Jüri ENGELBRECHT*

COMPLEX SOCIETY AND VALUES

Abstract: Contemporary society is a highly complex system which involves many constituents starting from alliances and states to individual persons. Like in other complex systems (physics, biology, etc), the links between constituents and the corresponding interactions along them determine the behaviour of a system as a whole. In physical systems such interactions are determined by physical laws, in social systems, however, the properties of links and the characteristics of interactions are not so clearly determined. In this case one should interpret these characteristics not only by certain material quantities but also by values which generate behaviour of the society. A short analysis of values in society is presented together with some examples.

Key words: *complexity, society, values*

INTRODUCTION

Complexity is an important notion not only in natural sciences but also in society. In a nutshell, complex systems are composed of a very large number of different constituents (elements) which interact with each other (mostly) nonlinearly. As a consequence, one cannot characterize a complex system by studying the behaviour of its constituents only because due to interactions the full system behaves in a manner which is not deduced simply by summing up the behaviours of its constituents. The contemporary studies of complexity started from ideas of L. von Bertalanffy and N. Wiener in mid-20th century in systems theory and cybernetics and then got a full swing in the second half of the 20th century in studies of chaos theory, self-organization, networks, multi-agent modelling, etc. The vast literature (see for example [1–8]) deals mostly with natural sciences. One should stress some basic ideas emphasized in these studies:

* Estonian Academy of Sciences and WAAS

One of the most highly developed skills in contemporary Western civilization is dissection: the split-up of problems into their smallest possible components. We are good at it. So good, we often forget to put the pieces back together again.

A. Toffler (1984) [9]

Complexity science offers a way of going beyond the limits of reductionism, because it understands that much of the world is not machine-like and comprehensible through a cataloging of its parts; but consists instead mostly organic and holistic systems that are difficult to comprehend by traditional scientific analysis.

R. Lewin (1993) [10]

With new terminology applied in different fields of knowledge, one should be careful because the notions could be understood differently. Take for example Humpty-Dumpty's attitude from Lewis Carroll („Through the Looking Glass"). Alice asked him „whether you can make words mean so many different things?" The answer was, „the question is, which is to be master — that's all". Here we follow notions from the analysis of physical systems and leave aside notions like algorithmic complexity, computational complexity, etc. Given the lessons from the analysis of such systems, the further attention in this essay will be turned towards complex society. Indeed, contemporary society is a highly complex system which involves many constituents starting from alliances and states to individuals — all entangled into a whole. Without any doubt, the complex social systems are a part of a complex world like described in an excellent collection of essays „Philosophy of Complex Systems" [11]. A special analysis of social systems from the complexity viewpoint is given in [12]. However, as far as in physical, biological, etc complex systems the interactions between the constituents can be described by quantitative links based on physical/physiological measures, in social systems the situation is much more complicated [13]. Yes, one can collect data from opinion polls, create databases of indices, characterize the structures (networks, etc but as a matter of fact, the qualitative measures which are of special importance in societies, are hard be characterized. In very general terms, one can call these qualitative measures as values. In this essay the discussion will be centred on values in complex societies.

In Section 2 the main lessons from the analysis of physical systems are described. The next Section 3 deals with values from the general viewpoint and further, in Section 4, the problem of values in societies is discussed. Some examples which could cast more light on these discussions are presented in Section 5. Finally, Section 6 is devoted to some conclusions.

COMPLEXITY OF PHYSICAL SYSTEMS

1) PHENOMENA

The signatures of complexity in physical systems are described in many monographs, see for example [6,7]). Starting from simple nonlinear cases, many important phenomena characterize the life in complex systems and much can be learned from them. It is even surprising that very simple nonlinear systems like the logistic equation or the three body system display rich dynamics that help in understanding more complicated cases. Even more, the simple sandpile dynamics [4] can open door for understanding earthquakes, traffic jams and economy.

First, some words about nonlinearity. In simple words it means that the rule of proportionality does not work and the links between inputs and outcomes are described by nonlinear rules. That means also that summing the influence of interactions is much more complicated than simple summing. Although known long time ago:

The whole is more than the sum of its parts.

Aristotle, Metaphysica

the full understanding of the importance of being nonlinear is the result of, let us say, the last half a century [14].

