probability for 6, 5 or 1 to occur is always $1/6$, while when tossing a coin is $1/2$ respectively. However, though, the systems with equally probable outputs are not so common in reality. This requires the derived formula (6) to be summarized.

Let one technological innovation system (TIS) for production or management have an n number of outputs and let each output have a probability of occurrence (realization) p_i, while the condition $0 \leq p_i \leq 1$ is fulfilled. In this case the following will be fulfilled:

$$\sum_{i=1}^{n} p_i = 1, \quad (7)$$

because in at least one of the possible cases p_i should occur.

Out of (7), (6) will be transformed into the form of:

$$I = -k \sum_{i=1}^{n} p_i \log_a p_i, \quad (8)$$

IOP Conf. Series: Materials Science and Engineering 1031 (2021) 012044 doi:10.1088/1757-899X/1031/1/012044

The question about measuring information via formula (8) needs to be addressed, i.e. the unit of measure. Naturally, the smallest amount of information is accepted to be a unit of measure. Considering the properties of the uncertainty function $f_{UN}(y)$ of a TIS for management, presented in (2), this will lead to the conclusion that the smallest amount of information different from zero will result from the fulfillment of the condition $n = 2$.

This is typical of a system of management with two outputs, i.e. information system for communication with two levels 0 and 1; TIS with two conditions: "fit for work – out of order"; diagnostic system with two conditions "has – has not"; positions of the coin – "head – tails" etc.

As noted above, the two symbols are enough for the transmission of any discrete message. Therefore, the amount of information I_2 for transferring of both symbols 0 and 1 will be held in a single impulse, i. e. it will be equal to 1. The probability p_i for transmitting of both equally possible symbols 0 and 1 is $p_i = 0{,}5$. From (7) and (8) will follow:

$$I_2 = -k \log_a 0{,}5 = 1, \tag{9}$$

Because k is a random coefficient, then we could assume that it is equal to one, which results in:

$$I_2 = -\log_a 0{,}5 = 1, \;\; \log_a 0{,}5 = -1,$$

$$a^{-1} = 0{,}5; \;\; {}^{1}/_{a} = 0{,}5; \;\; a = 2.$$

Thus, the logarithm base in equation (8) is determined by the transformations above and it will be $a = 2$.

Therefore, the amount of information I_2 for transmitting of both symbols 0 and 1 will be a unit of measure. It is called bit.

This will lead to the conclusion that every system for management (informational, technology-economic, chemical, biological and so on) with two possible output conditions ("yes-no") includes one bit of information.

Formula (8) about the amount of information when transferring more symbols is written in a final:

$$I = -\sum_{i=1}^{n} p_i \log_2 p_i; \;\; \sum_{i=1}^{n} p_i = 1. \tag{10}$$

The fundamental formula (10) is called Shannon's formula about the amount of information that passes through a random technology-economic system for management.

Contemporary information theory has progressed so much that there exist opportunities for automatic calculation of different types of information which are exchanged between the systems. However, the information theory is almost inapplicable in the economic-social area. Usually, only formula (10) is used that represents the amount of information in a specific flow of documents, calculated on the basis of the symbols used. A scientific revolution in this area is coming.

It should be noted that long before Claude Shannon discovered formula (10) for the amount of information, Norbert Wiener and the English statistician Fisher had come up with the common idea for the usage of information in economic-social and biological systems. It was discovered by Ludwig Boltzmann and was used for measuring disorder (chaos) of physicochemical and biological systems (i. e. for measuring the entropy of systems conditions) [16].

Due to this fact it is correct to name formula (10) Bolzmann - Shannon.

From (2) the following important philosophical conclusion could be drawn: The more possible output conditions a system has (TIS, in particular), the less its reliability in the observed space is.

The statement above allows us to build up the following reliability-information structural scheme of TIS functioning:

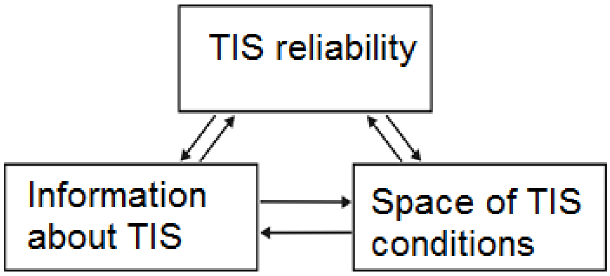

Figure 1. Reliability - information structural scheme of TIS.

This scheme of TIS functioning leads to a new formula for the amount of flowing through the system information and the reliability of TIS functioning, i. e. a formula for the amount of reliable information:

$$I_{RI} = -\sum_{i=1}^{n} p_i . \log_2 p_i . \{P_{FFO}(\Delta t)\}. \quad (11)$$

In (11) the probability function for faultless operation $P_{FFO}(\Delta t)$ of the system in the observed interval $\Delta t = t_1 - t_2$ is defined by the basic "Law of reliability" of TIS in a stationary, ordinary flow of failures and lack of consequences according to the equation:

$$P_{FFO}(\Delta t) = e^{-\int_{t_1}^{t_2} \omega(t)dt} = exp\left[-\int_{t_1}^{t_2} \omega(t)dt\right], \quad (12)$$

where: $\omega(t)$ is the intensity of failure flow (violations) in TIS for the time interval that is under observation$\Delta t = t_1 - t_2$; $e \approx 2{,}718$ represents the number of the Scottish mathematician John Neper.

From (11) and (12) follows the final formula for the amount of reliable information I_{RI} that passes through a TIS.

$$I_{RI} = -\sum_{i=1}^{n} p_i . \log_2 p_i . \left\{exp\left[-\int_{t_1}^{t_2} \omega(t)dt\right]\right\}. \quad (13)$$

The unit of measurement of the introduced in such a way new reliability characteristic for the amount of information will be Bit-Fita. We should recall that the unit of measurement of failure flow intensity is called Fit, where 1 Fit = 1 ref/h.

5. Conclusions

As a result of the research done by the authors, the following scientific conclusions have been drawn:

1. The more possible output conditions a technological innovation system has, the less its reliability in the observed space is.
2. The formula that is derived for the amount of reliable information defines the quantity of information flowing through the system as well as the reliability of TIS functioning.
3. The tech change on Earth requires a high-grade new approach to information-digital thinking and an assessment of the reliability in relation to the future of the world.

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