What follows is a brief survey of main effects which are important for understanding complexity.

(i) non-additivity and nonlinear interactions. This is the source for chaotic motions and typical for many physical systems modelled by mappings or differential equations. A typical example of a nonlinear interaction is the gravitational force between different masses. The three-body system (Sun, Earth, Moon) analyzed by H. Poincaré already more than a century ago has revealed the ideas of possible instabilities. Another iconic example is the Lorenz attractor describing simplified atmospheric motion using the system of three nonlinear differential equations.

(ii) deterministic unpredictability. The behaviour of deterministic nonlinear systems may not be predicted and lead to the chaotic regimes of motion. A typical example is a simple logistic equation (mapping) derived for calculation of changes in the number of species. The weather is described by nonlinear Navier-Stokes equations that again do not permit the accurate forecasts for longer periods.

(iii) sensitivity to initial conditions. Small changes in initial conditions for a dynamical nonlinear process may lead to large changes of the resulting quantities in the course of time. This phenomenon within the framework of a nonlinear simple model was discovered by Lorenz although Maxwell has already hinted to such a possibility in the 19^{th} century and Poincaré in the beginning of the 20^{th} century. As far as the accuracy of physical quantities is limited in their value, there exists a so-called predictability horizon [15] because for example one simply cannot determine the temperature distributions needed for long-term weather forecasts with the accuracy of many digits after comma.

(iv) there are several typical phenomena characterizing the behaviour of nonlinear systems like bifurcations when the new solutions emerge after small changes of control parameters, emergence when new patterns arise, attractors where the solutions are attracted to a certain space of variables (phase space), multiple equilibria which are characterized by several (co-existing) attractors, thresholds which mark the borders between the various states, coherent states where effects are balanced, etc.

(v) despite the variety of chaotic motions there are several rules which govern the processes: period doubling and Feigenbaum numbers, power laws, self-similarity, fractality of attractors, etc and also a number of methods which allow to analyse the processes: Melnikov method, renormalization method, determination of the Kolmogorov entropy and Lyapunov exponents for determining the scale of chaotic motions, etc.

Above is only a short-list of phenomena and methods in the nonlinear world. For more information one should consult the „Encyclopedia of Nonlinear Science" [16]. One should also stress the following. The usual understanding (common sense) is that nonlinear models are just a little bit corrected linear models. The world around us, however, is deeply nonlinear and the linear models, as a rule, are simplifications. Yes, in many cases simplifications work but essential effects are nonlinear. Next, the nonlinear physical problems are intensively studied and the ideas and methods can be used also in other fields, at least in the metaphoric sense bearing in mind that models in other fields might be more complicated and the characters of interactions are not so well described like in physical systems.

2) STRUCTURES

Here we explain briefly the main structural cornerstones of complex world and processes — fractals and networks.

The word „fractal" is coined by B. B. Mandelbrot [17] using Latin „frāctus" (broken or fractured) for describing irregular non-differentiable structures. The famous Mandelbrot fractal is generated by a quadratic mapping in the complex plane and possesses a wonderful property — self-similarity. In simple words, under various degrees of amplification (zooming) each small part of this fractal replicates the structure of the whole. It means that such objects are scale-invariant and in addition are characterized by non-integer (fractional) dimensions. The fractal geometry [18] is based on the idea of using feedback procedures that is simple repetitive rules for constructing very complicated structures. The iconic fractals named after Mandelbrot, Koch, Sierpinski, Cantor, Barnsley etc display explicitly the properties of fractals. The fields of usage fractals for describing physical phenomena cover a wide area of nature and technology: from coastlines to crystals, from describing attractors in phase spaces to Brownian motion, from fractals in biology to structure of time-series of financial markets, from characteristics of seismic activity to music, from mountain ranges and structure of lightning to heart rate, etc.

The lesson to be remembered is that the repetitive usage of simple rules generates complicated objects which possess some universal rules.

Another important notion is networks. In simple words, a networks is formed by a a large set of elements (nodes) which are connected through a pattern of different interactions (links). The world is full of networks: the ecosystems form networks and webs of species, our computers are linked to Internet or connected to the cloud computing, public transportation forms a network starting from local connections to intercontinental flights, economics and electric grids form a global network, social networks unite persons, etc. Again, there are several universal rules which help to understand life in global networks [8,19]. A powerful tool for describing networks is the graph theory which started with the problem of crossing Königsberg's bridges. L. Euler showed in the 18th century that given the number of bridges it is impossible to walk over all the 7 bridges only once. Nowadays we know much more about the structure and behaviour of networks. Despite the large number of nodes and links, a small world phenomenon exists with only six degrees of separation. Networks are in general terms stable and large networks do not usually break under the failure of one node or link but in some cases domino effects and cascading failures occur. The cases of failure of electric grids are known as warning examples with large-scale effects. The power-law governs the network structure but not as an ideal rule because in reality the power-law might have fat tails. There are certain limits in networks, in social systems for example, the Dunbar number (which is estimated around 150) limits the number of possible active social relations. The Matthew effect (the rich get richer) seems to be important not only in economy but also in science where attention is given preferably to known names (to Nobelists, for example). Hierarchical networks exist, possessing self-similarity and fractality.

Summing up, networks are skeletons of the complex world [8].

VALUES

Values play an important role in psychology, ethics, religion, etc and field of studies into values is called axiology (Greek *axios* — worth and *logos* — theory) — see for example [20].

Human behaviours are strongly influenced by values. In general terms, the basic values accepted by society according to T. Ash [21] are: freedom, peace, justice, prosperity, diversity, and solidarity. His analysis is concerned mainly with Europe and he stresses that this skeleton of values must have flesh in order to be acceptable at all circumstances in our 24-hour, 7/365 non-stop global world. But the values are space-dependent and environmental-dependent. It is not secret that the top athletes and top actors can earn more than top scientists, reflecting so the attitude from the society. Values are related to culture but the personal values of people may not entirely coincide with the general norms in societies. And certainly the societies are different when we speak about values. Inglehart and Welzel have constructed a cultural map of the world [22], where survival values and self-expression values are depicted against traditional values and secular-rational values. This map shows clearly the groupings of English speaking countries and Latin America, catholic Europe, protestant Europe and Confucian countries, ex-communist countries and Africa. Another possibility [23] is to use GDP per capita as one of the scales. Depicted against happiness and overall life satisfaction, their results show that religion, tolerance and society's level of democracy play important role for the happiness index. Religion and national pride were stronger factors in less developed countries than in developed ones. One should stress also that the level of satisfaction is more strongly influenced by economic conditions than the level of happiness. But their analysis takes also into account the temporal changes, for example the sense of free choice and subjective well-being shows clearly how the societies have been changed in time. Such an analysis [23] leads to demonstrating the human development path: from economic development, democratization and social liberalization the increase in sense of freedom follows which is in a strong correlation with the increase in subjective well-being.

Recently the attention is paid to happiness metrics which was proposed by the King of Bhutan in 1972 and later enlarged by many studies [24,25]. The Gross National Happiness (GNH) index measures the societal well-being based on several subjective and objective measures including beside the GDP also environmental wellness, social relation wellness, etc [24]. In some sense, it is a derivative of values because the factors of happiness include values into the key determinants of happiness (World Happiness Report, [26]).

SOCIAL SYSTEMS AND VALUES

Society is a complex social system. It can be modelled by networks and clusters, communities and alliances and is spatially and temporarily differentiated. Society is able to function not only because its structures but the behaviour of its members (constituents is physical sense) and links (interactions in physical sense) between them play the most important role. Turning to complexity of physical systems (Section 2), the interactions between the constituents are described by physical laws and can be measured at least with certain accuracy. In complex social systems the situation is much more complicated because the links are based on accepted rules (laws), traditions, language, and governance, on economic and environmental conditions and certainly on values. This leads to an interesting question how to combine our knowledge on complexity with „soft" qualities like values.

The problem is certainly old. For example, Plato believed into an objective measure of values in order to keep the system (ie society) in a state of harmony (see [27]). Actually his idea was related to maintaining a system with political power. In the contemporary world the situation is much more complicated. The qualities (good/bad, pleasant/unpleasant, etc) cannot be measured and the estimations of the qualities are based on observations, opinion polls and subjective judgements. Here a well-known experience from the history of science may be recalled. The Ptolemaic model of the Earth-centred solar system was based on observations. In order to explain the motions of planets, Ptolemy used combinations of epicycles which moved on a larger circle (deferent) and placed Earth out of centre of the deferent for describing the apparent speeding up and slowing down of planets. This theory proposed about 2000 years ago was used for about 13 centuries and only in the 16^{th} century Copernicus proposed the Sun-centred system. His ideas were elaborated by Tycho Brahe, Kepler and Galileo but the explanation was finally given by Newton. The Newton's gravity law explained the reason why planets move in such away. By the way, the gravity law is nonlinear. So the observations were not enough, one should find the reasons.

The large cornucopia of knowledge in physical sciences can support the modelling of social systems including descriptions of phenomena and structures (Section

2). For example, the notion of hierarchical structures is useful in social sciences but the archaeologists have added heterarchy as another important notion [28] following ideas from neural nets [29]. When hierarchies have elements which can be ranked and ordered then heterarchies have elements which are unranked or have potential to be ranked in a different way.

When considering the effects and behaviours in social systems, the main problem is: whether the observations are good enough to give the full picture of social processes or something is hidden. And another problem follows: knowing the gravity law one can predict the motion of planets but what is the predictive power of observations? And what can be overtaken from studies of complexity in other fields into modelling and understanding social systems? And what is the role of values for interactions in society?

First important question to start is: what are values? The next question is whether values are fixed or are changing. It must be stressed that Inglehart et al.[23] have shown by analysing the changes in certain values in society over 1981–2007 that these values are indeed changing in time. The subjective well-being (SWB) index demonstrates many changes due to changing environment. One should also understand what universals in the content and structure of values are and what priorities in values are [30]. Based on those notions, other studies have also indicated how values are different in various cultures [31]. However, the values have clearly inertia. A detailed analysis on value system in Estonia [32] has shown that the Soviet occupation of Baltic Countries before and after the WWII could not change all the inherited values. Said the authors: „in spite of the Soviet dominance of officially visible societal culture, the older Estonian generations seem to have been able to transfer a basically West-European value structure to their children and grandchildren."

Another example on changes illustrates the erosion of values. Once I wrote an essay on beauty of science (Engelbrecht, [33]) bearing in mind the beauty of nonlinear dynamics. It is well known that Paul Dirac and Pierre Duhem admired the beauty of physics. Writing the essay, I checked many encyclopedias and dictionaries on the definition of beauty, starting from the celebrated Encyclopedia Britannica from 1769. I collected many definitions such as beauty „is pleasing to the sense and intellect" and „is the combination of all the qualities of a person or thing that delight the senses and please the mind". However, in one of the recent dictionaries the entry „beauty" has a very laconic explanation — see „cosmetics"! No comments are needed.

In order to manage organizational complexity, the notion of values has been introduced as attractors of chaos [34]. It is argued that neither rigid objectives nor instructions are effective but a shared set of values should be accepted by members of an organization. These values can be divided into ethical (honesty, integrity, sincerity, loyalty, etc) and competence (creativity, flexibility, order, intelligence, etc) values and the final state of an organization is then described as an attractor in a self-organized system.

Based on the conversation between Alice and Humpty-Dumpty (Section 1) let us remind how the concept of truth is understood by different scientists and scholars [35]. The concept of truth is related to notions: correct, valid, coherent and right. According to [35] natural scientists trust only the first two, social scientists the first and third, humanists the third and fourth. It seems that the starting question is to find the common language which may divide natural scientists and humanists like Snow showed in 1959 in his famous lecture „The Two Cultures" [36]. Kagan [35] added social scientists in his „The Three Cultures" to this pair and showed how the scientists and scholars of different fields use different wording and methods. Complexity might be a unifying area of knowledge where all three might find a common language.

The interest to complexity in social systems is growing. An overview by Byrne [12] is an excellent introduction to social systems from the viewpoint of complexity but one cannot find „value" in its index. In the large overview on complexity [11] describing many field of knowledge, is only one short subsection on values concerning the role of values in public policy resolution of complex dynamics.

EXAMPLES

Some examples how the knowledge from physical complex systems has improved understanding of social systems follow.

First, let us mention that the methods derived for the analysis of physical processes can also be effectively applied for the analysis of time-series in social processes. For example, the multi-scaling of low-variability periods and multi-affinity of time-series can be used for the analysis of financial time-series [37]. Further, the same authors have introduced „good" and „bad" notions for the analysis of portfolio optimization [38] attributing these notions to fluctuations of portfolio distributions. Actually these studies belong to the fast growing field of research called econophysics (cf [39]. A textbook describing macro-economical processes like business cycles, interregional trade, monopolies and oligopolies etc using the language and methods of nonlinear dynamics is masterly written by Puu [40].

One could use also network analysis for country-country and product-product links in order to estimate the structure of the world economy [41]. This analysis has estimated unexpected socio-geographic links which can be characterized as nonlinear interactions between the diversification of a country and the ubiquity of its products.

There are not so many examples where values are introduced into the analysis. One example is related to using the GDP which is usually taken only at its face value for determining the effectiveness of countries. A new metrics introduced for estimating the countries' fitness could give much more information [42]. The idea is to assess the non-monetary competitive advantage of diversification using nonlinear maps and taking into account the country fitness and product complexity. The fitness actually measures the level of the competitiveness of a country and is proportional to the sum of the products exported weighted by their complexity. Such an approach is able to understand the hidden potential of a country for development, ie to predict the growth. Typically, the power laws characterize the fitness [42]. The analysis has revealed the strongly heterogeneous patterns of evolution [43]. In the fitness-income plane the laminar and chaotic zones are estimated. For chaotic zones where the predictability is low, a data-driven method has proposed for assessing the future developments of countries. In these studies, fitness could be linked to values.

Information and communication technology (ICT) is a trademark of the contemporary society. The world-wide web with its nodes and links is an excellent example of a complex system. The use of the ICT has an essential impact on economy and social system but raises also ethical problems, ie value problems. The EU Future Emerging Technologies (FET) Flagship pilot project „FuturICT" had one of its goals Value Sensitive Design (VSD). The basic idea of the VSD is making social and moral values central to the development of ICT [44] stressing that it is a primary goal not a by-product. In general terms, the VSD aims at making values part of technological design, which means embedding technology into the complex society needs ethics taken into account. The „FuturICT" paid a lot of attention to a code of conduct of scientists developing the ICT: to promote human well-being, reduce vulnerability of the society, promote fairness, increase social capital and the happiness of people, protect privacy, etc [44].

FINAL REMARKS

Society is without any doubt a complex system and the idea to use the knowledge from the analysis of physical complex systems in the analysis of societal problems is tempting. Indeed, the notions of nonlinearity, interactions, self-organization, stability and chaos, unpredictability, sensitivity to initial conditions, etc are phenomena which could characterize also social systems. However, not everything is easy because:

„...physical and computational measures of complexity exist in abundance. These can provide a starting point for creating social complexity metrics, but they need refinement for the simple reason that electrons don't think".

„To harness complexity,..., we must take a generative perspective and see social outcomes as produced by purposive authors responding to incentives, information, cultural norms, and psychological predispositions."

S. E Page (2010) [45]

As shown above, one of preconditions is to speak in the common language. It is not the problem of cultures only [31], it is also a problem of scientific communities [35]. Another important problem is causality because the observations cannot always reveal the reasons. Forcing societies to fit in a box without understanding the reasons may lead to serious consequences like we witness in many world affairs. Interdisciplinarity is really a way the society together with scientists and scholars must move. There are surprising similarities in many fields of human activities and much can be learned from these [46]. Metaphors encompass often our everyday communication and can also be used in explaining the behaviour of complex social systems. Such an approach is advocated by Wheatley [47] for management and leadership. She does not enter into the technical details of chaos theory and complexity in terms of physical systems but recommends convincingly using these ideas to management of social systems and also for educational purposes.

Many phenomena in the physical world can be measured and counted. Even in social systems the counting has taken enormous pace, let it be citations of research papers or indices of productivity. However:

„Not everything that can be counted counts, and not everything that counts can be counted."

W. B. Cameron (1963) [48]

This saying is sometimes attributed to A. Einstein but actually it belongs to a sociologist not to a physicist. Now the important question comes: what shall we do with that which cannot be counted but is important? In physical complex systems constraints are used in order to limit or guide the process, in social systems it seems that values are leading and guiding factors. Common sense says that constraints may have slightly negative meaning but actually they describe certain limits of processes. On other hand, values generally have positive meaning but value systems in different communities may also be different and that may cause problems like we witness not only in Europe but worldwide. An interesting idea based on using metaphors is to determine values as attractors [4]. This means that the behaviour in a system may be attracted (trapped) to a certain space domain and not to another. However, following this idea, we might think about the co-existing attractors. In this case an external influence will move the motion, ie the behaviour to another space domain. Here is much to be discussed and analysed.

Beside values, the structures of systems are also important as well as interactions but social systems need something more. This is why we must think very carefully how to embed values into the analysis and explanations of processes. This is where physical scientists and social scientists could meet and learn from each other [50].

REFERENCES

[16] I. Prigogine and I. Stengers: *Order out of Chaos.* Heinemann, London, 1984.
[17] M. M. Waldrop: *The Emerging Science at the Edge of Order and Chaos.* Simon and Schuster, New York et al., 1992.
[18] S. Kaufmann: *At Home in the Universe: The Search of the Laws of Self-Organization and Complexity.* Oxford University Press, New York, 1995.
[19] P. Bak: *How Nature Works.* Oxford University Press, Oxford et al.,1996.
[20] S. Strogatz: *Sync.* Allen Lane Penguin Books, London et al., 2003.
[21] G. Nicolis and C. Nicolis: *Foundations of Complex Systems.* World Scientific, New Jersey et al., 2007
[22] P. Érdi: *Complexity Explained.* Springer, Berlin and Heidelberg, 2008.
[23] A. Barabasi and J. Frangos: *Linked: The New Science of Networks.* Basic Books, 2014.

[24] A. Toffler: „Foreword". In: I. Prigogine and I. Stengers. *Order out of Chaos*, Heinemann, London, xi-xxvi, 1984.
[25] R. Lewin: Complexity. Life at the Edge of Chaos. J. M. Dent Ltd, London, 1993.
[26] C. Hooker (ed.): *Philosophy of Complex Systems*. Elsevier, Amsterdam et al., 2011.
[27] D. Byrne: *Complexity Theory and the Social Sciences. An Introduction*. Routledge, London and New York, 2001.
[28] C. Mesjasz: „Complexity of social systems". *Acta Phys. Polonica A, 2010, 117, 4, p. 706–714.*
[29] A. Scott: *Nonlinear Science*. Oxford University Press, Oxford, 1999.
[30] J. Lighthill: „The recently recognized failure of predictability in Newtonian dynamics". *Proc. Roy. Soc. London, 1986, A 407, p. 35–50.*
[31] A. Scott (ed.): *Encyclopedia of Nonlinear Science*. Taylor & Francis, New York, 2005.
[32] B. B. Mandelbrot: *Les objets fractals: forme, hazard et dimension*. Flammarion, Paris, 1975.
[33] H.-O. Peitgen, H. Jürgens and D. Saupe: *Chaos and Fractals. New Frontiers of Science*. Springer, New York et al., 1992.
[34] G. Caldarelli and M. Catanzaro: *Networks. A Very Short Introduction*. Oxford University Press, Oxford, 2015.
[35] S. L. T. McGregor: „Transdisciplinary axiology: to be or not to be?" *Integral Readership Review 11(3), 20 pp, 2011*
[36] T. G. Ash: „Europe's True Stories". *Prospect, 2007, 131, p. 36*
[37] R. Inglehart et al. (eds): *Human Belief and Values. A Cross-Cultural Sourcebook based on 2002–2004 Value Surveys*. Siglo XXI, Mexico City, 2004.
[38] R. Inglehart, R. Foa, C. Peterson, C. Welzel. „Development, freedom and rising happiness". *Persp. Psychol. Sci, 2008, 3(4),p. 264–285.*
[39] R. Di Tella and R. MacCulloch: „Gross national happiness as an answer to the Easterlin Paradox". *J. Developm. Econ., 2008,86, p. 22–42.*
[40] M. Pennock and K. Ura: „Gross national happiness as a framework for health impact assessment". *Environm. Impact Assessment Rev., 2011, 31, p. 61–65.*
[41] *World Happiness Report*, ed by J. Helliwell, 2013, www. earth. columbia. edu/sitefiles
[42] K. Mainzer: *Thinking in Complexity*. Springer, Berlin et al., 1997.
[43] C. L. Crumley: „Historical ecology". In: C. L. Crumley and W. H. Marquardt (eds), *Regional Dynamics*. Academic Press, New York, 1987, p. 237–264.
[44] W. S. McCulloch: „A heterarchy of values determined by the topology of neurons". *Bull. Math. Biophys., 1945, 7, p. 89–93.*
[45] S. H. Schwartz and W. Bilsky: „Toward a universal psychological structure of human values". *J. Personality and Social Psychology, 1987, 53, 3, p. 550–562.*
[46] K. Leung, A. Au, X. Huang, J. Kurman, T. Niit and K.-K. Niit: „Social axioms and values: a cross-cultural examination". *Eur. J. Personality, 2007, 21, p. 91–111.*
[47] M. Lauristin and P. Vihalemm (eds): *Return to the Western World. Cultural and Political Perspectives on the Estonian Post-Communist Transition*. Tartu University Press, Tartu, 1997.
[48] J. Engelbrecht: *Nonlinear Wave Dynamics. Complexity and Simplicity*. Kluwer, Dordrecht et al, 1997.
[49] S. L. Dolan, S. Garcia, S. Diegoli and A. Auerbach: „Organizational values as „attractors of chaos": an emerging cultural change to manage organisational complexity". *UPF Economics Working Paper, 2000, 16 pp.*
[50] J. Kagan: *The Three Cultures*. Cambridge University Press, Cambridge, 2009.
[51] C. P. Snow: *The Two Cultures and a Second Look*. Cambridge University Press, Cambridge, 1969.

[52] R. Kitt and J. Kalda: „Properties of low-variability periods in financial time series". *Physica A, 2005, 345, p. 622–634.*
[53] R. Kitt and J. Kalda: „Scaling analysis of multi-variate intermittent time series". *Physica A, 2005, 353, p. 480–492.*
[54] B. Roehner: *Pattern of Speculation: A Study in Observational Econophysics*. Cambridge University Press, Cambridge, 2002.
[55] T. Puu: *Attractors, Bifurcations & Chaos. Nonlinear* Phenomena in Economics. Springer, Berlin and Heidelberg, 2003.
[56] G. Caldarelli, M. Cristelli, A. Gabrieli, L. Pietronero, A. Scala and A. Tachella: „A network analysis of countries' export flows: firm grounds for the building blocks of the economy". *PLoS ONE, 2012, 7(10), e 47278.*
[57] A. Tachella, M. Cristelli, G. Caldarelli, A. Gabriel and L. Pietronero: „A new metrics for countries' fitness and products' complexity". *Sci. Rep. 2012, 2, p. 723.*
[58] M. Cristelli, A. Tachella, L. Pietronero: „The heterogeneous dynamics of economic complexity". *PLos ONE, 2015, 10(2), e 0117174.*
[59] J. van den Hoven, D. Helbing, D. Pedreschi, J. Domingo-Ferrer, F. Gianotti and M. Christen: „FuturICT — The road towards ethical ICT". *Eur. Phys. J. Special Topics, 2012, 214, p. 153–181.*
[60] S. E. Page: „Complexity in social, political and economic systems". *American Economic Association, Ten years and Beyond: Economists answer NSF's Call for Long-Time Research Agendas, 2010, 6 pp.*
[61] T. Puu: *Arts, Sciences, and Economics*. Springer, Heidelberg et al., 2015.
[62] M. Wheatley: *Leadership and the New Science: Discovering Order in a Chaotic World*. Berret-Koehler Publ. Inc, San Francisco, 2006.
[63] W. B. Cameron: *Informal Sociology*. Random House, New York, 1963.
[64] A. Judge:. „Human values as strange attractors". *UNiS Journal, 1994, 5, 3, p. 12–30.*
[65] D. Helbing: „Pluralistic modelling of complex systems". *arXiv: 1007.2818 v 1, 2010, 20 pp.*